



**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 ADAMA ZURIA WOREDA,**  
**ETHIOPIA, USING GEOSPATIAL TOOLS**

**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**

**BELETE TAFESSE**

(GSR/0469/08)

**Advisors**

**Dr.K.V.SURYABHAGAVAN**

**Prof. M.BALAKRISHNAN**

**Addis Ababa University**

**June, 2017**



**IMPACT OF LAND-USE/LAND-COVER CHANGES ON LAND  
SURFACE TEMPERATURE IN ADAMA ZURIA WOREDA,  
ETHIOPIA, USING GEOSPATIAL TOOLS**

*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**

**BELETE TAFESSE HABTEWOLD**

**(GSR/0469/08)**

**Addis Ababa University**

**June, 2017**



## **Acknowledgments**

First and for most, I would like to thank the “**Almighty God**” who made it possible and for strength and patience that he gave me to complete my study successfully within the given short period of time. Next to “**God**”, many people and organizations deserve heartfelt thanks for their precious contributions to this study.

I express my heartfelt gratitude and indebtedness to my advisor Dr. K.V.Suryabhagavan and to my Co-advisor Prof. M.Balakrishnan, who helped me from the very beginning of the research to its compilation and for sharing me their time for valuable discussions and giving me their kind helpful guidance throughout this study.

Further, I would like to extend my thanks to all Earth Science Department staff members and Remote Sensing and Geo-informatics stream staff members for securing lab. facility and unreserved support.

I have a great gratitude to acknowledge the Ethiopian Mapping Agency, Central Statistical Agency, Ethiopian Geological Survey and Ethiopian Meteorology Agency for providing me the necessary data and information to carry out this study.

Special thanks go to all my family members and my classmates for their appreciation and continuous support. Finally, I want to thank all of those people who, once upon time, were my teachers, Friends and others, who helped me, to begin this long journey. Their names are too numerous to list, but many of them inspired me to learn and upgrade.

## Table of Contents

<b>Acknowledgments</b> .....	i
<b>List of Tables</b> .....	vi
<b>List of Figures</b> .....	vii
<b>List of Appendices</b> .....	ix
<b>List of Acronyms</b> .....	x
<b>Abstract</b> .....	xi
<b>CHAPTER ONE</b> .....	1
<b>1. INTRODUCTION</b> .....	1
1.1. Background of the study .....	1
1.2 Statement of the problem .....	3
1.3. Objectives of the study .....	3
1.3.1. General Objective .....	4
1.3.2 Specific Objectives .....	4
1.4. Research Questions .....	4
1.5. Scope of the study .....	4
1.6. Significance of the study .....	5
1.7. Limitations of the study.....	5
1.8. Structure of the thesis.....	5
<b>CHAPTER TWO</b> .....	7
<b>2. LITERATURE REVIEW</b> .....	7
2.1. Concept of land-use/land-cover change .....	7
2.2. Causes of land-use and land-cover changes.....	7
2.3. Land-use and land-cover change in Ethiopia .....	8
2.4. Remote Sensing.....	9

2.5. Geographic Information System (GIS) .....	9
2.6. Role of Remote Sensing and GIS in Land-use and Land-cover change .....	10
2.7. Land surface temperature .....	11
2.8. Urban heat island.....	11
2.9. The impact of land-use/land-cover change on land surface temperature.....	12
2.10. Normalized Difference Vegetation Index .....	12
<b>CHAPTER THREE .....</b>	<b>14</b>
<b>3. MATERIALS AND METHODS .....</b>	<b>14</b>
3.1. Description of the study area.....	14
3.1.1. Location .....	14
3.1.2. Topography.....	15
3.1.4. Population.....	18
3.2.1. Primary data.....	19
3.2.2. Remote Sensing data acquisition.....	19
3.2.3. Field data .....	23
3.2.4. Secondary data.....	23
3.2.5. Data description and source.....	24
3.2.6. Software Packages used.....	24
3.3. Methods.....	25
3.3.1. Data Preparation and Analyzing.....	27
3.3.2. Digital Image Processing (DIP).....	27
3.3.3. Image enhancement .....	27
3.3.4. Image classification .....	28
3.3.5. Classification accuracy assessment .....	29
3.3.6. Land-use/Land-cover change detection.....	33

3.4. Derivation of Normalized Difference Vegetation Index and Land surface temperature ...	33
3.4.1. Derivation of Normalized Difference Vegetation Index .....	33
3.4.2. Derivation of land surface temperature .....	34
3.4.3. Radiometric correction .....	35
3.4.4. Conversion at sensor spectral radiance.....	35
3.4.5. Conversion to top of atmosphere (TOA) reflectance .....	36
3.4.6. Conversion of radiance into brightness temperature .....	37
<b>CHAPTER FOUR</b> .....	42
<b>4. RESULTS</b> .....	42
4.1. Land-use/land-cover in 1989, 1999 and 2016 .....	42
4.2. Spatial extent of land-use/land-cover .....	44
Table 4.3: Land transformation for Adama Zuria Woreda (1989—2016).....	46
4.3. Settlement expansion during 1989–2016 .....	46
4.4. Accuracy assessment .....	47
4.5. Normalized difference vegetation index.....	48
4.6. Relationship between land-use/land-cover and Normalized difference vegetation index .....	50
4.7. Spatial pattern of land surface temperature in Adama Zuria Woreda .....	50
4.8. Impact of land-use/land-cover change on land surface temperature .....	52
4.9. Relationship between land-use/land-cover and land surface temperature.....	54
4.10. Relationship between normalized difference vegetation index and land surface temperature .....	55
4.11. Comparisons of LST distribution during 1989, 1999 and 2016.....	57
4.12. Verification of the result for land surface temperature.....	58
<b>CHAPTR FIVE</b> .....	60
<b>5. DISCUSSION</b> .....	60

5.1. Land-use/land-cover status of Adama Zuria Woreda .....	60
5.2. Normalized difference vegetation index .....	60
5.3. Land surface temperature .....	60
<b>CHAPTR SIX</b> .....	<b>63</b>
<b>6. CONCLUSION AND RECOMMENDATIONS</b> .....	<b>63</b>
6.1. Conclusion.....	63
6.2. Recommendations .....	63
<b>References</b> .....	<b>65</b>
<b>Appendices</b> .....	<b>71</b>

## List of Tables

<b>Table 3.1</b> Remote sensing data used in the study.....	19
<b>Table 3.2:</b> Landsat 4 Thematic Mapper sensor bands and description. ....	21
<b>Table 3.3:</b> Landsat 7 Enhanced Thematic Mapper Plus bands and description.....	22
<b>Table 3.4:</b> Landsat 8 Operational Land Imager and Thermal infrared Sensor bands and description.....	23
<b>Table 3.5:</b> Data Description and source used in this study. ....	24
<b>Table 3.6:</b> Land-use/land-cover classes and description of the study area. ....	30
<b>Table 3.7:</b> Emissivity constant value of Landsat 8. ....	35
<b>Table 3.8:</b> Thermal band calibration constant of Landsat 8.....	38
<b>Table 3.9:</b> Split window algorithm constant value. ....	39
<b>Table 3.10:</b> Thematic mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) thermal band calibration constant. ....	39
<b>Table 4.1:</b> Land-use/land-cover classes and area coverage of 1989, 1999 and 2016 in Adama Zuria Woreda, Ethiopia.....	42
<b>Table 4.2:</b> Land-use/land-cover distribution and net changes during 1989–2016.....	45
<b>Table 4.3:</b> Land transformation for Adama Zuria Woreda (1989—2016). ....	46
<b>Table 4.4:</b> Statistical information of accuracy assessment for the year 1989, 1999 and 2016.. ..	48
<b>Table 4.5:</b> Statistical information of NDVI value for the years 1989, 1999 and 2016. ....	48
<b>Table 4.6:</b> Zonal statistical description of LST in 1989, 1999 and 2016 over different LU/LC classes. ....	52
<b>Table 4.7:</b> Mean temperature of 1989, 1999, 2016 and changes in temperature during 1989–2016 in the study area. ....	54
<b>Table 4.8:</b> Trends of land surface temperature distribution during the study period in Adama Zuria Woreda during 1989–2016.....	57

## List of Figures

<b>Figure 3.1:</b> Location map of the study area. ....	14
<b>Figure 3. 2:</b> (a) Elevation and (b) Slope map of the Study area. ....	15
<b>Figure 3.3:</b> Monthly average rainfall distribution of the Study Area. ....	16
<b>Figure 3.4:</b> Distribution of annual rainfall in the study area (1989–2016). ....	17
<b>Figure 3.5:</b> Maximum, minimum and mean monthly Temperature during 1989–2016. ....	17
<b>Figure 3.6:</b> Population of Adama Zuria Woreda. ....	18
<b>Figure 3.7:</b> Landsat Images of 1989 TM, 1999 ETM+ and 2016 OLI and TIRS. ....	20
<b>Figure 3.8:</b> Methodological flow chart of the study. ....	26
<b>Figure 3.9:</b> Interpretation of Landsat image for LU/LC classification. ....	31
<b>Figure 3.10:</b> Steps and procedures followed to classify land-use/land-cover from a Landsat image. ....	32
<b>Figure 4.1:</b> Land-use/land-cover maps of the study area of the years of 1989, 1999 and 2016. ....	43
<b>Figure 4.2:</b> Land-use/land-cover distribution and changes in the study area during the period 1989–2016. ....	44
<b>Figure 4.3:</b> Land-use/land-cover changes during 1989–2016 in the Adama Zuria Woreda. ....	45
<b>Figure 4.4:</b> The trend of expansion of settlement area from the year 1989 to 2016 in Adama Zuria Woreda. ....	47
<b>Figure 4.5:</b> Normalized difference vegetation index maps of the study area (1989, 1999 and 2016). ....	49
<b>Figure 4.6:</b> Zonal statistical description of NDVI in 1989, 1999 and 2016 over different LU/LC classes in the study area. ....	50
<b>Figure 4.7:</b> Land surface temperature maps of the study area of the years 1989, 1999 and 2016. ....	51
<b>Figure 4.8:</b> Different views of land surface temperature of the study area for 2016. ....	53
<b>Figure 4.9:</b> Comparisons of mean land surface temperature in different land-use/land-cover classes during the study period in Adama Zuria Woreda. ....	54
<b>Figure 4.10:</b> Land surface temperature and normalized difference vegetation index correlation for the years 1989, 1999 and 2016 for the study area. ....	56
<b>Figure 4.11:</b> Comparisons between LST distributions of the years 1989, 1999 and 2016 in Adama Zuria Woreda. ....	57

**Figure 4.12:** a) Interpolated map of rainfall and b) Interpolated map of temperature of Adama Zuria Woreda. .... 58

**List of Appendices**

**Appendix 1:** Classification accuracy assessment report for the year 1989. .... 71

**Appendix 2:** Classification accuracy assessment report for the year 1999. .... 72

**Appendix 3:** Classification accuracy assessment report for the year 2016. .... 73

**Appendix 4. Plate 1:** Sample of different LU/LC photographs. .... 74

**Appendix 5. map 1:** Location of meteorological stations map ..... 75

**Appendix 6 map 2:** GPS point data map ..... 76

### **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

Land-use/land-cover change is one of the main environmental problems and challenges, which strongly influence 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. The research was conducted in Adama Zuria Woreda, located East Shewa Zone of Oromia region, in the main Ethiopian rift valley. Land-use/land-cover, LST and NDVI were extracted from Landsat TM (1989), Landsat ETM + (1999), Landsat 8 OLI/TIRS (2016) using GIS and remote sensing tools. Remote sensing and GIS were found to be a robust technique to quantify and map the LU/LC changes and its drawback on LST. Land surface temperature was done using split window algorithm. Changes in LU/LC, which occurred between 1989 and 2016 in the study area was evaluated and analyzed using geospatial tools and verified by field data. The result of LU/LC indicated that farmland covered more than 60% during the study periods (1989–2016) and followed by shrub land covering more than 12%. The study indicated that most areas having lower LST in 1989 were changed to higher LST in 1999 and 2016. This happened due to the increased in different LU/LC changes especially the decreasing of vegetation cover in the study area. By linking the LU/LC classes and LST parameter using zonal statistics as table, it has been found that, LST has negative relationship with vegetation cover. Land surface temperature result showed that the northwestern, south (Wenji showa sugarcane plantation), lake Koka area and along Awash River have relatively low value ranged 9°C–21°C. This happened because of high NDVI value. While the eastern, Adama Town and western part had high LST value reached up to 42°C. Therefore, the visual comparison of 1989, 1999 and 2016 images showed that the LU/LC type and NDVI status play a great role for variability of LST values. Land-use/land-cover change could not be stopped easily. However, different measures have to be taken by environmental experts and the concerned bodies to minimize the influence of changes on the LST and environments. At last, this study implies that the use of geospatial tools as time saving and cost effective methods for LST analysis and evaluation.

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

## CHAPTER ONE

### 1. INTRODUCTION

#### 1.1. Background of the study

The planet earth has been in a state of continuous change since a long time ago and has faced with the problem of overwhelming increase in LST as compared from year to year. Land-use/land-cover (LU/LC) changes caused by natural and human processes have played a major role in global as well as regional scale patterns of the climate and other aspect of the earth (Ramachandra *et al.*, 2012). Now a day's global warming makes massive LU/LC changes, which affects many aspects of the natural environment. All over the world the change in LU/LC leads to environmental changes, rainy season fluctuation, sea level rise and increase land surface temperature (LST). Massive LU/LC changes are result of the need of land for settlement and agricultural in relation to the increasing human population. Land is a scarce (limited) natural resource, which cannot be changed when the population increases. Land-use should correspond to land capacity and it should respect the overall climate condition and the environment (FAO/UNEP, 1999). Human population is increasing and it causes transformation of natural setting/environment into human landscapes. Human settlements, the need for farmland, and especially industrial areas and large urban areas significantly modify their environment. Changing from permeable and moist land uses to impermeable and dry one with paving and building material can have a negative effect on LST and energy budget (Guo *et al.*, 2012), and also, many other surface properties such as the surface infiltration, runoff rate, evaporation and drainage system. Therefore, it is critical to study to have detailed information, spatial-temporal LU/LC dynamics and the rate of changes.

One of the main environmental problems in both rural and urban areas is the increase of LST due to conversion of vegetated surfaces into a settlement, bare land and agricultural land. Land surface temperature is one of the main variables measured using thermal bands of different sensors such as AVHRR, MODIS, Landsat-5TM, Landsat-7ETM+ and Landsat-8TIRS (Gebrekidan, 2016). Land surface temperature is the temperature of the land derived from solar radiation (Kumar and Singh, 2016). It is also defined as the temperature of the skin of earth surface phenomena and the feeling of how much hot the surface of the earth as derived from direct measurements/ from remotely sensed information (Kayet *et al.*, 2016).

According to Rajeshwari and Mani (2014), LST is the temperature emitted by the surface and measured in Kelvin/Celsius. In remote sensing language, LST is the surface radiometric temperatures emitted by the land surfaces and adhere/observed by a sensor at instance viewing angles (Prata and Caselles, 1995; Schmugge *et al.*, 1998). It is highly influenced by increasing greenhouse gases in the atmosphere. The changes of LST integrated with many factors, such as dynamics in land-use, seasonal variation of rainfall, weather condition and socio-economic development (Jiang and Guangjin, 2010). Urban thermal is sway out by the physical characteristics of the earth surface and by human socio-economic activities. Also to the rural area, it influenced by way of land-use and agricultural activities (Yue *et al.*, 2007). The thermal environment can be considered to be the main and significant indicator for describing the urban vegetation and environment (Yue *et al.*, 2007).The total energy-balance of urban areas is similar to the rural areas; however, there is difference in the ratio of shortwave and long wave radiation (Orsoloya *et al.*, 2016).

Being a less developed society, the adhered dynamics of the land are rapid in Africa than in developed continents. Environmental degradation (deterioration) is a main phenomenon in Ethiopia since agricultural activities were begun (Orsoloya *et al.*, 2016). Increasing number of population or High population pressure, low production, decline land holding size, loss of soil fertility and increasing demand for fuel energy and construction are some of the expected challenges for Ethiopia for the future. Modification and conversion of environment have impact on ecology and foster pressure on the living standard of the society. As Asubonteng (2007), stated land-use and rapid modification of land-cover have adept or practiced implications for human survival.

Changes in the land-cover occurs predominantly because of fire (Nunes *et al.*, 2005) and deforestation for agriculture and settlement (urban expansion) (Huang and Siegert, 2006). A Land-cover change further disturbs the biogeochemical cycling that induces global warming, erosion of soil and land-use patterns.

Remote sensing and GIS or geospatial tools are now providing new tools 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 Adama Zuria Woreda Ethiopia. Remote sensing and GIS also used for evaluating and processing meteorological data such

as rainfall and 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**

Global climate appears to be changing at an alarming rate (Naissan and Lily, 2016). Both urban and rural areas are experiencing warm temperature condition and it is increasing from time to time. The earth's environment is a dynamic system, including many interacting components (physical, chemical, biological and human) that are continuously varying (Emilio, 2008). Due to the increase of population, industrialization and other natural and human activities, its land-use/land-cover patterns are changing. One of the main factors that responsible for the increment of LST is land-use land-cover change. In the recent time, global warming and environmental problems are a headache for both within developing and developed countries. Practices such as overgrazing, deforestation, unplanned land-use for settlement and other activities lead our environment to warm temperature. In East Shewa (Misrak shewa) zone, Adama Zuria (surrounding) Woreda LST has been increasing from season to season. Therefore, what signifies the relevance of this study is a wide array of applications that gives information of LST and LU/LC status of the area as an input for planning and decision-making. According to Aires *et al.* (2001) LST is a main parameter in land surface processes, not only acting as an index of climate change, but also to control the upward terrestrial radiation, and consequently, the control of the surface sensible and latent heat flux exchange with the atmosphere.

In this study, RS and GIS approach or geospatial tools were used to examine and better understand LU/LC, the relationship between LU/LCC and LST of Adama Zuria Woreda. In addition, thermal infrared remote sensing is a part of the electromagnetic spectrum and one of the best observation tools for calculating and quantifying LST.

The basic argument why this study is proposed and done in Oromia national, regional estate, East Shewa Zone Adama Zuria Woreda is that, the area is characterized diverse vegetation, climate, and topographic pattern and different land-use/land-cover.

## **1.3. Objectives of the study**

This study was carried out in the Adama Zuria Woreda, Oromia national, regional estate, Ethiopia and was intended to meet the following general and specific objectives.

### **1.3.1. General Objective**

The general objective of this research was to investigate the impact of LU/LC dynamics on LST change in Adama Zuria Woreda, Ethiopia based on Landsat imagery using geospatial tools.

### **1.3.2 Specific Objectives**

To achieve the general objective, the following three specific objectives were formulated. These are:

- To examine temporal and spatial changes in the LST in relation to land-use/land-cover dynamics in the study area
- To analyze the relationship between LST and NDVI over time.
- To produce maps of land-use/land-cover, NDVI and LST from multi temporal Landsat satellite images.

### **1.4. Research Questions**

Understanding the impact of LU/LC and vegetation on LST could serve to be useful for land management and planning strategies focused on LST mitigation and the adaptation of the study area to the challenges of climate change. All the activities that are to be based on the above general and specific objectives should correlate with the following research question.

- ❖ What are the spatiotemporal patterns of LU/LC changes of the study area?
- ❖ What is the major LU/LC class of the study area?
- ❖ What is the role of NDVI in LST?
- ❖ What is the correlation between LU/LC and LST in the study area?
- ❖ What is the impact of LU/LC dynamics on LST change in the study area?

### **1.5. Scope of the study**

The present study was conducted in the Adama Zuria Woreda (Adama surroundings Woreda) Oromia Region; Ethiopia. The study areas have different land-use/land-cover patterns and the LU/LC has been changing from time to time. As a result, LST of the Woreda has been rising from time to time. However, the increase of LST is not supported by research rather than perception of local communities. In order to know and compute the trend of LU/LC change, to know the correlation between LST and Land-use/land-cover (LU/LC) and to analysis, the impact of LU/LC dynamics on LST change. For each land-use/land-cover classes the LST values assessed and LU/LC classification should be supported by field verification. Increasing LST leads to environmental

problem such as climate change and seasonal fluctuation. Unless land for Settlements and farmland properly managed, it can affect and have a negative impact on the environment. Therefore, to overcome this problem, the present study would contribute for decision makers as information and identifying different LU/LC classes and changes.

