Analyzing Land Surface Temperature and Land Cover Distribution Change Using Spectral Radiance and Split Window Algorithm: A Case of Adama Woreda.

By:

Kebene Megersa Tola

Thesis Submitted to:

Department of Geodesy and Geomatics Engineering

School of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for the Degree of Master's in *Geodesy and Geomatics Engineering.*

Office of Graduate Studies

Adama Science and Technology University

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APPROVAL SHEET

This undersigned hear by certify that they have read and recommend to Adama Science and Technology University, School of Civil Engineering and Architecture for acceptance a thesis entitled: **"Analyzing land surface temperature and land cover distribution change using spectral radiance and split window algorithm: A case of Adama Wereda"** by **Kebene Megersa** in partial fulfillments of the requirements for the degree of Master of Science in Geodesy and Geomatics Engineering.

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DECLARATION

I hereby declare that this MSc Thesis is my original work and has not been presented for a degree in any other university, and all sources of material used for this thesis have been duly acknowledged.

Name: ____

Signature: ____

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

Name: ____

Signature: ____

Date of submission: ____

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Kebene Megersa

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LIST OF ACRONYMS

CSA	Central Statistical Agency
DEM	Digital Elevation Model
DIP	Digital Image Processing
DN	Digital Number
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
LULC	Land Use Land Cover
LULCC	Land Use Land Cover Change
NDVI	Normalized Difference Vegetation Index
NIR	Near Infrared
OLI	Operational Land Imager
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.
VI	Vegetation Index.

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 utilized for analyzing Land Use Land Cover (LULC), and its impact on Land Surface Temperature (LST) in Adama Wereda or vice versa. Split window algorithm and spectral radiance model were used for determining LST from Landsat 8 OLI/TIRS, Landsat 7 ETM+ and Landsat 5 TM, respectively. The changes in LULC occurred between 1999 and 2017 in the study area was analyzed using geospatial tools and verified by field data. The results indicated that bare land covered more than 65% area during the study periods (1999–2017) and followed by agricultural land covering more than 9 %. The study indicated that most areas having lower LST in 1999 were changed to higher LST in 2009 and 2017. The mean maximum of LST was increased 1.9^{o}C from 1999 to 2017 and moreover the mean minimum was also recorded the same trend which increased 1.88^{o}C during the same time span. Therefore the minimum and maximum LST in increasing continuously because of urbanization that directly influence the urban heat. This happened due to the increased in different LULC changes especially the decreasing of forest and range land cover in the study area and increasing of urban area. The LST values were found highest in urban, bare/barren land and others are affected as per the permeable and impermeable features. Moreover the NDVI results also indicated that the impermeable surface is increasing and permeable surface is minimizing during the study period that is responsible contributor for increasing the mean LST. Therefore, the visual comparison of 1999 and 2017 images showed that the LULC type and NDVI status play a great role for variability of LST values. Interestingly the results shows that the LULC change and changes in pervious and impervious surface directly affects the LST. If this trend would continue with the same growth rate so the LST will also increase and urban residential people may affected more by this heat flux and climate changes.

Keywords: *Land Use Land Cover, Land Surface Temperature, Normalized Difference Vegetation Index, Split window algorithm and Adama Wereda*.

CHAPTER ONE

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 (LULC) 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). All over the world the change in LULC leads to environmental changes, rainy season fluctuation, sea level rise and increase land surface temperature (LST). Massive LULC 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 LULC 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 5 TM, Landsat 7 ETM+ and Landsat 8 TIRS (Kidan, 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 Rajesh and Mani (2014), LST is the temperature emitted by the surface and measured in Kelvin/Celsius. In remote sensing, 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. 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 (Orsolya *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 (Orsolya *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 that 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.

Various remote sensing techniques have been applied to infer information about land cover changes specifically about forest information from satellite images. One of the widely used techniques is Normalized Difference Vegetation Index (NDVI), which 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. The value of NDVI usually ranges from -1 to 1, the negative values are indicative of water, snow, clouds, non-reflective surface and other non-vegetated, while the positive value expresses reflective surfaces such as vegetated area (Burgan and Hartford 1993). Vegetation has a direct match/correspondence with thermal, moisture and radioactive properties of the earth's surface that determine LST (Weng, 2004).

Remote sensing and GIS or geospatial applications 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 map the status of LULC and LST in Adama Woreda.

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. Anthropogenic activities associated with urbanization and industrialization were the most important driving force in land cover changes and UHI formation, as expected (Xie and Zhou 2015). One of the main factors that responsible for the increment of LST is LULC change. In the recent time, global warming and environmental problems are a headache for both 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 zone, Adama 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 LULC status of the area as an input for planning and decision-making. 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. (Aires *et al*., 2001).