### **1.6. Significance of the study**

The significance of the study could be, 1) Give information about the trend of LU/LC and LST Change of the area. 2) It could be used as an input for government policy makers, urban and rural land management, natural resources managers, environmental experts and other concerned bodies for their decision making processes related to how LU/LC and LST changes through time. In addition to this, it can be a reference or initial step and use as input for coming researchers based on the analysis of the study. In addition, it helps to quantify the relationship between LST and LU/LC, and can be an important input to predict future land warming.

The output of the study would provide better information about the changes in urban areas and surrounding integrated application of GIS and remote sensing techniques or geospatial tools and its applicability, which is time and cost effective for analysis and impact of LU/LC dynamics on LST. It also provides the opportunity to understand the trends of changes and its driving factors.

### **1.7. Limitations of the study**

The present study was attempted with all possible efforts in acquiring required inputs in the form of primary and ancillary data collection, interpretation and analysis. However, the study has encountered certain limitations. One of the limitations was routine process to get data from different organizations.

### **1.8. Structure of the thesis**

The first Chapter introduces introduction, statement of problem, objectives of the study, research questions, 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 land-use/land-cover changes, LST and NDVI in general. The third chapter focuses on the general methodology followed, 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, land-use/ land-cover 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 the basic concepts and meaning of LU/LC, LST, NDVI, RS and GIS. Furthermore, it tries to explore the findings of relevant studies that have been studied previously in different area.

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

The earth's surface has been changed considerably in the past decades by human's as a result human induced factors of deforestation, agricultural activities and urbanization. Land is the ultimate resource of the biosphere and the definition 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 negative socio-ecological feedback that comes from a rigorous (severe) degradation in ecosystem services/ as a result of from 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 3 centuries, the extent of earths cultivated land has grown by more than 45% increasing from 2.65 million km<sup>2</sup> to 15 million km<sup>2</sup> 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), 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/LC changes in different part of the country and the expansion of cultivated land at the expense of forestland 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 and Yimer, 2017).

#### **2.4. Remote Sensing**

Remote sensing is the capability to gather information without being in direct contact with it (Lillesand and Kiefer, 2000). The modern use of the term remote sensing has more to do with technical ways of collecting airborne and space born 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 remote sensing 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 geographic information system 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 (areas, points and lines) but also capable of spatial analysis based on the relation between these objects, including the r/ship between objects defined by their location and geometry.

According to Foresman (1998), the combination of computer technology and cartography in the 1960s paved the way for the possibility of using techniques of superimposing 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 geographic information system 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 remote sensing data, the reduction in data cost and increased resolution from satellite platforms, remote sensing 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 Landsat7 (Enhanced Thematic Mapper Plus sensors) by the United State in 1999.

According to Macleod and Congation (1998), there 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 remote sensing 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**

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 is 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, Md Shahid, 2014). According to Kerr *et al.* (2004) land surface temperature gives information about the difference of the surface equilibrium state and vigorous/vital for many applications. LST also defined as, the monitoring of surface temperature based on pixel derived observation through remote sensing (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 radiative 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 surface temperature 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 occurs when air and surface temperatures (ST) in urban areas became significantly greater than those experienced in nearby 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 mean

temperature (IPCC, 2014). There are number of contributor 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 land surface temperature is LU/LCC and Different researchers agree with that land-use change and unplanned use of land resources lead to increasing land surface temperature. 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 1°C variation and increase in surface temperature of vacant land, built-up area and stream, while cultivated land and vegetation also had increases of 0.95°C ,respectively. The influence of LU/LC changes 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, land cover were transformed to grazing 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 land surface temperature and normalized difference vegetation index calculated by 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). To calculate the Normalized Difference Vegetation Index, subtracting the red band from near infrared and then dividing to near infrared plus red band. The value is ranging from -1 to1, 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 radiative properties of the earth's

surface that determine LST (Weng, 2004). In addition to NDVI, Normalized Difference Moisture Index (NDMI) 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 vegetations and it is an excellent indicator of dryness. Values greater than 0.1 are symbolized light colors and they signal high humidity level, whereas 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/LC changes on land surface temperature. 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 centre 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 Normalized difference vegetation index and Land Surface Temperature and the study indicates the need for urban greening and plans to increase vegetations 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

Adama Zuria Woreda (Adama and surrounding Woreda) is one of the Woredas in the East Shewa Zone of the Oromia, Regional State of Ethiopia. The Administrative center of the Woreda is Adama, which is located southeast of Addis Ababa the capital city of Ethiopia approximately about 90 km at latitude and longitude of  $8^{\circ} 14' 0''$ – $8^{\circ} 43' 0''$ N and  $39^{\circ} 6' 0''$ – $39^{\circ} 25' 0''$  E, covering a total area of  $901.5 \text{ km}^2$  (Fig.3.1). Altitude of the area range from 1415 to 2505 m above sea level and it is located within the Great Ethiopian Rift Valley.

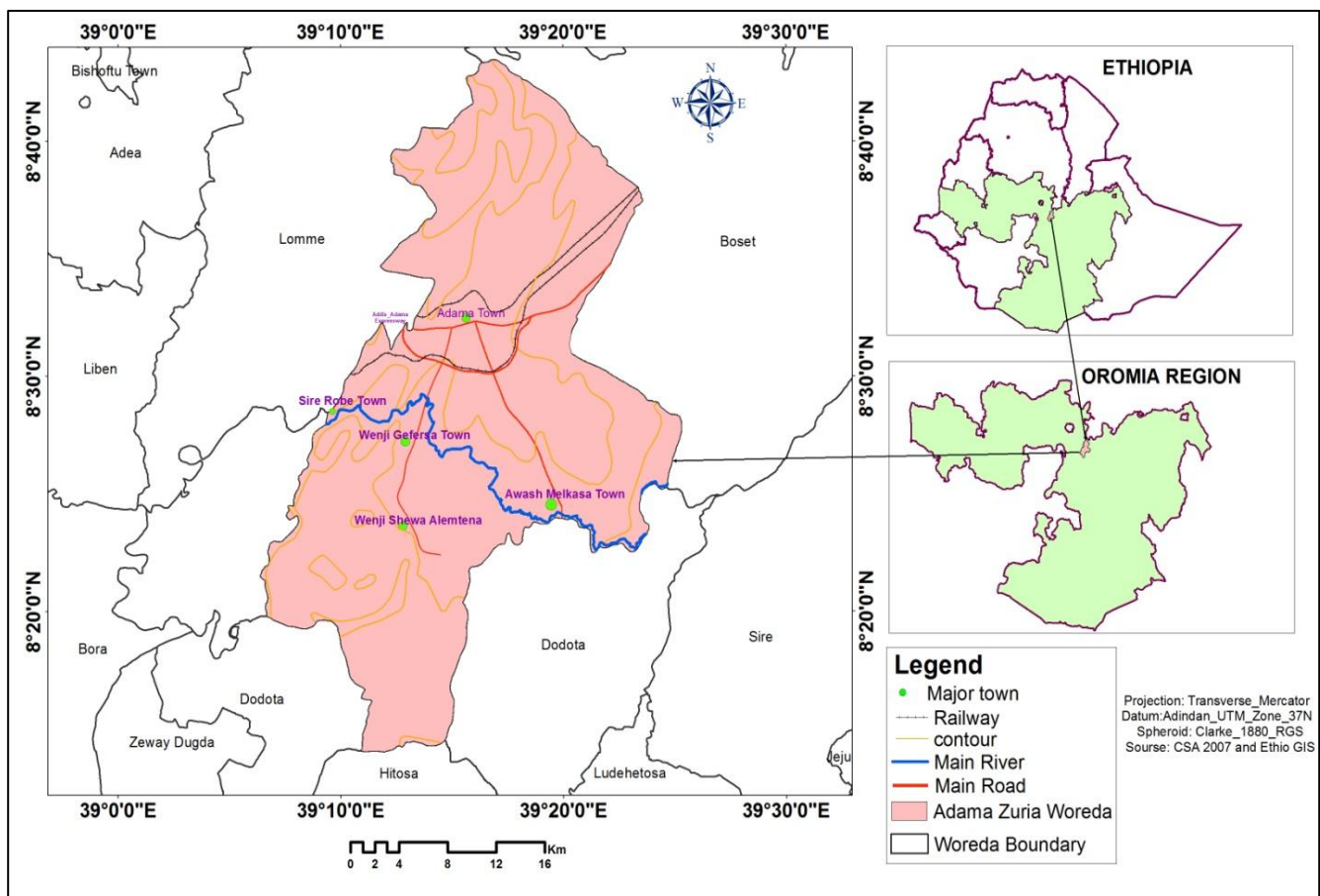
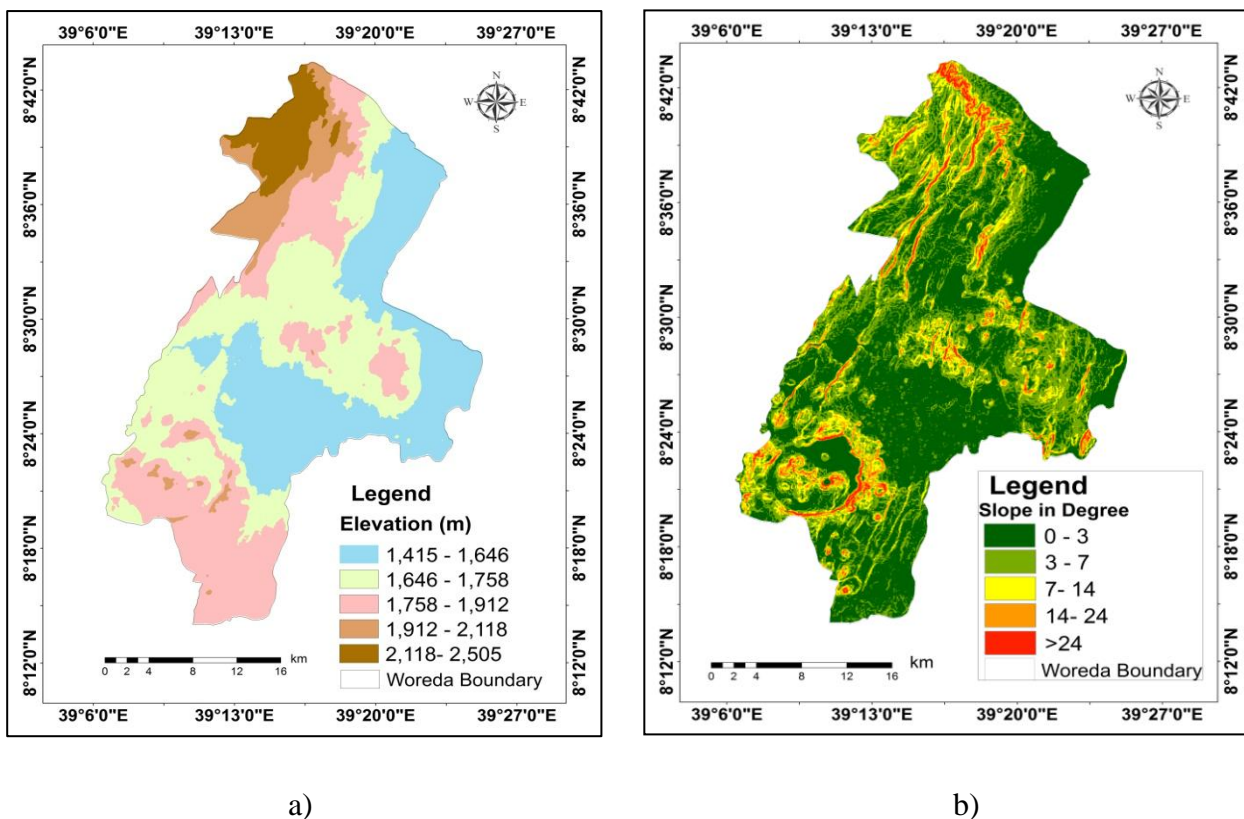


Figure 3.1: Location map of the study area.

### 3.1.2. Topography

Topography is the study of the shape and feature of the surface of the earth and other related phenomenon or it is an integral part of the land surface. It includes such as landforms, elevation, latitude, longitude and topographic maps. The Adama Zuria Woreda has a broad flat area. However, in its northwest part there is relatively rugged topography. It also bordered on the south by the Arsi Zone, on the Southwest by Koka reservoir, which separates it from Dugda Bora on the west by Lome on the north by the Amhara Region, and on the East by Boset; the Awash River, the only important river in this Woreda, defines the Woreda boundaries on the east and south. The elevation of the study area is indicated in (Fig. 3.2 a).

Slope of Adama Zuria Woreda shows that, 61.73% of the area is between 0 and 3 °. 26.55% of the area is between 3 and 7 °, 8% of the area between 7 and 14 °, 3% of the area 15 between 24 ° and 0.62 % of the area is more than 24 ° of slope. Slope of the area with greater than 24 ° is located in the northern, northwest, southwest ridge part of the area. The slope of the area is indicated in (Fig.3.2 b).

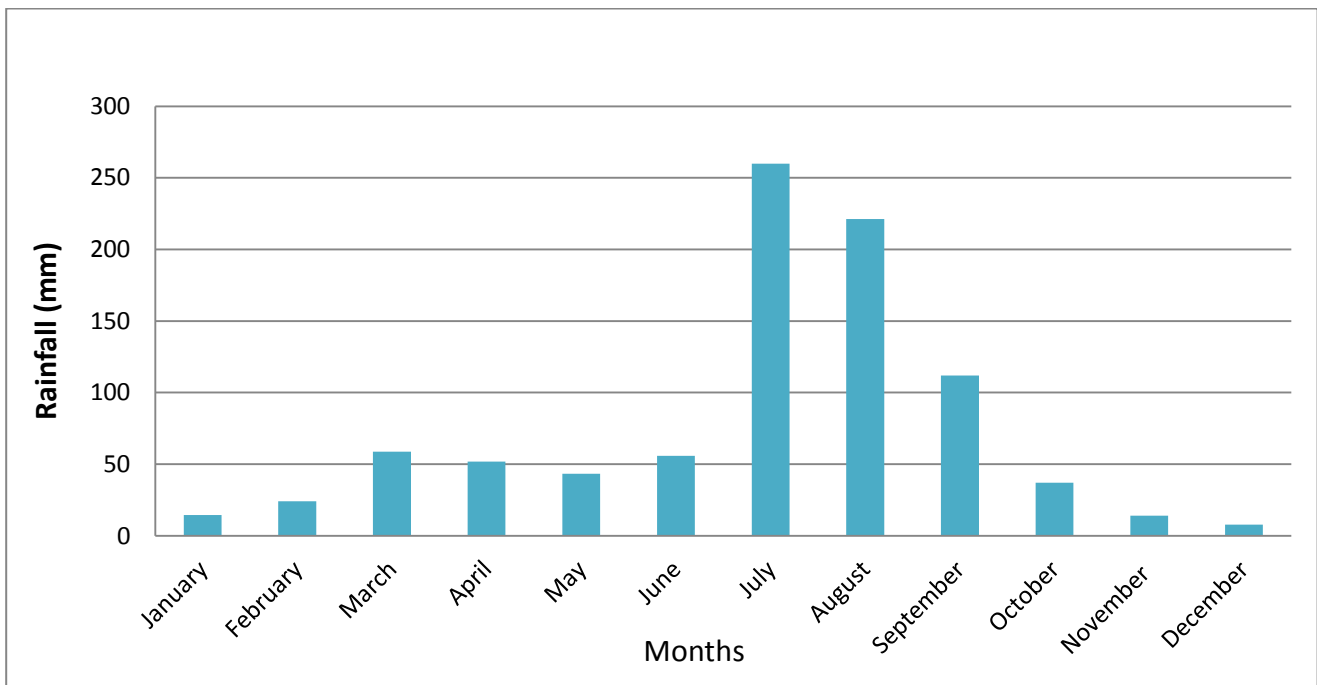


**Figure 3.2:** (a) Elevation and (b) Slope map of the Study area.

### 3.1.3. Climate and Vegetation

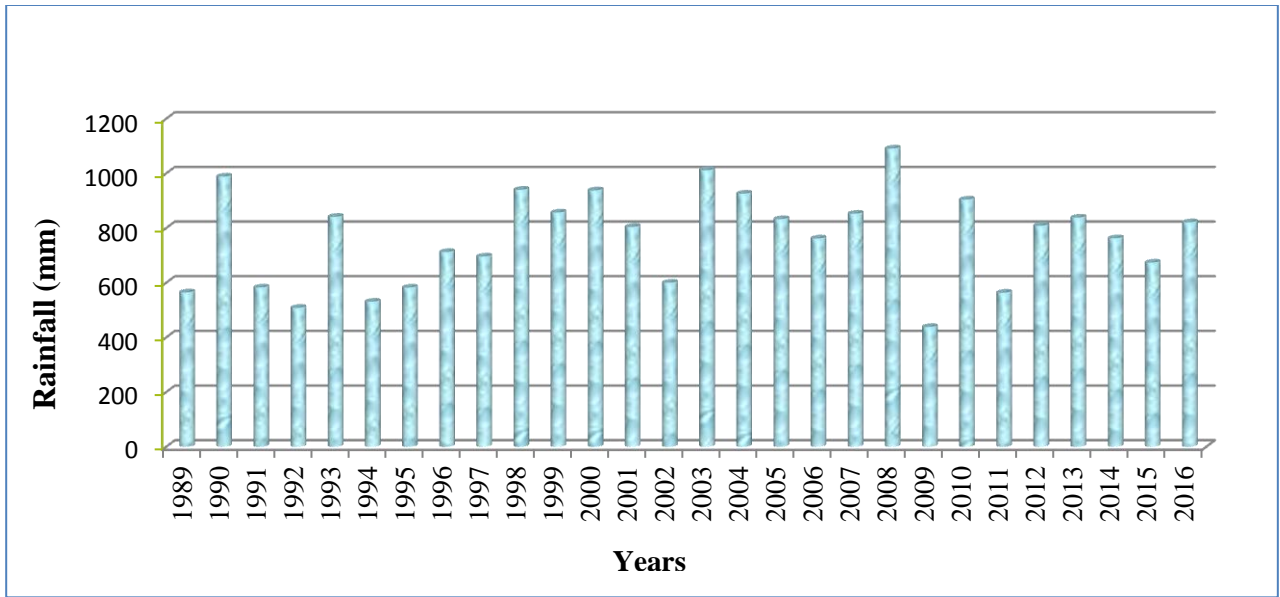
#### A. Rainfall

A long-term rainfall record from 1989 to 2016 at the Adama meteorological station shows an average annual rainfall of 844.20 mm and the maximum monthly average rainfall was 259.8 mm in the month of July (Fig.3.3). On the average, most rainfall or rainy season is June, July, August and September. Whereas, the dry month is in January, October, November and December. On average, the warmest month is May and coolest month is July. Among all months, the driest month is December.



**Figure 3.3:** Monthly average rainfall distribution of the Study Area.

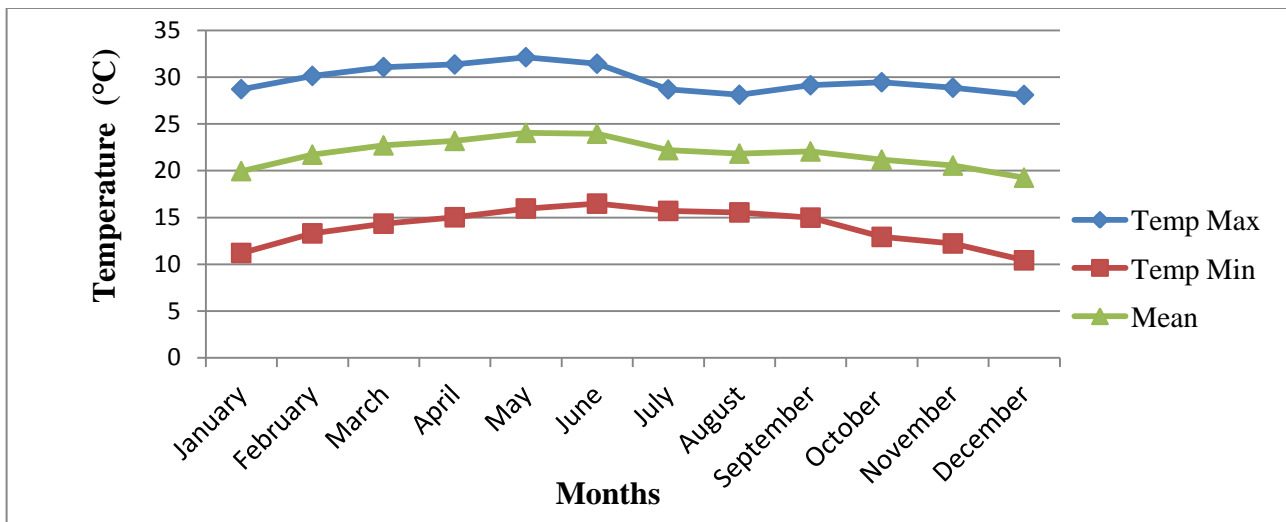
The average rainfall recorded between 1989 and 1999 was 709.9 mm, while 1999 and 2010; it was 833.24 mm and 745 for the years between 2010 and 2016. The distribution of annual rainfall from (1989–2016) is presented in (Fig.3.4).



**Figure 3.4:** Distribution of annual rainfall in the study area (1989–2016).

### B. Temperature

The mean annual temperature of the Adama Zuria Woreda is 27.8°C. It can be classified as semi-humid to semi-arid climate, which characterizes the altitude range between 1,500–2,400 m above mean sea level. In the study area, the hottest month with maximum mean temperature of 30.7°C was May. The detailed information presented in (Fig. 3.5).



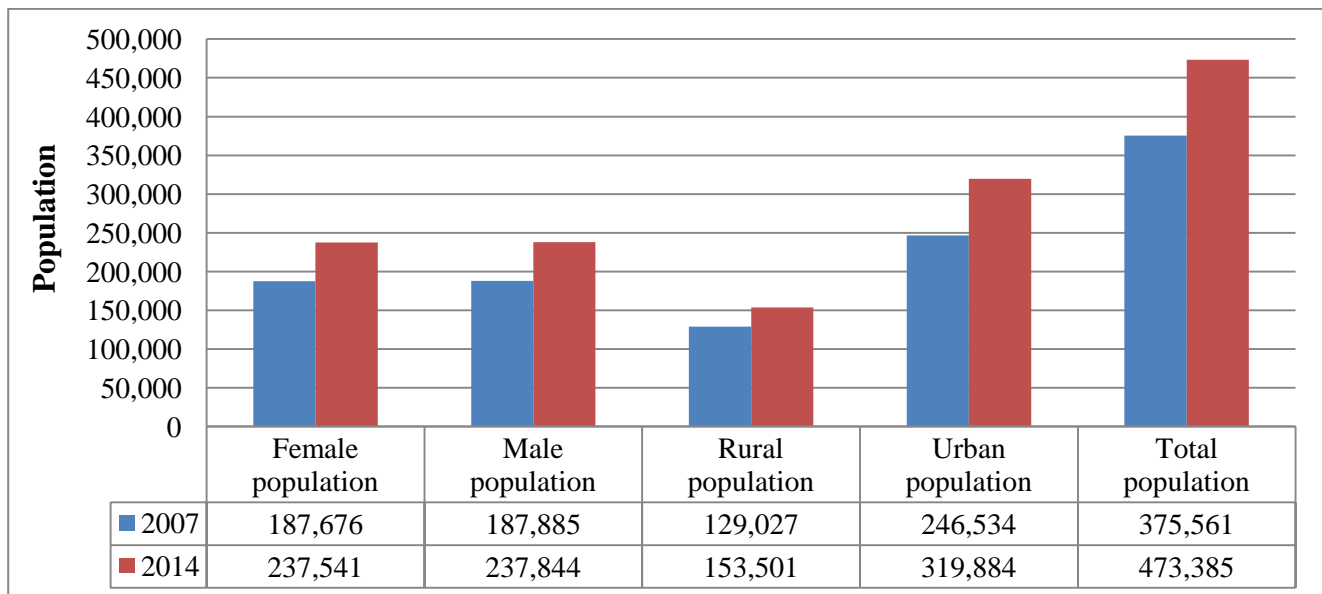
**Figure 3.5:** Maximum, minimum and mean monthly Temperature during 1989–2016.

### 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. The local people cultivate, some types of crops cultivated in the area are Teff, wheat, Barley, maize and sorghum. The harvesting season is between October and December at which the rain is very low.

#### 3.1.4. Population

According to CSA (2007), the total human population of Adama Zuria Woreda including Adama Town is about 375,561. Out of this, 187,676 are women and 187,885 are men. While in 2014 CSA projected data (estimated population) the total population is about 473,385. From this, about 237,541 are women and 237,844 are men. The detail information is presented in (Fig.3.6).



**Figure 3.1:** Population of Adama Zuria Woreda.

### 3.2. Data and software

Data used for this research comprise both primary and secondary (Ancillary). The most important source was the primary data (satellite data). Ancillary source of data was collected from governmental and nongovernmental organization and published information.

### 3.2.1. Primary data

The primary data includes Landsat satellite image (Landsat data): Thematic Mapper (TM) 1989, Enhanced Thematic Mapper Plus (ETM+) 1999 and Operational Land Imager/Thermal Infrared (OLI/TIRS) obtained from USGS. Digital Elevation Model (DEM) data with the resolution of 30\*30m for mapping the elevation and slope of the area and field data, GPS point and photo of different classes of LULC were used.

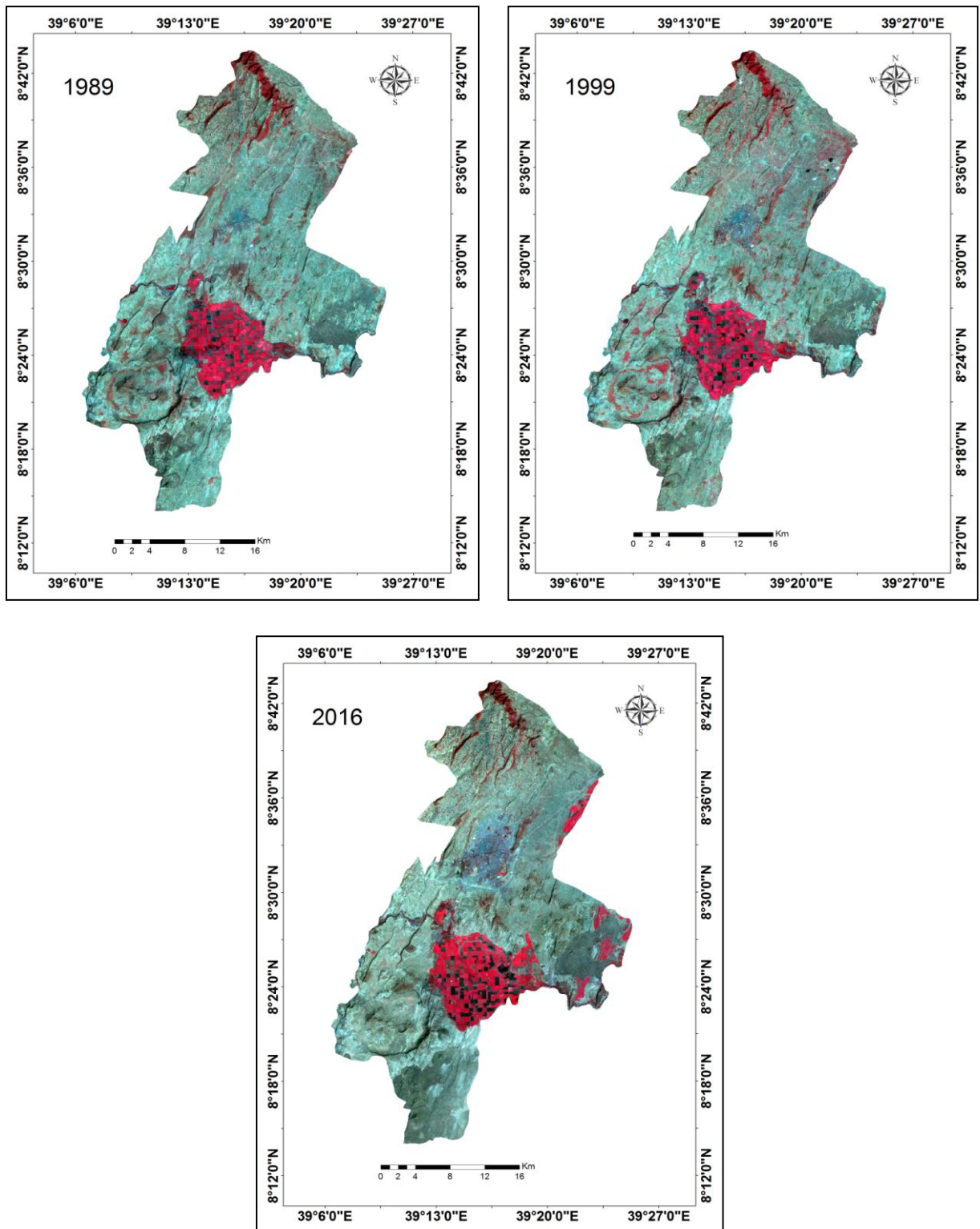
### 3.2.2. Remote Sensing data acquisition

One scene of Landsat 4 TM (1989), Landsat7 ETM+ (1999) and Landsat 8 OLI/TIRS (2016) cloud free image of the study area with the path of 168 and row 054 were acquired (downloaded) from the website of earth explorer. usgs.gov, United States Geological survey (USGS) and Landsat8 from <https://libra.developmentseed.org>.The-acquired data is world datum (WGS84) projection system.

Remote sensing images used to calculate LST, NDVI and LULC in Adama Zuria Woreda are shown in the following (Table 3.1) and multispectral band in (Fig.3.7).

**Table 3.1:** Remote sensing data used in the study.

Date of Acquisition	Sensor	Path	Row	Multispectra l Band	Thermal Band	Spectral range (micrometers)	Spatial Resolution (Pixel Spacing)	Source
11/21/1989	TM	168	054	1 to5 and7	6	10.45-12.45	120	USGS
12/3/1999	ETM+	168	054	1 to5 and7	6	10.45-12.51	60	
11/23/2016	OLI and TIRS	168	054	1 to7 and9	10 and 11	10.60-12.51	100	



**Figure 3.7:** Landsat Images of 1989 TM, 1999 ETM+ and 2016 OLI and TIRS.

### A. Landsat Thematic Mapper (TM)

The Landsat Thematic Mapper (TM) sensor was carried on-board four and five from July 1982 to May 2012 with 16-day repeat cycle. Thematic Mapper sensor has seven spectral bands; three in the visible range and four in the infrared range. Band 6 is specifically sensitive to thermal infrared radiation to measure surface temperature. Detailed information is shown in Table 3.2.

**Table 3.2:** Landsat 4 Thematic Mapper sensor bands and description.

	Bands	Description	Wavelength (Micrometers)	Spatial resolution (m)	Repeating time	Source
Landsat4 Thematic Mapper (TM)	Band 1	Blue	0.452-0.518	30	16 days	USGS
	Band 2	Green	0.528-0.609			
	Band 3	Red	0.626-0.693			
	Band 4	Near Infrared (NIR) 1	0.776-0.904	120		
	Band 5	Near Infrared (NIR) 2	1.567-1.784			
	Band 6	Thermal	10.45-12.45	30		
	Band 7	Middle Infrared (MIR)	2.097-2.349			

### B. Landsat 7 Enhanced Thematic Mapper plus (ETM+)

The Landsat Enhanced Thematic Mapper Plus sensor onboard the Landsat 7 satellite has acquired images of the Earth nearly continuously since July 1999, with a 16 day repeat cycle. Landsat 7 ETM+ images consist of eight spectral bands with a spatial resolution of 30m for bands 1-5 and 7 where as the thermal band 6 and panchromatic band 8 has a resolution of 60 and 15 m, respectively. Detail information is shown in Table 3.3.

**Table 3.3:** Landsat 7 Enhanced Thematic Mapper Plus bands and description.

Satellite /sensor	Bands	Description	Wavelength (micrometer )	Spatial resolution (m)	Repeating time	Source
Landsat 7 Enhanced Thematic Mapper Plus (ETM+)	Band 1	Blue	0.452-0.514	30	16 days	USGS
	Band 2	Green	0.519-0.601			
	Band 3	Red	0.631-0.692			
	Band 4	Near Infrared (NIR) 1	0.772-0.898			
	Band 5	Near Infrared (NIR) 2	1.547-1.748	60		
	Band 6	Thermal	10.31-12.36	30		
	Band 7	Middle Infrared (MIR)	2.065-2.346	15		
	Band 8	Panchromatic	0.515-0.896			

### C. Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)

Images consist of nine spectral bands with a spatial resolution of 30 m for band 1-7, 9, and TIRS with two bands (band 10 and 11). New band 1 (ultra-blue) is useful for coastal and aerosols studies. Another new band 9 is useful for cirrus cloud detection. Landsat 8 was launched in February 11, 2013 (Table 3.4).

**Table 3.4:** Landsat 8 Operational Land Imager and Thermal infrared Sensor bands and description.

Satellite/ sensor	Band	Description	Wavelength (micrometers)	Resolutio n (m)	Repeating time	Source	
Landsat 8 OLI/TIR S	Band 1	Coastal aerosol	0.43-0.45				
	Band 2	Blue	0.45-0.51				
	Band 3	Green	0.53-0.59				
	Band 4	Red	0.64-0.67				
	Band 5	Near Infrared (NIR)	0.85-0.88		30		
	Band 6	Short -Wave Infrared (SWIR) 1	1.57-1.65			16 days	USGS
	Band 7	Short -Wave Infrared (SWIR) 2	2.11-2.29				
	Band 8	Panchromatic	0.50-0.68		15		
	Band 9	Cirrus	1.36-1.38		30		
	Band 10	Thermal Infrared (TIRS) 1	10.60-11.19		100		
	Band 11	Thermal Infrared (TIRS) 2	11.50-12.51				

### 3.2.3. Field data

Field data used for this research was from GPS data and used for accurately checking the LU/LC classified image into different classes. After Random point, generated GPS point was collected and pictures captured showing different LU/LC classes. Field data was used for validation accuracy assessment based on ground truth.

### 3.2.4. Secondary data

Secondary data used in this study comprises meteorological data such as average monthly temperature (1989–2016) and average monthly rainfall (1989–2016). These meteorological data was used for evaluation and validation. In addition to this, the other data used in this study were

geological map from Ethiopian Geological Survey to see the geological setting of the area and population data from CSA to understand the status of the population of the study area (CSA, 2007).

### 3.2.5. Data description and source

Primary and ancillary data that used in this study was collected from different sources as indicated in Table 3.5.

**Table 3.5:** Data Description and source used in this study.

GIS Data layer	Data Description	Data source
Vector (polygon)	Woreda (Woreda) Boundary	CSA,2008
Vector (line)	River and Roads	CSA,2008
Vector (point)	Major Town	Ethio-GIS
Raster	Elevation and Slope	DEM 30m SRTM
Attribute table	Rainfall and Temperature	National Metrological Agency
Attribute table	Population	CSA,2007
Raster	Satellite Image <ul style="list-style-type: none"> <li>• 1989 Landsat4 TM</li> <li>• 1999 Landsat7ETM+</li> <li>• 2016 Landsat 8 OLI and TIRS</li> </ul>	USGS 1989,1999 and 2016
Ground truth	Ground truth 2016	Field survey

### 3.2.6. Software Packages used

Software packages used for this study were ArcGIS 10.3 for image analysis; calculate LST, NDVI and map preparation, ERDAS (Earth Resources Data Analysis System) Imagine 2014 for RS application in order to process satellite images including image enhancement, preprocessing and for LU/LC classification.

PCI Geomatica 2015 was also used for top of atmospheric correction, change detection and export to Google earth. Google earth also used to check and compare results with ground truth, especially

for the year 1989 and 1999 LU/LC verification. Quantum GIS (QGIS): open source software was used for raster manipulation include neighborhood analysis and map algebra. In addition to ERDAS Imagine software, ENVI software used for classification to compare and contrast the results. Microsoft office, Microsoft Excel and Microsoft power point was used to create word documents, analyze spreadsheets, to do graphs, manage databases and for presentation.

### **3.3. Methods**

In this study, the methods used to achieve the objectives of the research were begun with acquisition of Landsat imagery for the year 1989, 1999 and 2016 from website of earth explorer (USGS) and Landsat 8 from <https://libra.developmentseed.org>. The reason behind that these years chosen were because of the availability of the data. The image acquired or downloaded was during the dry season and was cloud free image. Figure 3.8 show the general methodological flow chart of the study.

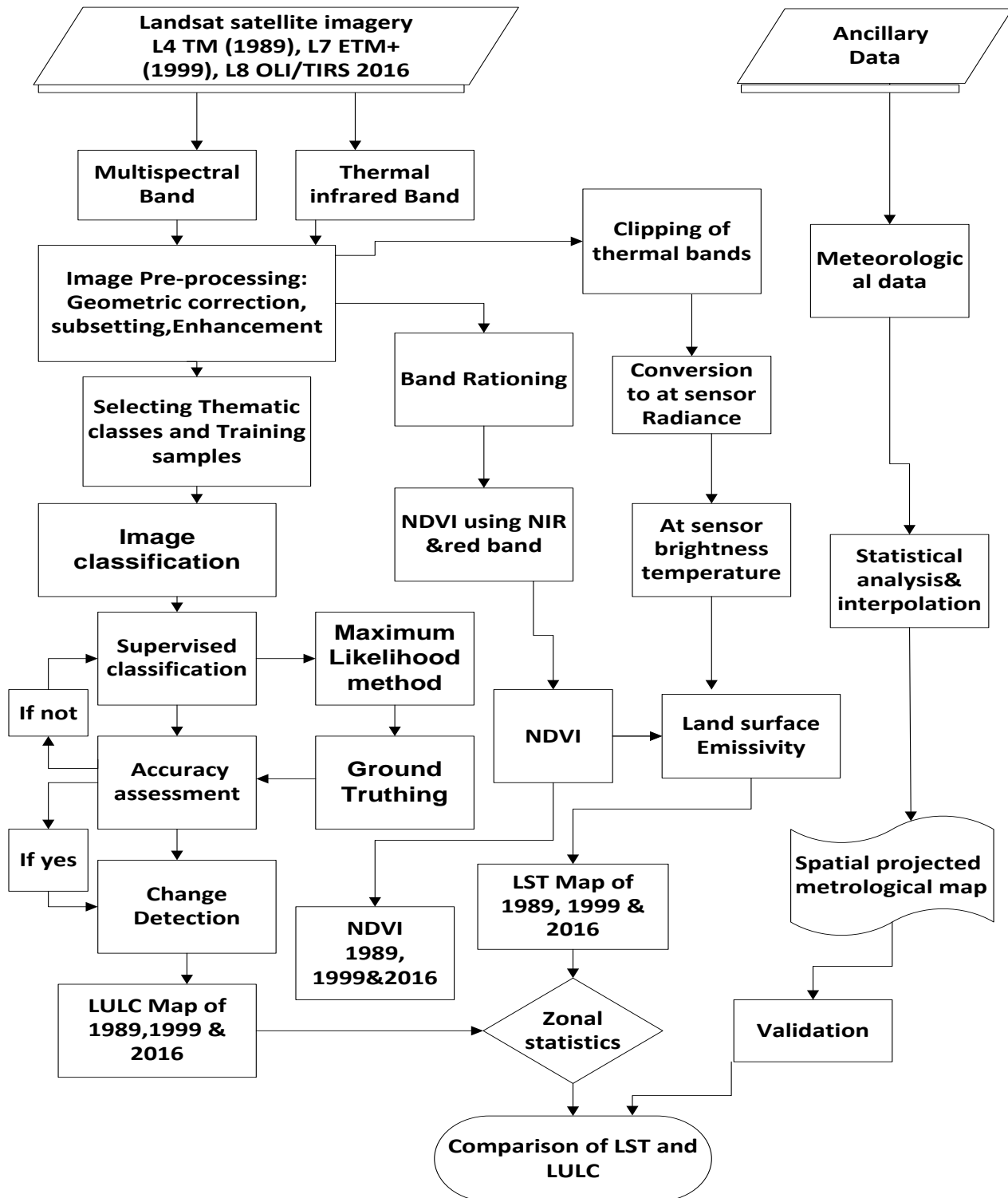


Figure 3.8: Methodological flow chart of the study.

### **3.3.1. Data Preparation and Analyzing**

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 the boundary of Adama Zuria Woreda, 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 Woreda. During georeferencing 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 digital image is a sampled quantized numeric representation of the scenes and made up of picture element called pixels. It 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 separability of the objects on the image.

### **3.3.3. Image enhancement**

Image enhancement is the procedure applied to image data in order to make more effectively 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 human viewers, or to provide better input for other automated image processing techniques.

### **3.3.4. Image classification**

In remote sensing, Image classification is the task of extracting information classes from a multiband 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 were 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. In this research supervised classification techniques is used.

#### **A. Supervised classification**

Supervised classification is the techniques most often used 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 can be identified 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 was performed. For bare land, farmland, shrub land and settlement LU/LC types taken 20 training site, where as for plantation and water body LU/LC types was taken 15 training areas 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 1989 and ETM+ 1999 and OLI 2016 1 to 7 Bands of the preprocessed images the land-use/ land-cover pattern mapped was by supervised classification with the likelihood classification algorithm of ERDAS Imagine 2014 software. In supervised classification, with the help of image processing techniques, the user specified type of the land-use land-cover classes. The six major classes studied in Adama Zuria Woreda were Farm Land, bare Land, settlement, shrub land, plantation and water body. The advantage of the supervised classification was development of information classes, self-assessment using training sites and training sites reusable. However, information classes may not match spectral classes, the signature homogeneity, uniformity of information classes may be varies.

## **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 classification 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 (small scale agriculture),shrub land, sugarcane plantation (large scale agriculture),water body ,bare land and settlement (urban and rural settlement).These LU/LC classes were used in producing the map legends and with the assist of GPS, training set data used for image classification were acquired. During this ground truthing activities, photos of scenes of interest and coordinates from sampled LU/LC classes were captured.

### **3.3.5. 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).

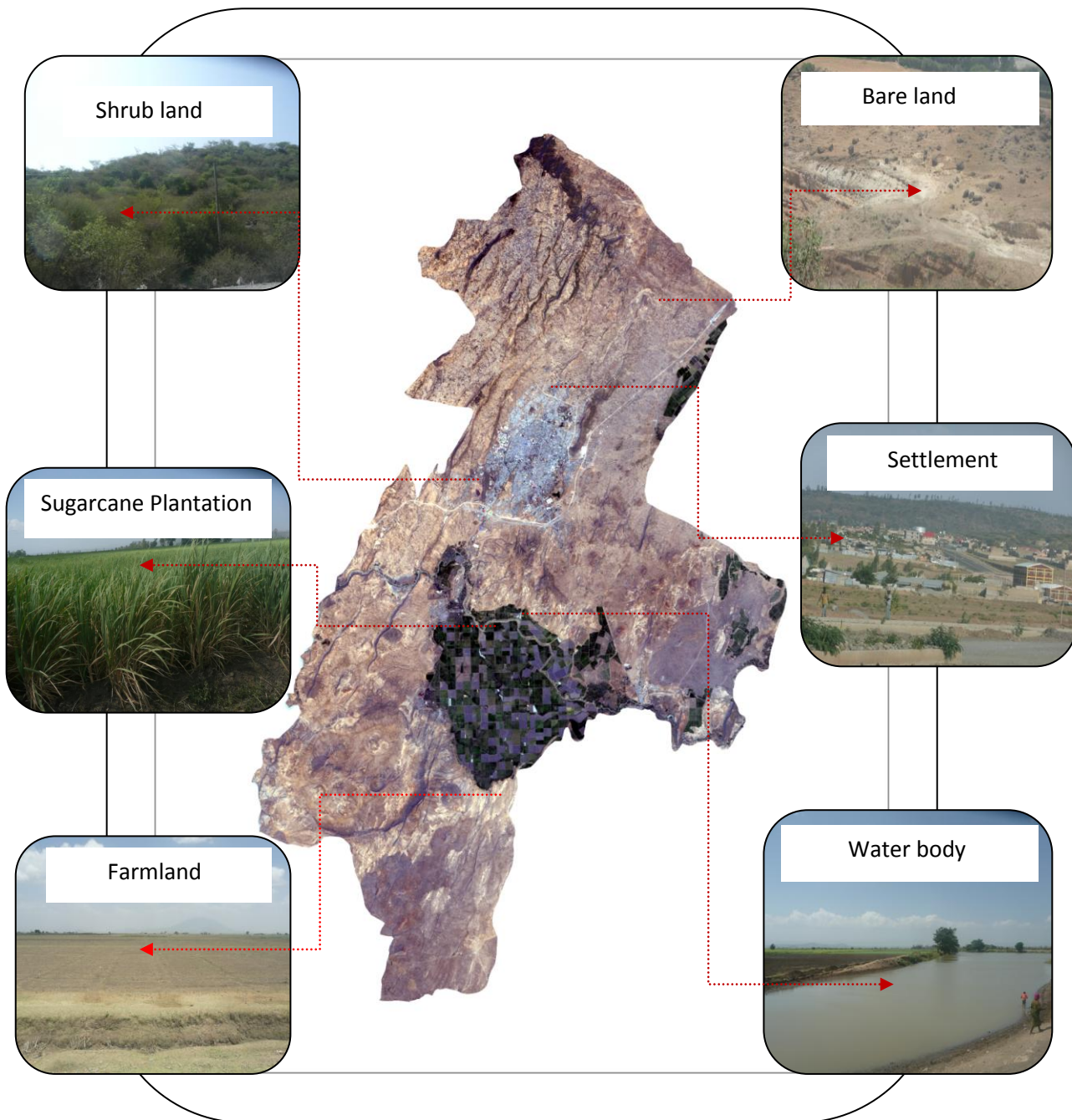
The supposed true map may be derived from *in situ* examination or quite often from the interpretation of remotely sensed data obtained at a larger scale or higher resolution. Shortly, accuracy assessment is performed by comparing the created by RS analysis to a reference map based on a different information sources. Using hand held Global Positioning System (GPS) field survey was conducted in the study area and about 60 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 1989, 1999, 2016 Land-use/Land-cover Map. Land-use and Land-cover classes and its description are presented in Table 3.6.

**Table 3.6:** Land-use/land-cover classes and description of the study area.

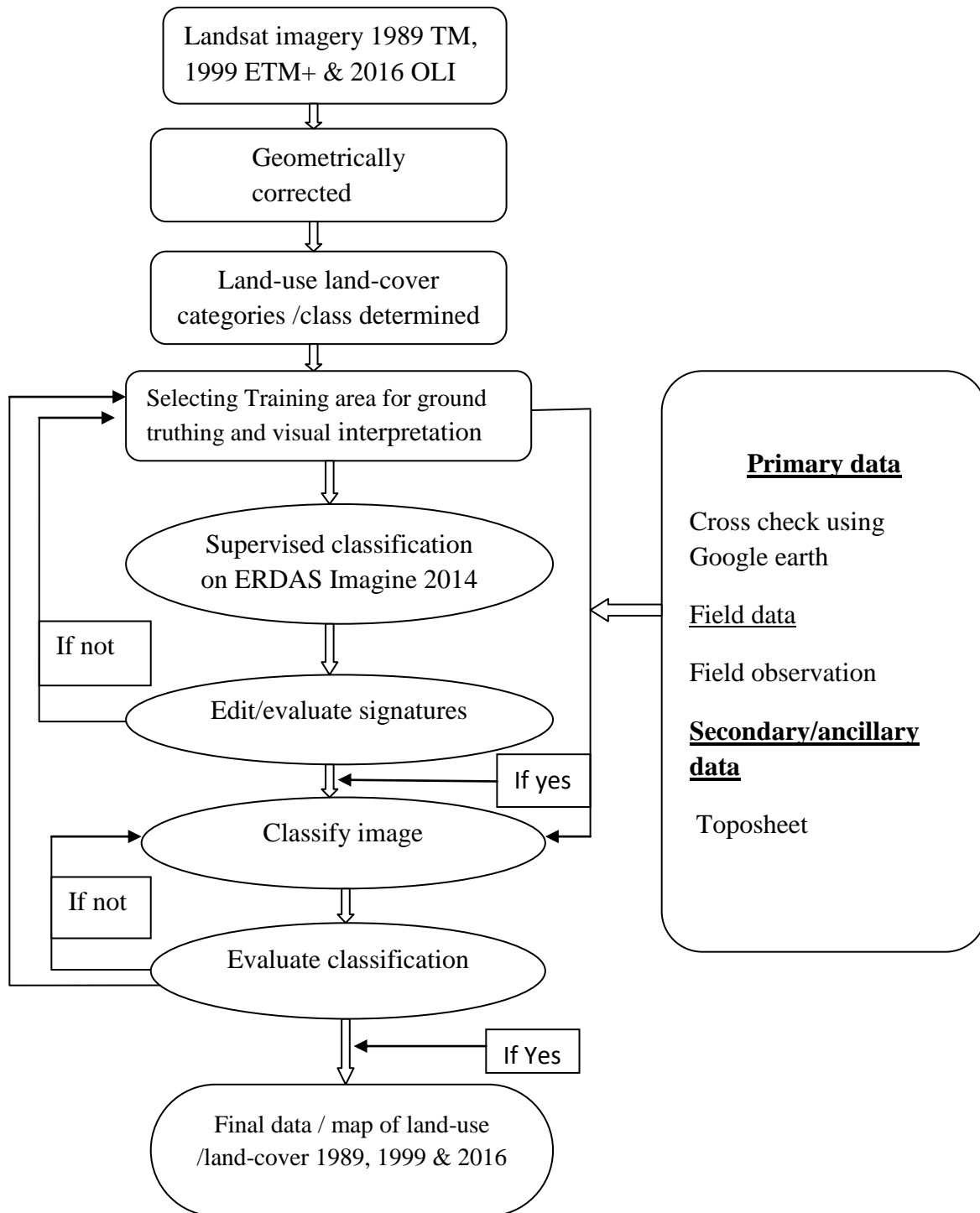
<b>LU/LC classes</b>	<b>Description</b>
Shrubs land	Areas covered with shrubs, bushes and small trees, with little useful wood, mixed with some grasses and less dense than forests.
Farm land	Areas used for crop cultivation, both annual perennials, and the scattered rural.
Settlement	Area occupied by houses buildings including road network residential, commercial, industrial, transportation, roads, mixed urban and other facilities.
Water body	Areas covered by natural and manmade small dams, like pond, lake and river.
Plantation	Plantation agriculture is a form of commercial farming where crops were grown for profit. it includes sugarcane, sweet potato and tobacco.
Bare land	Areas of has thin soil, sand/rocks and includes deserts, dry 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.

To determine and classify LU/LC of the study area; prior knowledge about the area is important. During field observation, there were six major LU/LC class identified. Based on the coordinate point Sample of LU/LC class and LST values of each LU/LC of the study area was shown in figure 3.9.



**Figure 3.9:** Interpretation of Landsat image for LU/LC classification.

Steps or processes that were followed to classify land-use/land-cover from a Landsat image were presented in Fig 3.10.



**Figure 3.10:** Steps and procedures followed to classify land-use/land-cover from a Landsat image.

### 3.3.6. Land-use/Land-cover change detection

Land-use/land-cover change detection was done by involving images of 1989, 1999 and 1999 and 2016. Using GIS techniques thematic image was compared. The cross operation process of mapping LU/LCC over time began with mapping the recent 2016-satellite imagery, then looking back in time to map the 1989 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 1989, 1999 and 2016 measured against each LU/LC classes. Therefore, to calculate LU/LCC in percentage equation (eq.3.1) were used (Lambin *et al*, 2001).

$$\text{Percentage change} = \frac{\text{observed change}}{\text{sum of Area}} \times 100 \quad \text{Eq. (3.1)}$$

### 3.4. Derivation of Normalized Difference Vegetation Index and Land surface temperature

#### 3.4.1. 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 -1 and 1. Normalized difference vegetation index (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 3.2.

$$\text{NDVI} = \frac{\text{NIR}-\text{R}}{\text{NIR}+\text{R}} \quad \text{Eq. (3.2)}$$

Where,

NDVI=Normalized Difference Vegetation Index

NIR= is the near infrared band 4, R= is the red band 3. Equation 3.2 is used to calculate NDVI for the sensor TM 1989, ETM+ 1999 and OLI 2016. 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. 3.3 was used.

$$FVC = \frac{NDVI - NDVI_s}{NDVI_v - NDVI_s} \quad \text{Eq. (3.3)}$$

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.

$NDVI_s$  is NDVI for soil and  $NDVI_v$  = NDVI for vegetation

Equation 3.4 was used to calculate Proportion of Vegetation that helps in calculating Landsat 8 land surface emissivity (LSE).

$$P_v = (NDVI - NDVI_{min} / NDVI_{max} - NDVI_{min})^2 \quad \text{Eq. (3.4)}$$

Where,

$P_v$  =Proportion of Vegetation

NDVI=Normalized Difference Vegetation Index

NDVI min= Normalized Difference Vegetation Index minimum value

NDVI max= Normalized Difference Vegetation Index maximum value

### 3.4.2. Derivation of land surface temperature

Calculating land surface temperature passes different steps.

To calculate the LSE, it is important know the inherent characteristics of the earth's surface and change the thermal radiance energy during calculating LST (Sobrino *et al.*, 2014). The emissivity constant values for vegetation and soil are stated in Table 3.7.

**Table 3.7:** Emissivity constant value of Landsat 8.

Emissivity	Band 10	Band 11
$\epsilon_s$	0.971	0.977
$\epsilon_v$	0.987	0.989

The following equation 3.5, 3.6 and 3.7 used to compute Land surface Emissivity, mean of LST and change of LSE of Band 10 and 11, respectively.

$$LSE=0.004Pv+0.986 \quad \text{Eq. (3.5)}$$

$$\text{Mean of LST} = \frac{LST_{10} + LST_{11}}{2} \quad \text{Eq. (3.6)}$$

$$\text{Difference of land surface emissivity (LSE)} = LSE_{10} - LSE_{11}$$

Eq. (3.7)

### 3.4.3. Radiometric correction

Radiometric correction requires converting a remote sensing digital number to spectral radiance values and data for comparisons. 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 (Parente, 2013). To perform the conversion of digital number to spectral radiance equation (3.8) was used.

$$L_{\lambda} = L_{min} + (L_{max} - L_{min}) * DN / 255 \quad \text{Eq. (3.8)}$$

Where,

$L_{\lambda}$  = spectral radiance

$L_{min}$  = spectral radiance of DN value 1

$L_{max}$  = spectral radiance of DN value of 255

DN = Digital Number

Equation 3.8 the above, was used to convert digital number into spectral radiance

### 3.4.4. 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 3.9 was used to perform the conversion at sensor spectral radiance or satellite data scaled into 8 bits.

$$L\lambda = \left( \frac{L_{\max\lambda} - L_{\min\lambda}}{Q_{\text{calmax}} - Q_{\text{calmin}}} \right) (Q_{\text{cal}} - Q_{\text{calmin}}) + L_{\text{MIN}\lambda} \quad \text{Eq. (3.9)}$$

Where,

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

$L_{\max\lambda}$  = spectral at Sensor Radiance that is scaled to  $Q_{\text{calmax}}$

$L_{\min\lambda}$  = Spectral at Sensor Radiance that is scaled to  $Q_{\text{calmin}}$

$Q_{\text{calmax}}$  = Maximum Quantized Calibrated Pixel values corresponding to  $L_{\max\lambda}$

$Q_{\text{calmin}}$  = Minimum Quantized Calibrated Pixel values corresponding to  $L_{\min\lambda}$

$Q_{\text{cal}}$  = Quantized Calibration Pixel value (DN)

#### 3.4.5. Conversion to top of atmosphere (TOA) reflectance

Landsat Thematic Mapper top of atmosphere reflectance data must be corrected and processed .because of variation in solar zenith angle due to time difference between data acquisition. The gained output also calibrated to reflectance value. Equation 3.10 was used to compute TOA.

$$P\lambda = \frac{\pi \cdot L\lambda \cdot d^2}{ESUN\lambda \cdot \cos\theta_s} \quad \text{Eq. (3.10)}$$

Where,

$P\lambda$  = planetary top of atmosphere (TOA) reflectance, which has no unit or it is unit less

$\pi$  = mathematical constant approximately equal to 3.14159. It is also unit less

$L\lambda$  = spectral radiance at the sensors aperture

$d$  = earth -sun distance/distance from the earth to the sun astronomical units

$ESUN\lambda$ =mean exoatmospheric solar irradiation (from meta data)

$\theta$  =Solar zenith angle

### 3.4.6. Conversion of radiance into brightness temperature

Thermal infrared data can be converted from atmosphere reflectance ( $L\lambda$ ) 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 6 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  $L\lambda$  (spectral radiance) to TB (brightness temperature) equation 3.11 was used Rajeshwari andMani, 2014).

$$TB = \frac{K2}{\left(\ln \frac{K1}{L\lambda}\right) + 1} \quad \text{Eq. (3.11)}$$

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

Landsat 8 has two thermal bands (band 10 and band 11). Table.3.8 shows the calibration constant used during performing the formula for brightness temperature.

**Table 3.8:** Thermal band calibration constant of Landsat 8.

Satellite	sensors	Categories	Band 10	Band 11
Landsat 8	OLI/TIRS	K1	777.8853	480.8883
		K2	1321.0789	1202.1442
		Radiance_MULT_BAND	0.0003342	0.0003342
		Radiance_ADD_BAND	0.01	0.01

LST was derived from Landsat TIRS using band 10 and band 11 based on split window algorithm, which was proposed for the first time by Mc Millin in 1975. As follows (eq.3.12).

$$LST = TB10 + C1 (TB10 - TB11) + C2 (TB10 - TB11)^2 + C0 + (C3 + C4W) (1 - m) + (C5 + C6W) \Delta m$$

Eq. (3.12)

Where,

LST=Land Surface Temperature

C0 up to C6=Split Window Coefficient Value

TB10=Brightness Temperature of band 10

TB11=Brightness Temperature of band 11

$m$ =Mean Land Surface Emissivity of thermal infrared bands (mean of band 10 and band 11)

$W$ =Atmospheric water vapor content (0.005) from Earth science reference table (ESRT)  
Relative humidity table.

$\Delta m$ =Difference in Land Surface Emissivity (LSE)

During performing/calculating LST of given area, using Landsat 8 thermal bands (Table 3.9) was used.

**Table 3.9:** Split window algorithm constant value.

Constant	Value
C0	-0.268
C1	1.378
C2	0.138
C3	54.3
C4	-2.238
C5	-129.2
C6	16.4

The calibration constant for Landsat 4 and Landsat 7 different from Landsat 8. For the case of Landsat 4 and Landsat 7 the following table 3.10 was used.

**Table 3.10:** Thematic mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) thermal band calibration constant.

satellite	sensors	constant	value
Landsat 4	TM	K1	607.76
		K2	1260.56
Landsat 7	ETM+	K1	666.09
		K2	1282.71

Source: Landsat7 handbook

Temperature was converted into degree Celsius, by subtracting 272.15 from the result, which was in degree Kelvin. Therefore, to convert degree Kelvin into degree Celsius the following formula was used (eq.3.13).

$$C=K-272.15 \qquad \text{Eq. (3.13)}$$

Where,

C: result in degree Celsius

K: result in degree Kelvin

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

### **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. Maps of LU/LC, NDVI and LST were prepared for the year 1989, 1999 and 2016. To examine the spatial difference of LST according to varies LU/LC; the result was summarized using the zonal statistics tool of the ArcGIS 10. 3. subsequently, summarized LU/LC, NDVI and LST map data were analyzed using excel. Zonal statistics as table is one of important methods that used to examine the correlation between LULC and LST.

### **Spatial interpolation**

Spatial interpolation is the procedure of using points with known values to evaluate values at other unknown points. For instance, to map rainfall and temperature of given area based up on nearby weather station.

In present study, meteorological data was used to interpolate and see the result and compare with the LST values that were done from Landsat thermal infrared bands. To interpolate rainfall and temperature data Inverse Distance Weighted (IDW) interpolation method was used. Inverse distance weighted is one of the interpolation methods in which the sample points are weighted during interpolation such that the impact of one point to another with distance declines from the unknown

point. Inverse Distance Weighted is the simplest interpolation method and deterministic models. Deterministic models include IDW, rectangular, natural neighbours and spline. Interpolation uses vector points with known values to estimate unknown locations to create raster surface covering an entire area (Legates and Wilmont, 1990).

The advantages of IDW interpolations are:

- ❖ Different distances are integrated in the estimation
- ❖ The distance weighting is able to precisely regulate the impact of the distances
- ❖ It allows very fast and simple calculation

Therefore, in the present study rainfall and temperature data was interpolated using sample points in ArcGIS 10.3 environment and finally the interpolated maps were used for validation.

## CHAPTER FOUR

### 4. RESULTS

#### 4.1. Land-use/land-cover in 1989, 1999 and 2016

Land-use/land-cover classification result of 1989 showed that the dominant LU/LC classes were farmland and shrub land. These classes accounted for 82.7% of the overall area coverage. From the total area of 901.50 km<sup>2</sup>, farmland accounted for 556.65 km<sup>2</sup> (61.7%) and shrub land accounted for 189.72 km<sup>2</sup> (21%). The other LU/LC the bare land, plantation, settlement and water body together accounted for 155.13 km<sup>2</sup> (17.3%) of the total area. The water bodies covered the smallest area than all than other classes. Analysis of 1999 image also showed that farmland constitutes the largest proportion of land in the study area with the value of 631 km<sup>2</sup> (70%), followed by shrub land, which accounted 108.94 km<sup>2</sup> (12.5%). Other LU/LC classes such as bare land, plantation, settlement and water body together accounted for 17.5% of the total area. In 1999, also water body covered the smallest area than all other classes. Land-use/land-cover classification results of 2016 image revealed that the dominant LU/LC categories were farmland and shrub land together accounted for 81.55% of the total area coverage. Farmland accounted for 623.4 km<sup>2</sup> (69.15%) and shrub land accounted for 110.99 km<sup>2</sup> (12.40%). Other LU/LC classes were bare land, plantation, settlement and water body, which together accounted 18.45% of the total area. However, the extent of farmland 2016 decreased by 0.85% from 1999. Generally, farmland is the major LU/LC of the area in relation to area coverage, followed by shrub land. Detailed statistical data for each of these classes and LU/LC map of the study period are shown in Table 4.1 and Figure 4.1.

**Table 4.1:** Land-use/land-cover classes and area coverage of 1989, 1999 and 2016 in Adama Zuria Woreda, Ethiopia

No	LU/LC classes	1989		1999		2016	
		Area , (km <sup>2</sup> )	Area, (%)	Area , (km <sup>2</sup> )	Area, (%)	Area, (km <sup>2</sup> )	Area, (%)
1	Farm land	556.65	61.7	631	70	623.4	69.15
2	Bare land	80.02	8.89	67.98	7.22	35.86	3.98
3	Plantation	66.21	7.41	68.97	7.57	72.90	8.00
4	Settlement	6.48	0.73	20.97	2.28	55.30	6.11
5	Shrub land	189.72	21	108.94	12.50	110.99	12.43
6	Water body	2.42	0.27	3.64	0.40	3.05	0.33

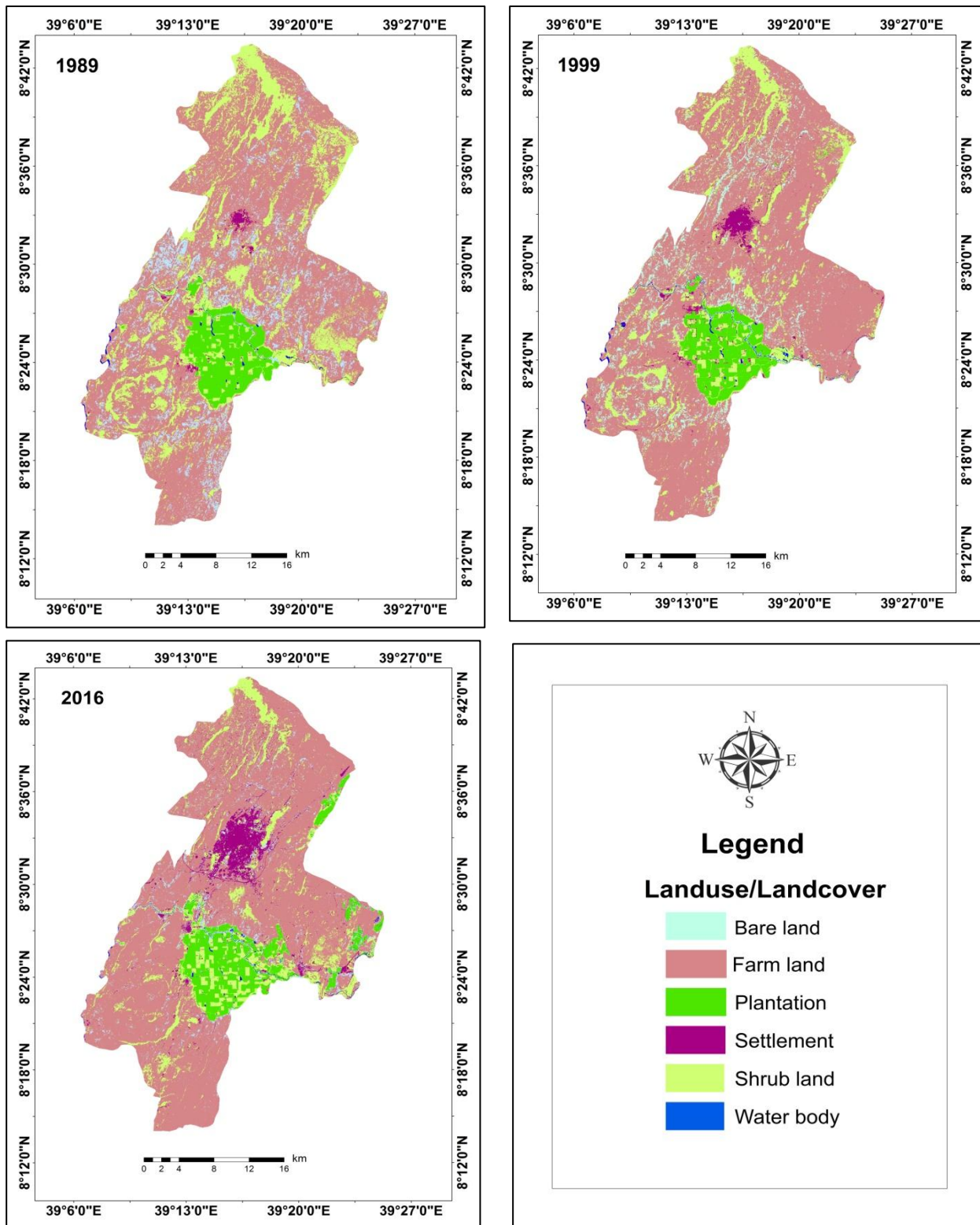
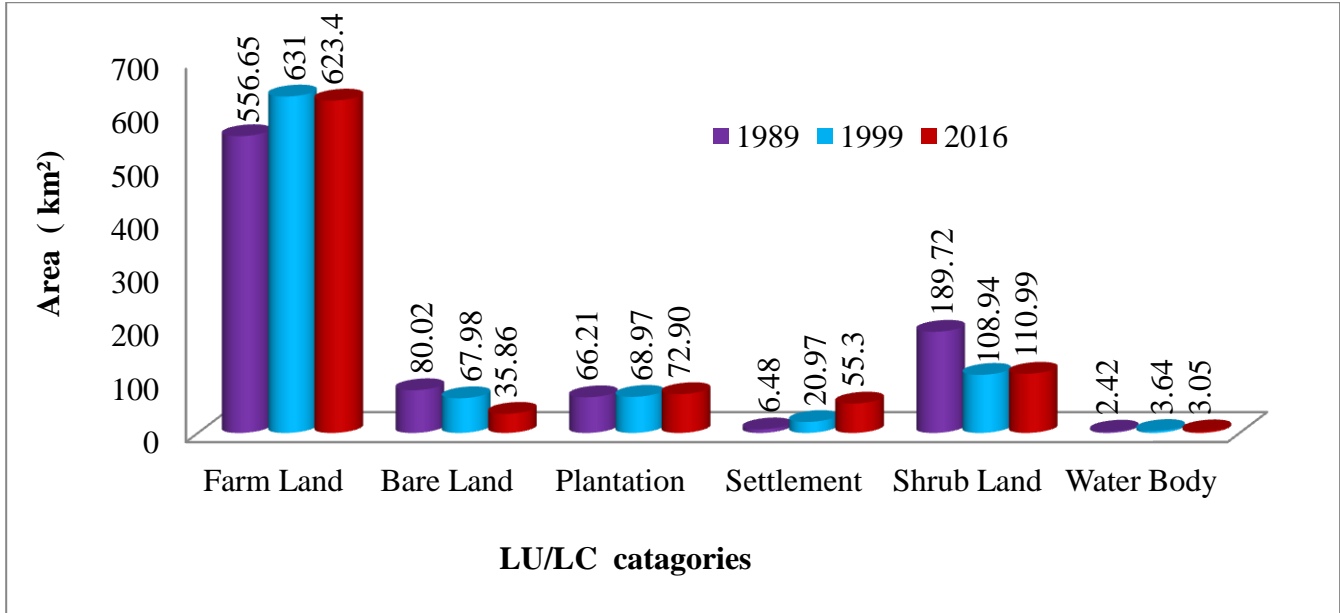


Figure 4.1: Land-use/land-cover maps of the study area of the years of 1989, 1999 and 2016.

Farmland habitat had the largest extent of all LU/LC in the study area during 1989–2016. The extent of farmland increased 1989 from 555.65 km<sup>2</sup> to 631 km<sup>2</sup> by 1999 but slightly decreased 623.4 km<sup>2</sup> by 2016 (Fig 4.2).



**Figure 4.2:** Land-use/land-cover distribution and changes in the study area during the period 1989–2016.

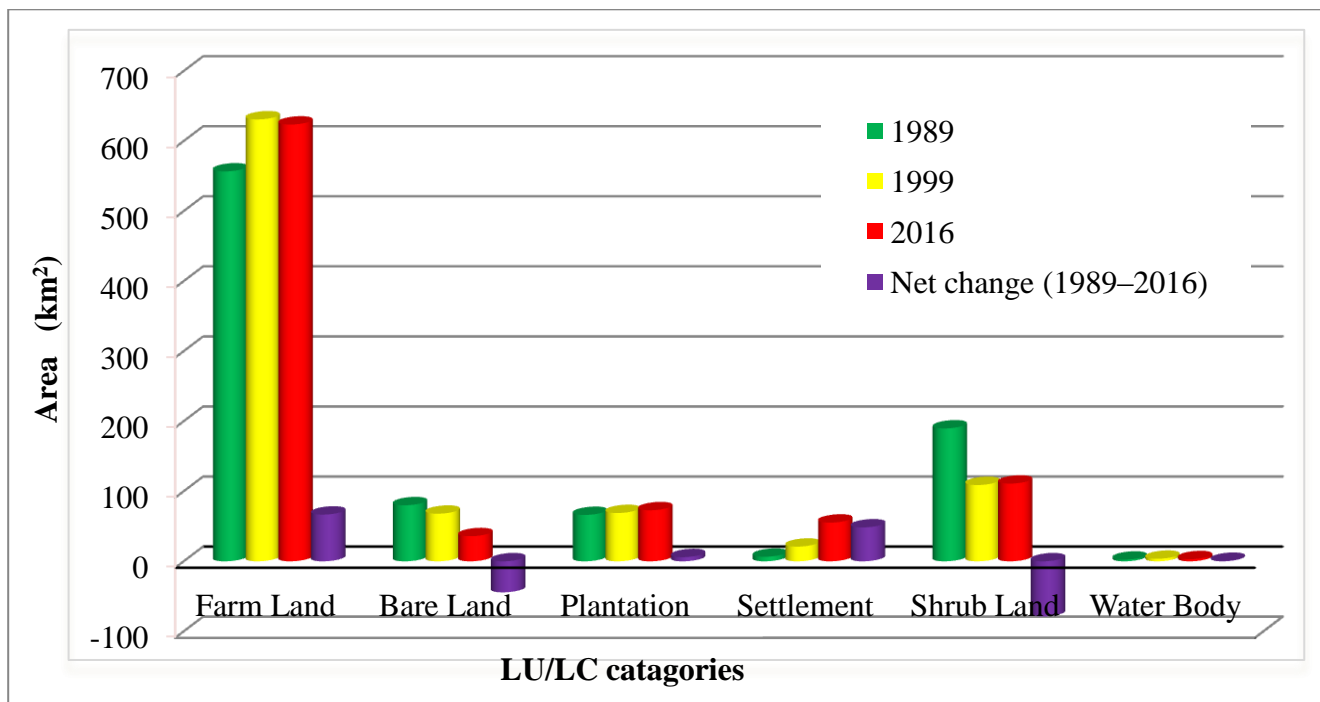
#### 4.2. Spatial extent of land-use/land-cover

Land-use/land-cover patterns in the study area have indicated a significant change in between 1989 and 2016 years. Among the six major LU/LC classes, farmland and shrub land covered more than 80% of the area in all the study years. Settlement area has been increasing from 1989 to 2016. It has increased from 0.73% in 1989 to 2.28% by 1999 and 6.11% by 2016. Plantation also increased from 1989 to 2016. It increased from 7.41% by 1989 to 7.51% by 1999 and 8 % by 2016. Shrub land and water body showed fluctuations from 1989 to 2016. Shrub land was 21% in 1989, which was decreased to 12.0% by 1999 and then increased to 12.4% by 2016. Water body also has changed from 0.27% in 1989 to 0.40% by 1999 and then decreased to 0.33% by 2016. Farmland increased from 61.7% by 1989 to 70% by 1999 and decreased to 69.15% in 2016. Bare land showed continuous decrement from 1989–2016. It was 8.89% in 1989, which decreased to 7.20% by 1999 and 3.98% by 2016 (Table 4.2).

**Table 4.2:** Land-use/land-cover distribution and net changes during 1989–2016.

No	LU/LC Classes	1989		1999		2016		Net changes during 1989–2016, km <sup>2</sup>
		Area ,km <sup>2</sup>	Area, %	Area, km <sup>2</sup>	Area , %	Area , km <sup>2</sup>	Area , %	
1	Farmland	556.65	61.7	631	70	623.6	69.15	+66.75
2	Bare land	80.02	8.89	67.98	7.22	35.86	3.98	-44.16
3	Plantation	66.21	7.41	68.97	7.57	72.90	8.00	+6.69
4	Settlement	6.48	0.73	20.97	2.28	55.30	6.11	+48.82
5	Shrub land	189.72	21	108.94	12.50	110.99	12.4	-78.73
6	Water body	2.42	0.27	3.64	0.40	3.05	0.33	+0.63
	<b>Total</b>	<b>901.5</b>	<b>100</b>	<b>901.5</b>	<b>100</b>	<b>901.5</b>	<b>100</b>	

The LU/LC change trends of the study area showed that shrub land and bare land have decreased by 78.73 km<sup>2</sup> and 44.16 km<sup>2</sup>, respectively. Other classes showed increasing and fluctuating area coverage. Figure 4.3.illustrated the LU/LC changes in the study area.



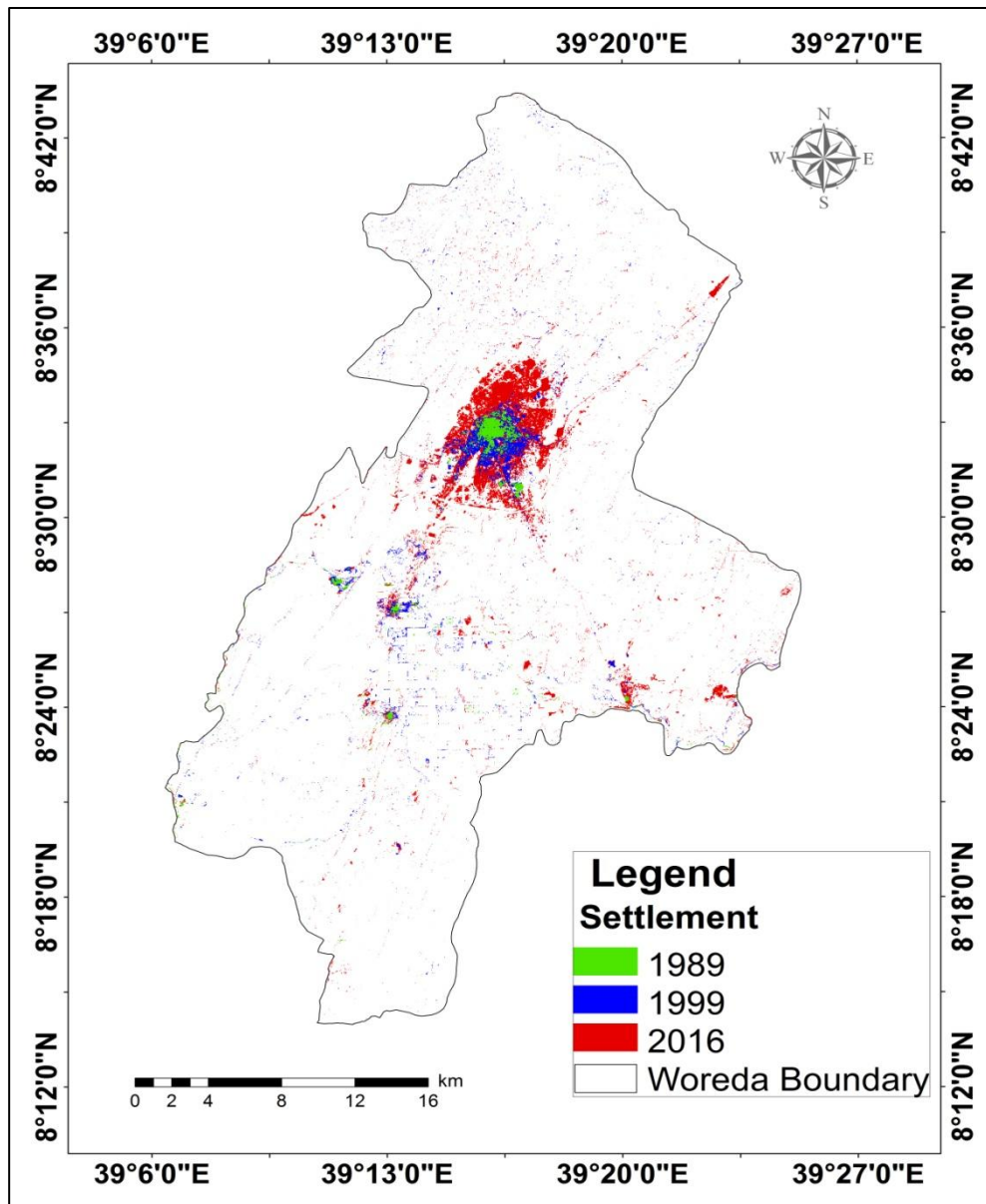
**Figure 4.3:** Land-use/land-cover changes during 1989—2016 in the Adama Zuria Woreda.

**Table 4.3:** Land transformation for Adama Zuria Woreda (1989—2016).

	2016							Class Total
	LU/LC Classes	Farm land	Bare land	Plantation	Settlement	Shrub land	Water body	
1989	Farm land	423.6147	23.9958	14.6853	47.6505	39.3093	0.9207	550.1763
	Bare land	61.7499	8.9118	1.9269	6.0228	2.673	0.0963	81.3807
	Plantation	0.693	0.9522	43.1469	1.8711	19.5426	0.5148	66.7206
	Settlement	0.5499	0.2088	0.5031	4.2822	0.5967	0.1584	6.2991
	Shrub land	98.6634	6.957	12.0681	14.4972	56.988	0.4311	190.6048
	Water body	0.3204	0.1521	0.2007	0.5472	0.3447	0.7245	2.2896
	Class Total	585.8451	41.202	72.5598	78.885	119.5173	2.8737	901.429

### 4.3. Settlement expansion during 1989–2016

An overlay analysis of settlement area detected from 1989, 1999 and 2016 satellite image of Adama Zuria Woreda revealed that the farmland, shrub land and bare land have been changed to settlement area in different direction of the Woreda. The spread of settlement area towards other LU/LC classes is shown in Figure 4.4.



**Figure 4.4:** The trend of expansion of settlement area from the year 1989 to 2016 in Adama Zuria Woreda.

#### 4.4. Accuracy assessment

The accuracy assessment of LU/LC for the years 1989, 1999 and 2016 recorded the overall classification accuracy of 88.33%, 90.00% and 88.33%, respectively. The classification Kappa statistics for 1989 is 0.85. For the years, 1999 and 2016 Kappa values are 0.87 and 0.84, respectively. The detailed information of producers and users accuracy is indicated in Table 4.4.

**Table 4.4:** Statistical information of accuracy assessment for the year 1989, 1999 and 2016.

class name	1989		1999		2016	
	producers accuracy	users accuracy	producers accuracy	users accuracy	producers accuracy	users accuracy
Plantation	87.50%	87.50%	77.78%	87.50%	100.00%	80.00%
Settlement	81.82%	90.00%	100.00%	90.00%	93.75%	88.24%
Water body	90.91%	90.91%	100.00%	90.91%	75.00%	100.00%
Farm land	92.31%	85.71%	92.86%	92.86%	89.47%	94.44%
Shrub land	90.00%	90.00%	90.00%	90.00%	66.67%	80.00%
Bare land	85.71%	85.71%	75.00%	85.71%	90.91%	83.33%
Overall classification accuracy	88.33%		90.00%		88.33%	
Overall Kappa statistics	0.8588		0.8790		0.8496	

#### 4.5. Normalized difference vegetation index

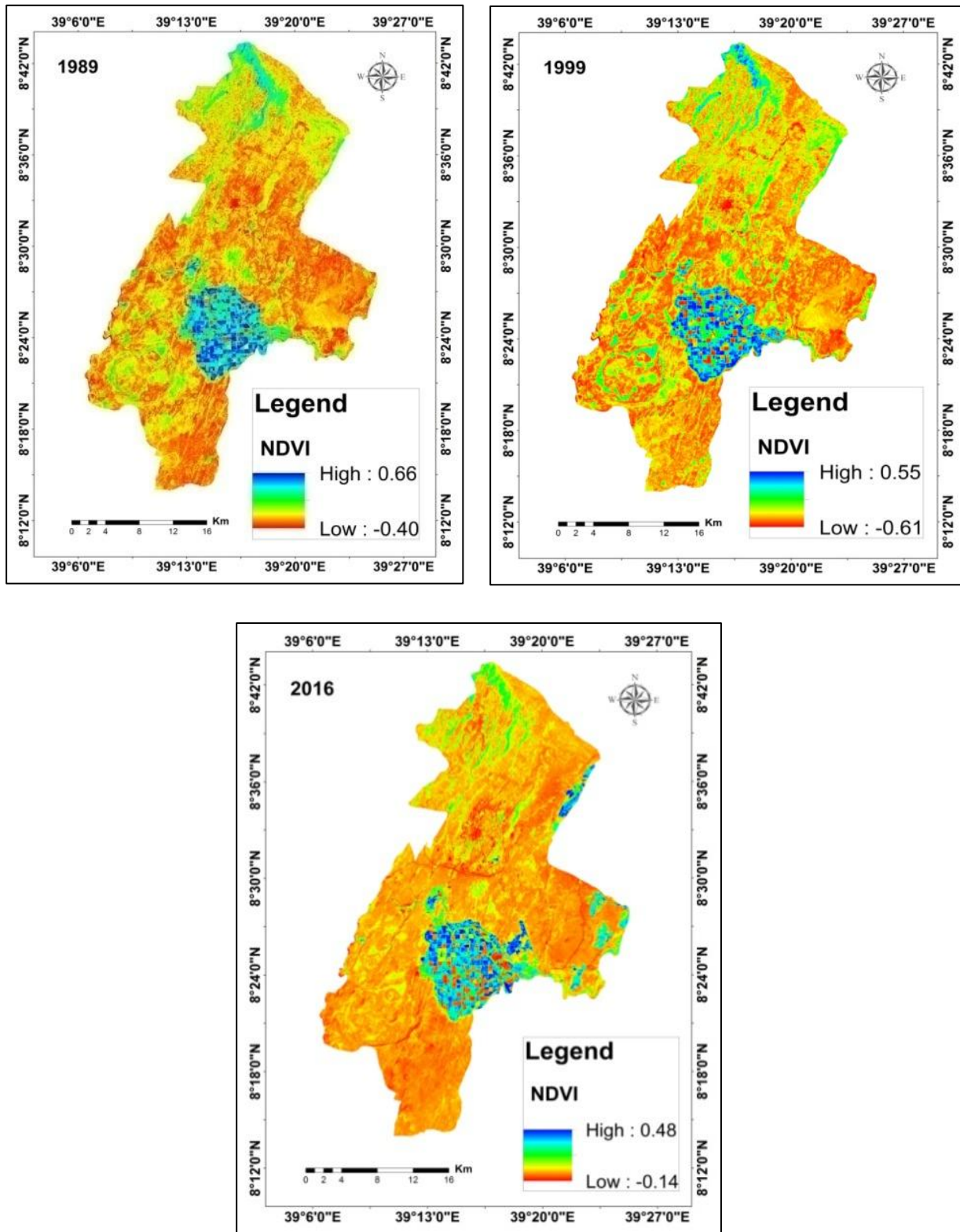
In this study, it has been observed that the vegetation cover was more in 1989 and 1999 with maximum NDVI values of 0.66 and 0.55, respectively. The highest value shows healthy vegetation. Vegetation cover has decreased for the year 2016 with the NDVI value of 0.48. Normalized difference vegetation index result for the years 1989, 1999 and 2016 are presented in Figure 4.5.

The normalized difference vegetation index result of 1989, 1999 and 2016 showed that the northern and northwest part of the study area resulted higher NDVI value and the area of Boku ridge and Wonji sugarcane plantation showed highest NDVI value. However, settlement area along Awash River and most parts in eastern region have relatively low NDVI values. As indicated in figure 4.5, vegetation cover has decreased and non-vegetated area has been increasing gradually over the study period. However, in 2016 sugarcane plantation, area has slightly increased due to the expansion of Wenji Shewa Sugarcane Plantation. Table 4.5 showed statistical information of NDVI value for the year 1989, 1999 and 2016.

**Table 4.5:** Statistical information of NDVI value for the years 1989, 1999 and 2016.

Year	Min	Max	Mean	Std
1989	-0.40	0.66	0.159	0.123
1999	-0.61	0.55	-0.099	0.138
2016	-0.14	0.48	0.140	0.069

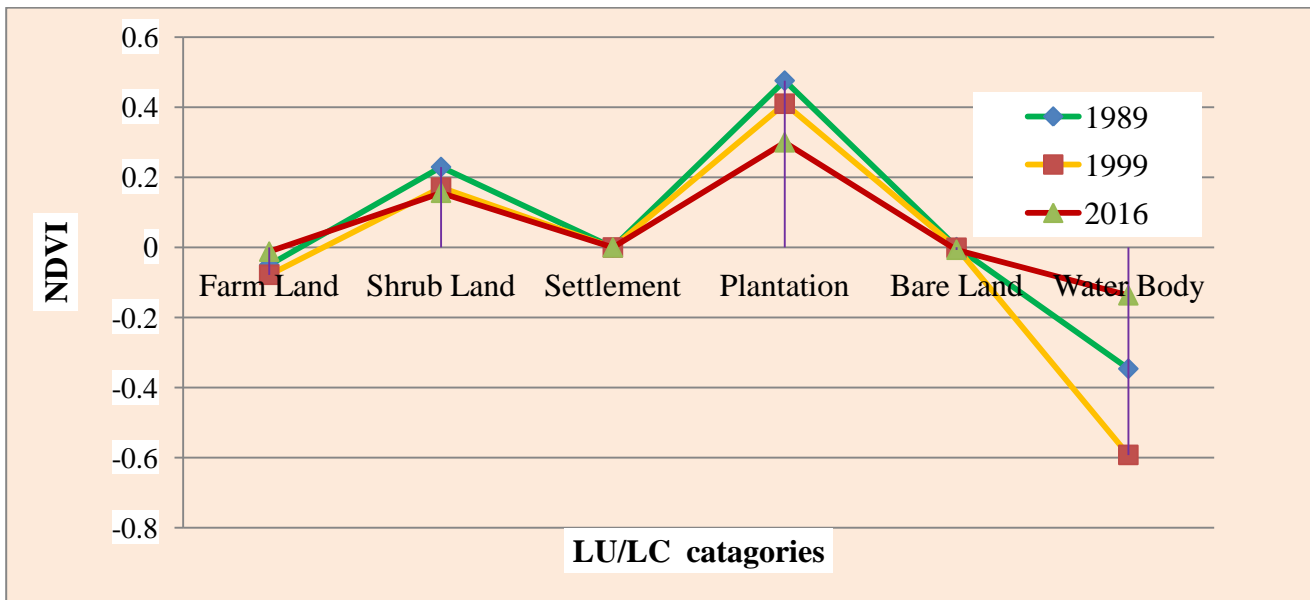
Where, Min = Minimum, Max = Maximum, Std = Standard deviation



**Figure 4.5:** Normalized difference vegetation index maps of the study area (1989, 1999 and 2016).

#### 4.6. Relationship between land-use/land-cover and Normalized difference vegetation index

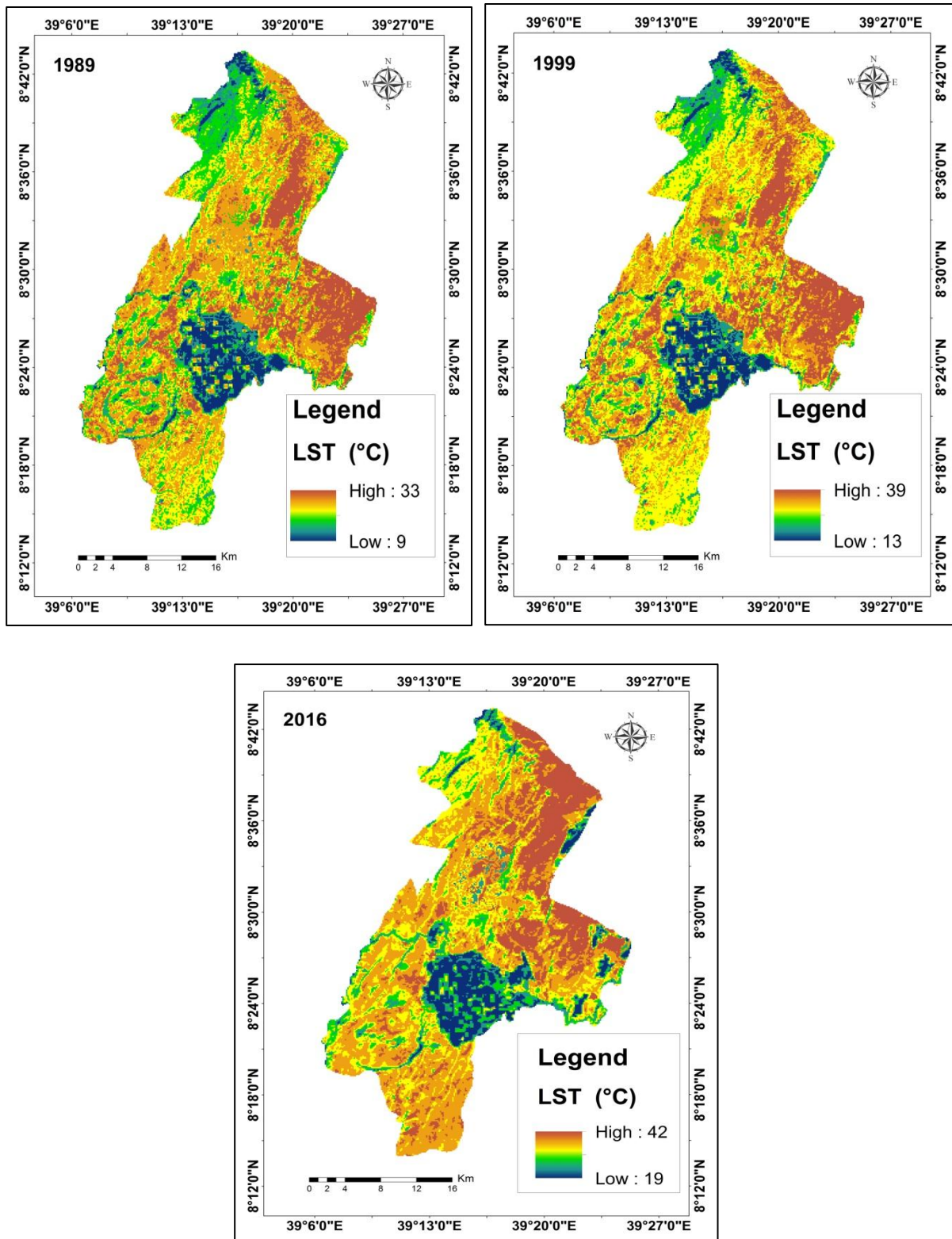
Normalized difference vegetation index maps extracted from near infrared and red-bands of the study periods indicated that different LU/LC has different NDVI values. As NDVI is related with the vegetation condition, the value varies from area to area based on vegetation intensity of the sites. Plantation and shrub land have the highest NDVI value than other classes (Fig. 4.6).



**Figure 4.6:** Zonal statistical description of NDVI in 1989, 1999 and 2016 over different LU/LC classes in the study area.

#### 4.7. Spatial pattern of land surface temperature in Adama Zuria Woreda

The spatial distribution of LST of the study area was extracted and quantified using Landsat TM of 1989, ETM+ of 1999 and OLI/TIRS thermal bands. The analysis from such images indicated that the LST value of the study period ranged from 9°C to 42°C. As it was observed from the processed thermal images, the east, northeast and southeast parts of the study area exhibited relatively high temperature. This is mainly due to altitude, slope and LU/LC types. On the other hand, Northwest part and Wenji Shewa sugarcane plantation area exhibited relatively low LST values. The Northwestern part of the study area had high altitude ranges from 2,118 to 2,505 meters a.s.l, and the southwestern part had altitude ranges from 1758 to 2,118 meters a.s.l. For each period, LST distribution is shown in Figure.4.7.



**Figure 4.7:** Land surface temperature maps of the study area of the years 1989, 1999 and 2016.

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

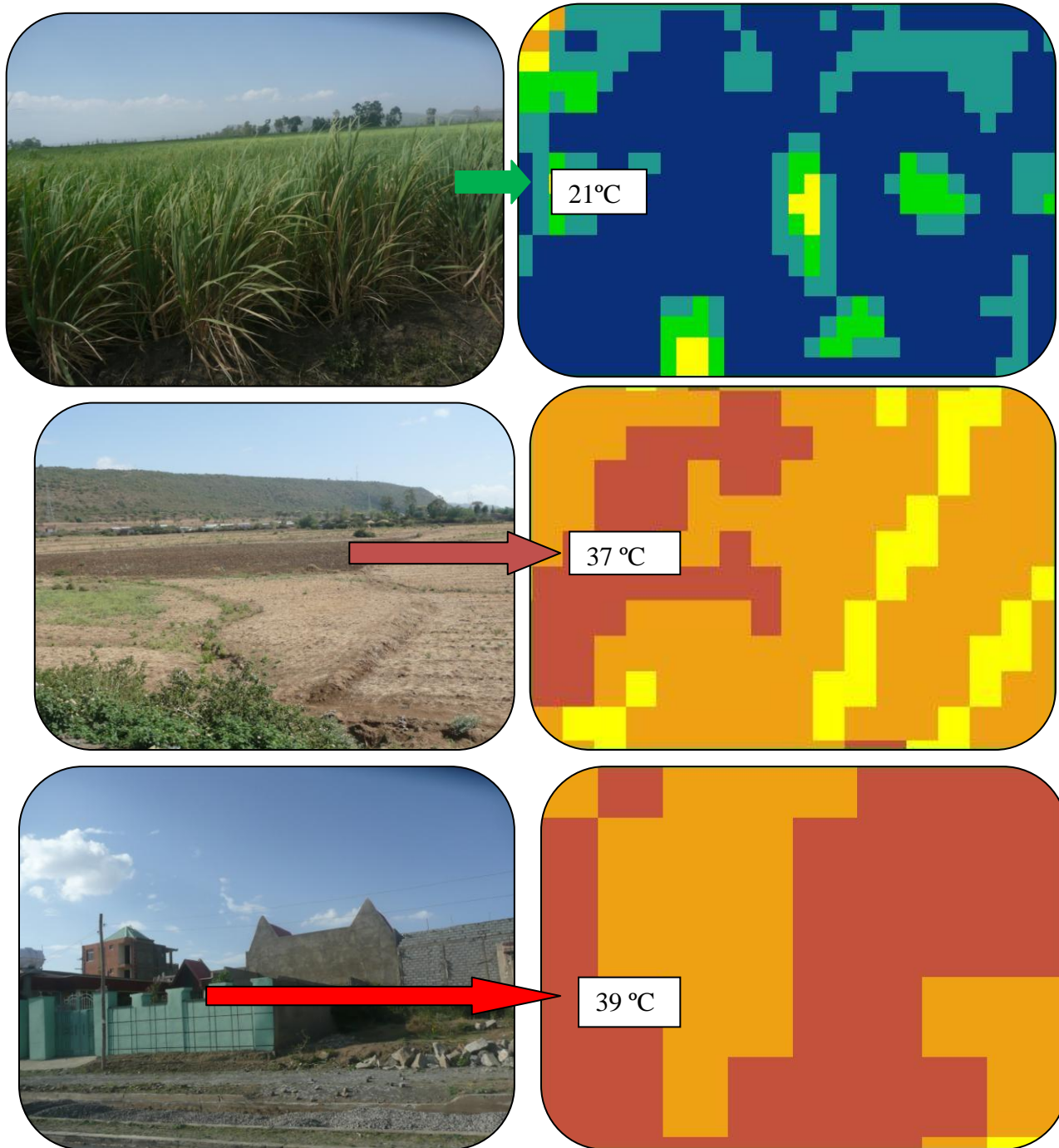
Land-use/land-cover dynamics has an impact on land surface temperature. The changes LU/LC resulted in alteration of land surface temperature, particularly in the settlement, farmland (after harvested) and bare land. The reason behind farmland LU/LC classes of high LST was that the image used for the analysis was taken during harvesting time 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 and other types of LU into settlement area also contributed to the increase of LST. As observed in Figure 4.4 (Expansion of settlement area from the year 1989 to 2016), the settlement area has highly increased especially the northern and southern parts of Adama town and along the main gate of town (Addis Ababa, Wenji Shewa, Asella and Metehara). In addition to that, settlement area has increased in small towns of the Woreda (Table 4.6).

**Table 4.6:** Zonal statistical description of LST in 1989, 1999 and 2016 over different LU/LC classes.

LU/LC classes	1989				1999				2016			
	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std
Farm land	10.44	32.82	25.49	2.32	14.96	38.37	31.11	2.36	21.24	41.86	35.55	2.12
Shrub land	9.02	32.12	22.55	3.30	13.62	35.00	26.47	2.95	19.83	39.75	31.79	3.27
Settlement	12.78	31.76	23.05	2.43	17.60	38.73	28.46	2.46	20.86	41.17	31.01	2.48
Plantation	9.78	28.55	18.55	2.65	14.04	32.71	22.73	1.34	19.71	38.00	31.48	3.03
Bare land	16.43	32.47	26.15	1.80	18.90	38.37	31.34	1.74	20.93	41.18	33.68	2.50
Water body	9.96	23.39	15.72	1.98	16.73	28.81	21.23	2.15	19.90	39.91	29.20	3.54

Where, Min = Minimum, Max = Maximum, Std = Standard deviation.

Most of the study area was under farmland cover, it covered more than 61% in all study period. The LST value has increased from the mean of 25.49°C in 1989 to 35.55°C in 2016. Figure 4.8 showed how LU/LCs changes affect the variability of LST.

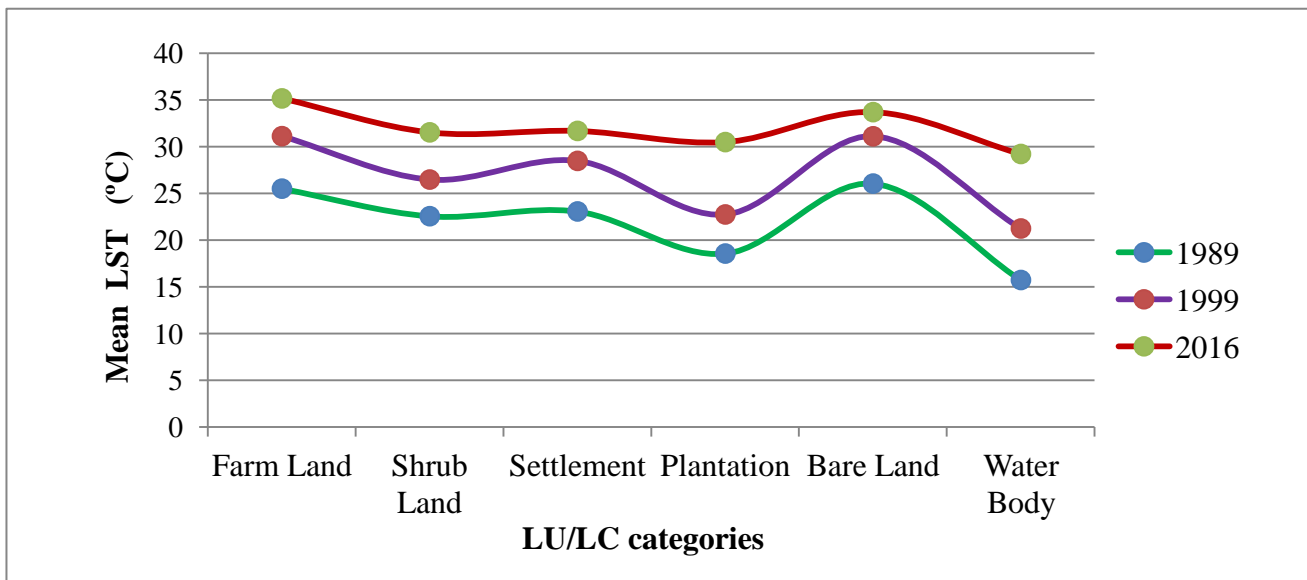


**Figure 4.8:** Different views of land surface temperature of the study area for 2016.

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

Land-use/land-cover 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 received minimum temperature was water body, plantation and shrub land, respectively. Water body and Vegetated area played crucial role in minimizing the LST. Vegetated area and 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 in farmland, settlement and bare land. The LST value was high in farmland during the acquisition time of the image.

From 1989 to 2016, the mean LST of Adama Zuria Woreda has increased by 9.66 °C. Table 4.5 indicates that all major LU/LC categories have recorded increase in the LST over the study period. The highest mean LST was recorded in farmland, bare land and settlement area. Whereas, the lowest mean LST was recorded in water body, plantation and shrub land area. Comparisons of mean LST with LU/LC classes for the study period are indicated in Figure 4.9. The land surface temperature in the study area has increased considerably from 1989 to 2016 (Table 4.7).



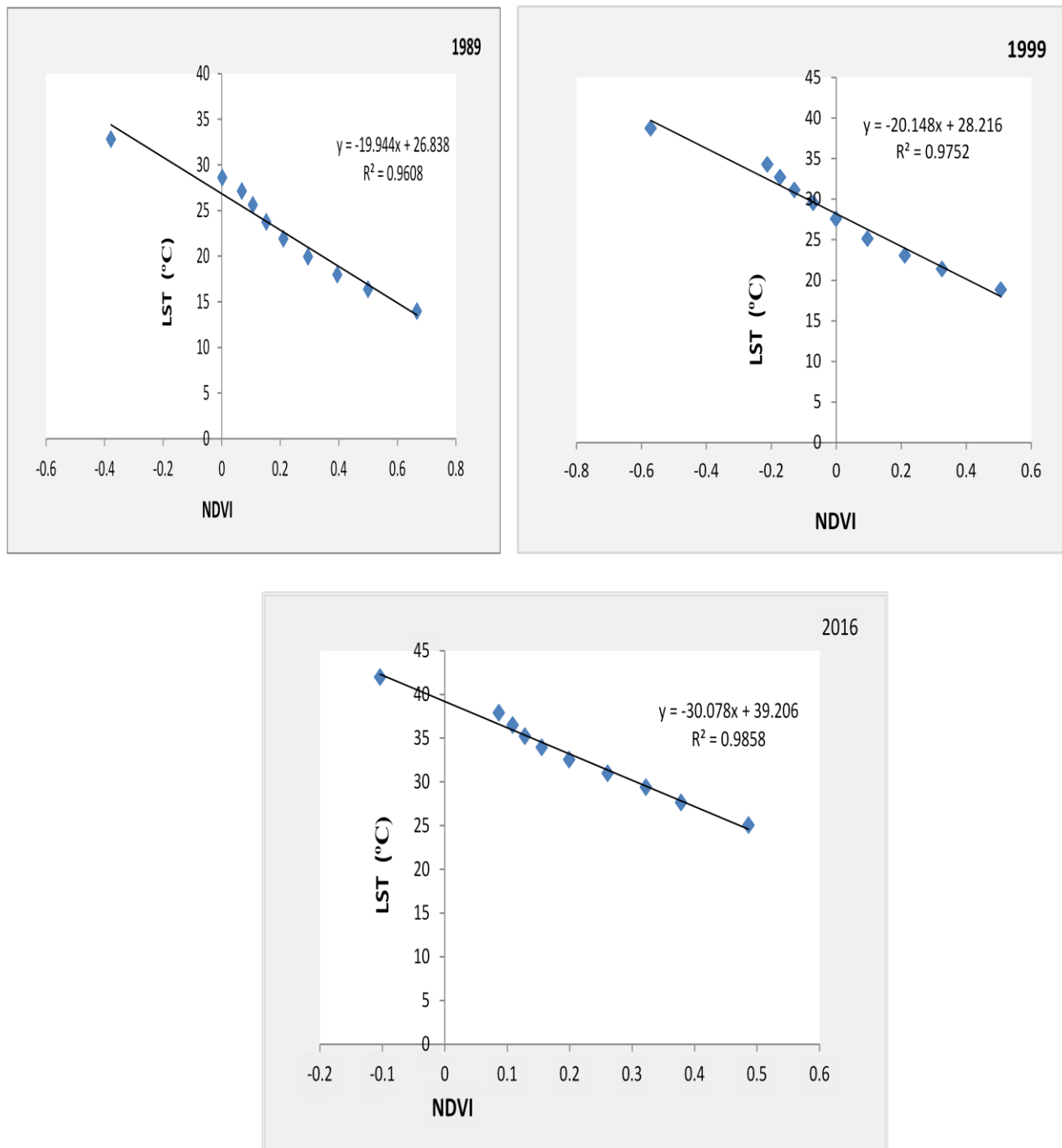
**Figure 4.9:** Comparisons of mean land surface temperature in different land-use/land-cover classes during the study period in Adama Zuria Woreda.

**Table 4.7:** Mean temperature of 1989, 1999, 2016 and changes in temperature during 1989–2016 in the study area.

LU/LC Classes	1989 Mean	1999 Mean	2016 Mean	1989–1999 Change in (°C)	1999–2016 Change in (°C)	1989–2016 Change in (°C)
Farm land	25.49	31.11	35.15	5.62	4.04	9.66
Shrub land	22.55	26.47	31.52	3.92	5.05	8.97
Settlement	23.05	28.46	31.67	5.41	3.21	8.62
Plantation	18.55	22.73	31.48	4.18	8.75	12.93
Bare land	26.15	31.34	33.68	5.19	2.34	7.53
Water body	15.72	21.23	29.20	5.41	7.97	13.48

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

The analyzed Landsat images of 1989, 1999 and 2016 indicated that NDVI and LST have indirect 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<sup>2</sup> values of the study period between NDVI and LST correlations indicated 96.08%, 97.52% and 98.58%, respectively. These results show that, in (1989) 96.08% value of LST variability was due to the difference in NDVI value, the coefficient variation values are also the same for 1999 and 2016. Generally, negative correlation was found between NDVI values with LST. Land surface temperature and NDVI correlation for the years 1989, 1999 and 2016 are shown in Figure 4.10.



**Figure 4.10:** Land surface temperature and normalized difference vegetation index correlation for the years 1989, 1999 and 2016 for the study area.

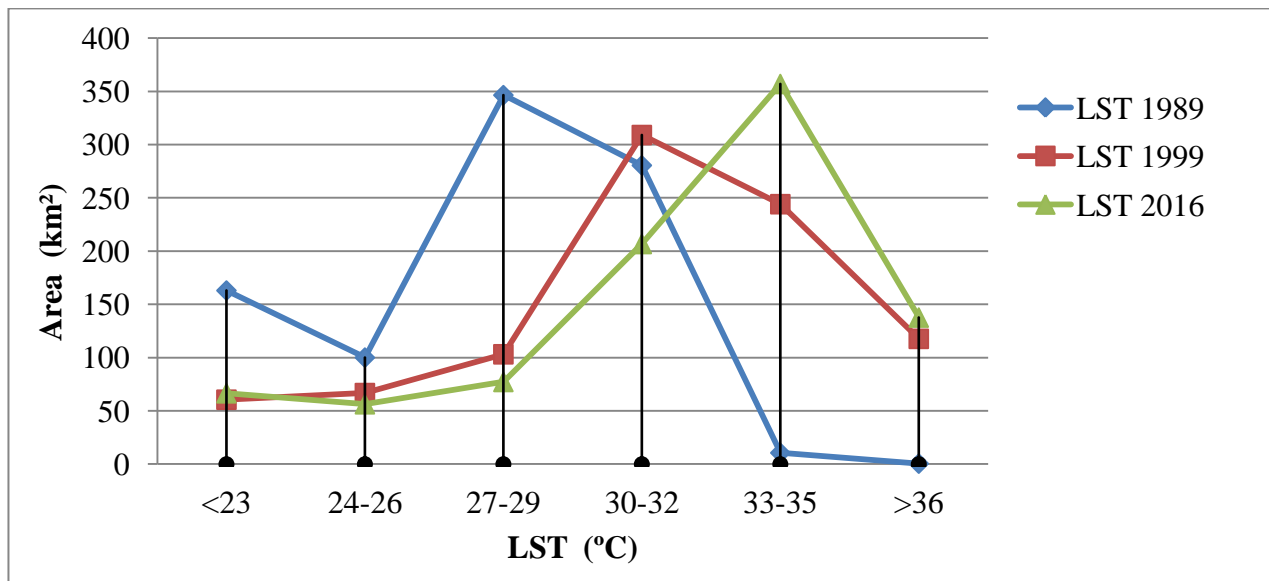
#### 4.11. Comparisons of LST distribution during 1989, 1999 and 2016

The results of the study indicated that throughout all the study period the LST value increased drastically. Land surface temperatures were classified into six groups ranging from 9 °C –42°C. The LST distribution statuses during study period are given in Table 4.8.

**Table 4.8:** Trends of land surface temperature distribution during the study period in Adama Zuria Woreda during 1989–2016.

Area coverage during study period (km <sup>2</sup> )			
LST	1989	1999	2016
<23	163.06437	60.56705	66.56781
23-26	100.098804	66.79957	56.26834
27-29	346.541255	103.1959	77.20713
30-32	280.591343	309.0823	206.7406
33-35	10.85228	244.1531	357.007
>36	0.347769	117.7	137.6997
Total	<b>901.5</b>	<b>901.5</b>	<b>901.5</b>

The trend of increase in LST shows that in Adama Zuria Woreda LST was increasing from year to year. A comparison between LST distributions of the selected years are given in Figure 4.11.



**Figure 4.11:** Comparisons between LST distributions of the years 1989, 1999 and 2016 in Adama Zuria Woreda.

#### 4.12. 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 validated with GPS point collected from field and Google Earth. Interpolation of rainfall and temperature were done based on the meteorological data collected from five stations within and nearby the study area. These stations were; Mojo, Koka Dam, Nazareth, Sodere and Welenchiti. There is strong relationship between LST and atmospheric temperature, which was interpolated from five 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 4.12a and 4. 12b.

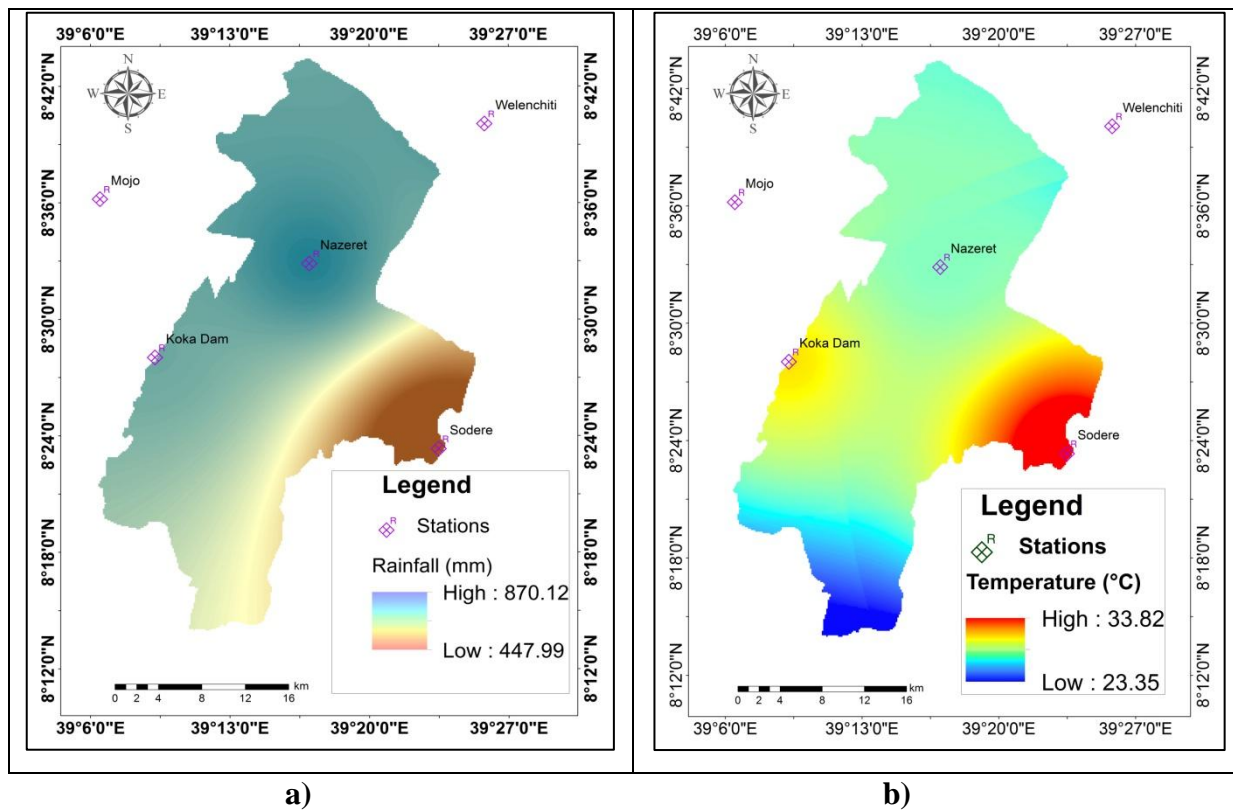


Figure 4.12: a) Interpolated map of rainfall and b) Interpolated map of temperature of Adama Zuria Woreda.

As observed from the interpolated map of the study area, both rainfall and temperature results was low at the eastern part. However, rainfall map of the northern and western parts have high values than eastern and southern parts. Interpolated map of temperature result showed that the southern and the northern part have higher value in °C than east and western relatively.

The result of LST extracted from Landsat thermal bands, also revealed that the eastern part had the highest value in each of the study periods, where as the northern part had low value. However, in the area of Wenji Shewa sugarcane plantation, LST was low. For instance, Wenji Sugarcane plantation area; the LST was very low but in the interpolated map it shows relatively medium temperature. The mean LST, which was extracted from thermal bands of the study period, was ranged from 25.49°C to 35.15 °C. Whereas, the interpolated atmospheric temperature result ranged from 23.35 °C – 33.82 °C.

## CHAPTR FIVE

### 5. DISCUSSION

#### 5.1. Land-use/land-cover status of Adama Zuria Woreda

The LU/LC changes experienced across Adama Zuria Woreda shows as a sign of population growth and the increase of needs of land for settlement and agriculture. These changes have brought about a series of adverse impacts on the environment. Houghton (1994) revealed 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 there were drastic changes in LU/LC. In 1989, the settlement area was 6.48 km<sup>2</sup> and then it reached 55.30 km<sup>2</sup> in 2016. It is one of the evidences for the increasing needs of settlement. The extent of sugarcane plantation also increased from 66.21 km<sup>2</sup> in 1989 km<sup>2</sup> to 72.90 km<sup>2</sup> in 2016 and bare land decreased from 80.02 km<sup>2</sup> in 1989 to 35.86 km<sup>2</sup> in 2016. Farmland, shrub land and water body showed fluctuation. In general, the classified satellite image indicates that there is a change in LU/LC.

#### 5.2. Normalized difference vegetation index

Normalized difference vegetation index is a measure of vegetation condition and 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 south towards to the north of the Woreda. As farmland and shrub land classes dominate the present study area, the vegetation cover also varied. The NDVI and LST correlation coefficient was evaluated in this study for 2016 was  $R^2=0.98$ , which indicate how the vegetation condition determine the LST of the area and NDVI accounts 98.58% in distribution of LST. In line with this, the present study revealed that NDVI have strong relation with LST (with the exception of water body class).

#### 5.3. Land surface temperature

A thermal band of Landsat image was important in quantifying the LST of the area. In the present study farmland, settlement and bare land have high LST. The main reason behind less NDVI and high LST values in the area of farmland LU/LC class is that the image was taken 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 had high surface reflectance. After harvest of crops, the land was very dry and at the same time, land reflectance high. Normalized Difference Vegetation Index value is less for water body, bare land, settlement and farmland classes. However, in the case of plantation 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 a great 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 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.

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, plantations (sugarcane plantation) and farmland the shrub land and open space have highly declined. This is clearly observed, especially at Adama town area. In this area, due to the expansion of settlement area, small-scale farmers moved and start to settled in open space and shrub land. In addition to this, Wonji Shewa sugarcane plantation also extended its area towards the previously open space, shrub

land and farmland. In 1989, at the Boku ridge area, there were some sparsely vegetated area 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 increasing 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 six major LU/LC classes and for each class LST value varies. Water body, plantation and shrub land have relatively low LST than settlement, farmland and bare land LU/LC class. Spatial and temporal distribution of LST during 1989,1999 and 2016 revealed that during the study period there was drastic changes took place in the area. In 1989, the distribution of LST was 9°C and 33°C, minimum and maximum, respectively, where as in 1999 and 2016, the minimum and maximum LST ranges were 13°C–39°C and 19°C–42°C, 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 4, ETM+7 and Landsat 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 Adama Zuria Woreda. 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 (Plantation and shrub 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 acts an important role or functions of LU/LC and alters temperature condition of the area.

The findings of this study showed that LSTs of Adama Zuria Woreda has increased during period of 1989, 1999 and 2016. This was because of LU/LC changes, human activities and climate variability of the area. The land surface temperature of the Woreda 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 somehow a good indicator of LST status of the study area. Therefore, the use of GIS 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 Adama Zuria Woreda based on Landsat imagery of 1989, 1999 and 2016. 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, Wenji sugarcane plantation had a positive contribution for the low LST value. Therefore, based on the result of this study, the following recommendations have 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 for 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 area, especially at high 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 on environmental issues.

## 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 Awash Basins of Ethiopia (Doctoral dissertation, Cornell University).

Asubonteng, K. O. (2007). Identification of land use/cover transfer hotspots in the Ejisu-Juabeng Woreda, Ghana. International Institute for Geo-information Science and Earth Observation Enschede, Netherlands.

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.

Bonini, M., Corti, G., Innocenti, F., Manetti, P., Mazzarini, F., Abebe, T., and Pecskey, Z. (2005). Evolution of the Main Ethiopian Rift in the frame of Afar and Kenya rifts propagation. *Tectonics* 24, TC1007.

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.

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 from 23-24 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.

Huang, S., and Siegert, F. (2006). Land cover classification optimized to detect areas at risk of desertification in North China based on SPOT VEGETATION imagery. *Journal of Arid Environments*, 67(2), 308–327.

IPCC. (2014). *Climate Change 2014–Impacts, Adaptation and Vulnerability: Regional Aspects*. Cambridge University Press.

Jiang, J., and Guangjin, T. (2010). Analysis of the impact of land use/land cover change on land surface temperature with remote sensing. *Procedia environmental sciences*, 2, 571–575.

- 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.
- Kazmin, V., and Seifemichael, B. (1978). Ethiopian institution of geological survey; *Geology and Development of the Nazret area, Northern Ethiopian Rift*, Addis Ababa.
- 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., Otle, C. (2004). Land surface retrieval techniques and applications: case of AVHRR, in: Quattrocci, 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 Uttarakhand 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.
- Legates, D. R., and Willmott, C. J. (1990). Mean seasonal and spatial variability in global surface air temperature. *Theoretical and applied climatology*, 41(1), 11–21.
- Lemlem Abraha (2007). *Assessing the Impact of Land Use and Land Cover Change on Groundwater Recharge using Rs and GIS; a Case of Awassa Catchment, 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., and Mugisha, 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. *The Geographical Journal*, 166(1), 2–13.
- Md Shahid, L., (2014). Land Surface Temperature Retrieval of Landsat 8 Data using split window Algorithm a case study Ranchi Woreda. *International Journal of Engineering Development and Research*, 2(4), 3840–3849.
- 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). Aesthetic Dermatology, effects of climate change on skin, *Dermatology news USA*, May 16, 2016.
- Nunes, M. C., Vasconcelos, M. J., Pereira, J. M., Dasgupta, N., Alldredge, R. J., and Rego, F. C. (2005). Land cover type and fire in Portugal: do fires burn land cover selectively?. *Landscape Ecology*, 20(6), 661–673.
- 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.
- Orsolya, G., Zalan T., Boudewijn V.L. (2016). Satellite based Analysis of surface UHI intensity. *Journal of Environmental Geography*, 9(2), 23–30.
- 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.
- Ramachandra, T. V., Aithal, B. H., and Sanna, D. (2012). Land Surface Temperature Analysis in an Urbanising Landscape through Multi-Resolution Data. Research and Reviews: *Journal of Space Science and Technology*, 1(1), 1–10.
- Santa, P. (2011). Forest cover and land-use changes: a study of Laljihadi forest (corridor), far western development region, Nepal. MSc Thesis Tribhuvan University.
- Schmugge, T., Hook, S. J., and Coll, C. (1998). Recovering surface temperature and emissivity from thermal infrared multispectral data. *Remote Sensing of Environment*, 65(2), 121–131.
- 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 1989.

ACCURACY TOTALS						
Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	
Plantation	8	8	7	87.50%	87.50%	
Settlement	11	10	9	81.82%	90.00%	
Water body	11	11	10	90.91%	90.91%	
Farm land	13	14	12	92.31%	85.71%	
Shrub land	10	10	9	90.00%	90.00%	
Bare land	7	7	6	85.71%	85.71%	
Totals	60	60	53			
Overall Classification Accuracy = 88.33%						
----- End of Accuracy Totals -----						
KAPPA (K <sup>^</sup> ) STATISTICS						
Overall Kappa Statistics = 0.8588						
Conditional Kappa for each Category.						
Class Name	Kappa					
Unclassified	0.0000					
	0.0000					
	0.0000					
Plantation	0.8558					
Settlement	0.8776					
Water body	0.8887					
	0.0000					
Farm land	0.8176					
Shrub land	0.8800					
	0.0000					
Bare land	0.8383					
----- End of Kappa Statistics -----						

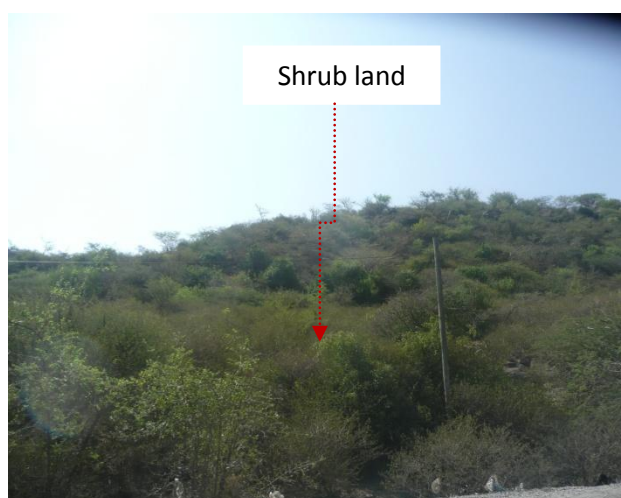
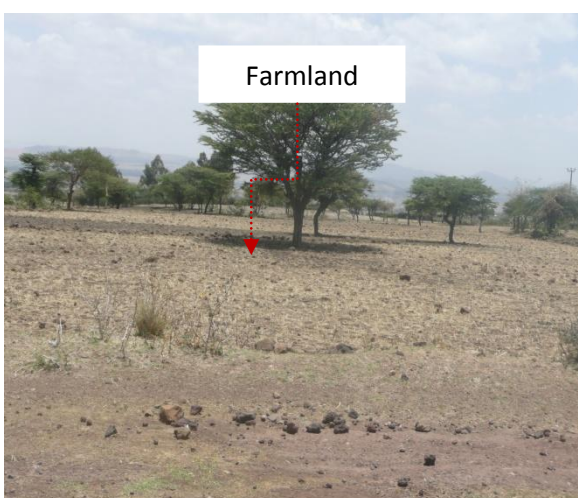
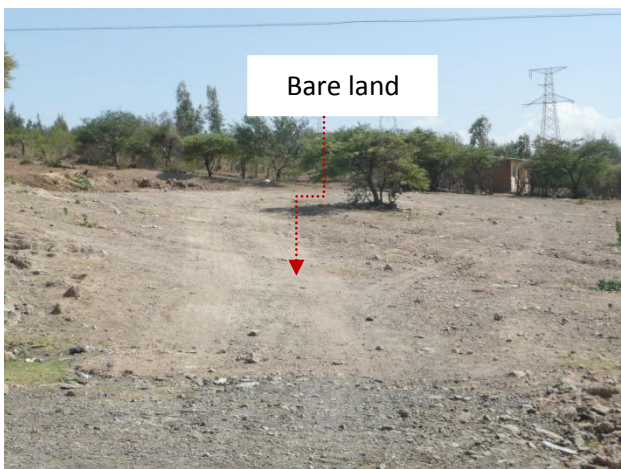
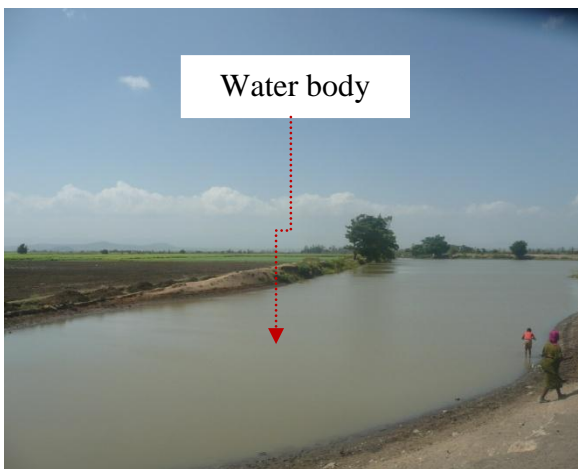
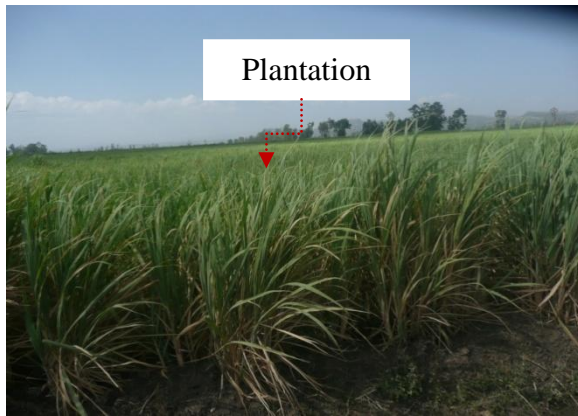
**Appendix 2:** Classification accuracy assessment report for the year 1999.

ACCURACY TOTALS						
Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	
Plantation	9	8	7	77.78%	87.50%	
Settlement	9	10	9	100.00%	90.00%	
Water body	10	11	10	100.00%	90.91%	
Farm land	14	14	13	92.86%	92.86%	
Shrub land	10	10	9	90.00%	90.00%	
Bare land	8	7	6	75.00%	85.71%	
Totals	60	60	54			
Overall Classification Accuracy =			90.00%			
----- End of Accuracy Totals -----						
KAPPA (K <sup>^</sup> ) STATISTICS						
Overall Kappa Statistics = 0.8790						
Conditional Kappa for each Category.						
Class Name	Kappa					
Plantation	0.8529					
Settlement	0.8824					
Water body	0.8909					
Farm land	0.9068					
Shrub land	0.8800					
Bare land	0.8352					
----- End of Kappa Statistics -----						

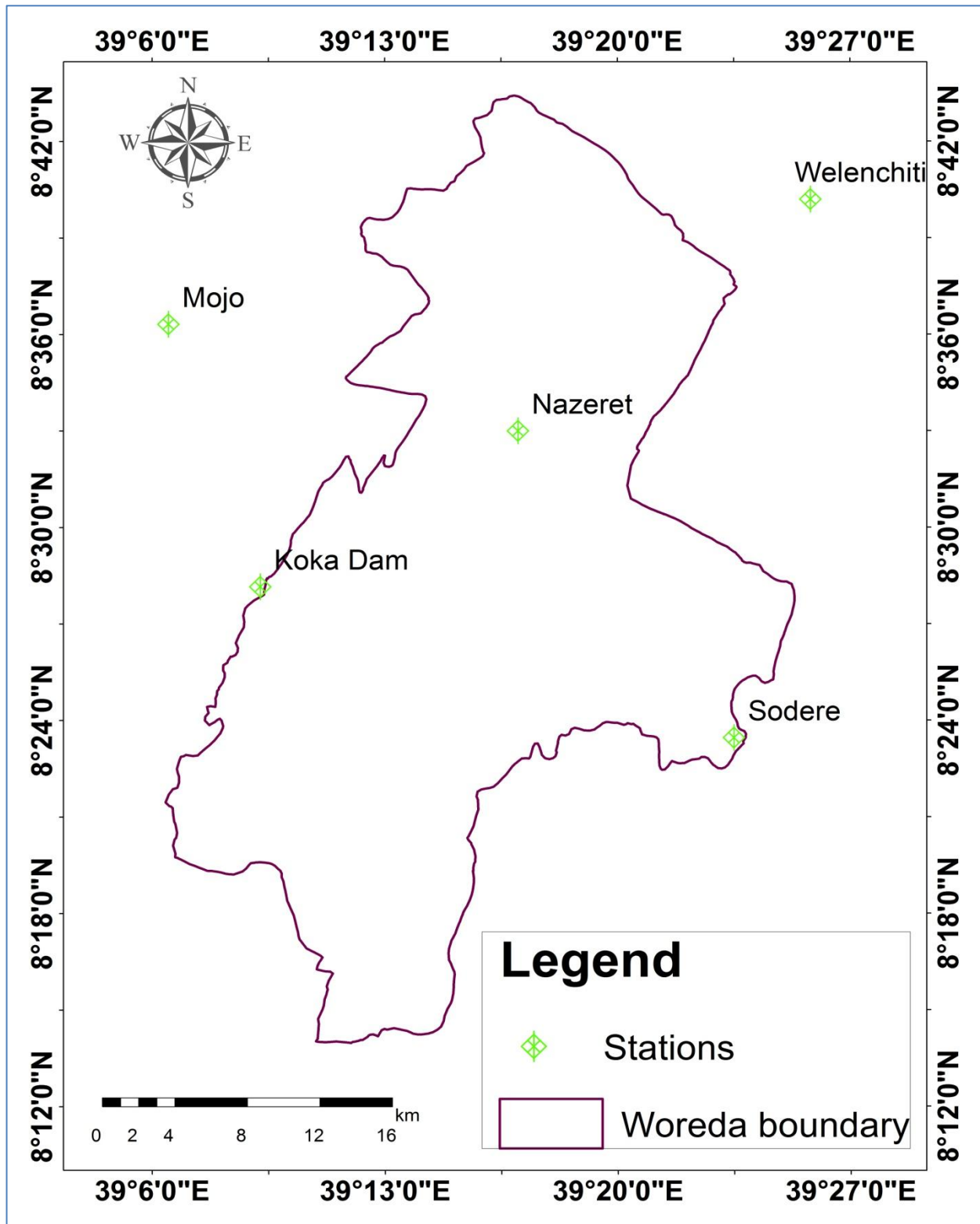
**Appendix 3:** Classification accuracy assessment report for the year 2016.

ACCURACY TOTALS						
Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	
Plantation	4	5	4	100.00%	80.00%	
Settlement	16	17	15	93.75%	88.24%	
Water body	4	3	3	75.00%	100.00%	
Farm land	19	18	17	89.47%	94.44%	
Shrub land	6	4	5	66.67%	80.00%	
Bare land	11	12	10	90.91%	83.33%	
Totals	60	60	53			
Overall Classification Accuracy = 88.33%						
----- End of Accuracy Totals -----						
KAPPA (K <sup>^</sup> ) STATISTICS						
Overall Kappa Statistics = 0.8496						
Conditional Kappa for each Category.						
Class Name	Kappa					
Plantation	0.7857					
Settlement	0.8396					
Water body	1.0000					
Farm land	0.9187					
Shrub land	0.7778					
Bare land	0.7959					
----- End of Kappa Statistics -----						

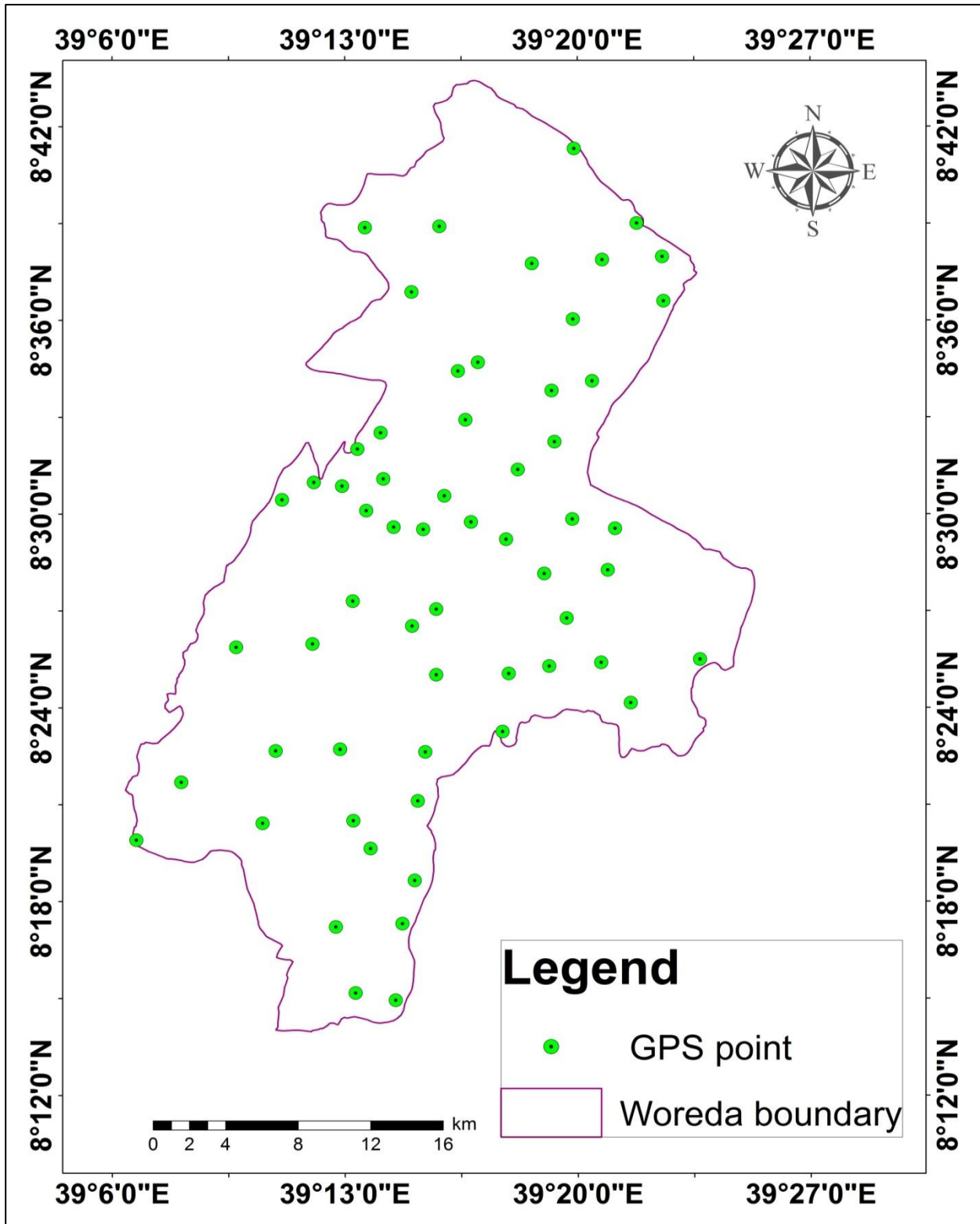
**Appendix 4. Plate 1:** Sample of different LU/LC photographs.



Appendix 5. map 1: Location of meteorological stations map.



Appendix 6.map 2: GPS point data map.



## Declaration of originality

I, undersigned, declare that this thesis entitled “IMPACT OF LAND-USE/LAND-COVER CHANGES ON LAND SURFACE TEMPERATURE IN ADAMA ZURIA WOREDA, ETHIOPIA, USING GEOSPATIAL TOOLS” is my original work and has not been presented for a degree in any other university and that all sources of materials used for this thesis have been interestingly acknowledged.

Belete Tafesse Habtewold

Signature \_\_\_\_\_

Date \_\_\_\_\_

Addis Ababa University

Addis Ababa

May, 2017

This is certified that the thesis entitled “**Impact of land-use/land-cover changes on land surface temperature in Adama Zuria Woreda, Ethiopia, using geospatial tools**” is original work of Mr. Belete Tafesse Habtewold for the partial fulfillment of the Degree of Masters of science in remote sensing and Geo-informatics from Addis Ababa University under our guidance and supervision.

This is

Dr.K.V.Suryabhagavan

Prof. M. Balakrishnan

Signature \_\_\_\_\_

Signature \_\_\_\_\_

Date \_\_\_\_\_

Date \_\_\_\_\_

School of earth science

Addis Ababa University