Many researches indicate that increasing of surface temperature in the past decades is high in Ethiopia in different parts of the rift Valley (Getnet 2010, Esubalew 2014). Not only the past, even in the future the temperature is expected to increase in the worst case than the previous records, For example, as the projections of IPCC, mid-range (A1B) emission scenario, the mean annual temperature will increase in the range of 0.9^{0}C -1.1 ^{0}C by 2030, in the range of 1.7^{0}C - 2.1 ^{0}C by 2050 and in the range of 2.7-3.4 ^{0}C by 2080 over Ethiopia compared to the 1961-1990 (MoWR and NMSA, 2007, 2007). For instance, the average number of ‘hot’ days per year in Ethiopia has increased by 73 (an additional 20% of days) and the rate of increase is seen most strongly in JJA when the average number of hot JJA days has increased by 9.9 days per month. The average number of ‘hot’ nights per year increased by 137 (an additional 37.5% of nights) between 1960 and 2003. All projections indicate substantial increases in the frequency of days and nights that are considered ‘hot’ in current climate (McSweeney et al, 2008)

In urban areas, like in the capital of Ethiopia, Addis Ababa, due to rapid expansion of population growth and urban expansion, Environmental problems are increasing from time to time, like Climate change, flooding, erosion, water supply and others are among the major environmental problems related to the city (Hailu, 2011). Hazards like, flooding, erosion and heat waves are the main climate change effects for Addis Ababa (CLUVA 2011). Similar environmental problems like flooding have been reported in Adama Town and the surrounding (Getahun and Gebre, 2015).

In this study therefore, Remote Sensing and GIS tools were utilized to examine and better understand Land use land cover change, the relationship between land cover change and land surface temperature in Adama Woreda. Specifically thermal infrared remote sensing, which is a part of the electromagnetic spectrum and one of the best observation tools for calculating and quantifying LST is highly used in this study.

The basic argument why this study is proposed and done in Oromia national, regional state, East Shewa Zone Adama Woreda is that, the area is characterized by diverse topography, land use, climate, and the area is part of rift valley which has high temperature record all the year.

1.3. Objectives of the Study

The **general objective** of this study is to analyze response of thermal land surface temperature in different land cover categories and examine the spatio-temporal variation of land use land cover changes in Adama Woreda based on multi-temporal Landsat imageries.

The **Specific Objectives** of the study is to:

- Assess the spatio-temporal variation LULC, NDVI and LST of 1999, 2009 and 2017 from Landsat satellite images.
- Analyze the relationship between LST and NDVI over a period of 17 years.
- Examine temporal and spatial changes in LST with relation to LULC dynamics and its impacts on each other.
- Analyze the LST from pervious and impervious surface.

1.4. Research Questions

Understanding the impact of land use land cover 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 LULC and NDVI changes of the study area?
- What is the impact of LULC dynamics on LST change in the study area?
- What is the relationship between LST & NDVI in the study area?
- In which land cover types that the LST is the highest?

1.5. Significance of the Study

Environmental conditions are highly influenced by land cover change and activities. The information on the spatial distribution of LST is limited in the study area. The result of this study is therefore helps to obtain an information about the trend of LULC and LST change in the area. 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 LULC and LST changes through time.

The output of the study would provide better information about the urban heat island and changes in urban areas and its surroundings integrated by the application of GIS and remote sensing techniques or geospatial tools and its applicability, which is time and cost effective for analysis LULC dynamics on LST.

1.6. Scope of the Study

The present study was conducted in the Adama Woreda, Oromia Region; Ethiopia. The study mainly focuses on land use land cover changes from satellite images. All the obtained information is based on the analyses of the Landsat satellite images. The LST is also extracted from satellite image. The scope of the study is therefore focuses on the major classifications of land cover and do not included detailed land use information specifically at a complex urban land cover classes.

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 and the validation of surface temperature through spectro radiometer.

1.8. Organization of the Thesis

The paper is divided into six parts. The first Chapter introduces introduction, statement of problem, objectives of the study, research questions, Scope of the study, Significance of the study and limitations of the study. Chapter two concentrates on reviewing literatures 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 analyses and detail explanation of the study area. Chapter four explains the results, which presents the detailed results from image classification and collected data. Moreover, change analysis of LULC 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 LULC, LST, NDVI, RS and GIS. Furthermore, it tries to explore the findings of relevant studies of LST and LULC change and their impacts on each other which have been studied previously in different area.

2.1. Conceptual Review

2.1.1. 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 LULC 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 (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 LULC 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.

2.1.2. 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 LULC 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 km² to 15 million km² and at the same time, other natural resources (land-cover) such as forest has been shrinking due to agricultural land expansion and urbanization(Santa, 2011). High rate of deforestation in many developing countries is most commonly associated with population growth and poverty (Mather and Needle, 2000).

Land use land cover changes have become major problems for the world, and it is a significant driving agent of global environmental changes (FAO, 1999). Such a large scale land use classes through the increase of agricultural land at rural area, deforestation (clearance of trees), and urbanization and other natural phenomena and human activities are inducing changes in global systems and cycles. However, the major change in land use, historically, has been the worldwide increase in agricultural land (Houghton, 1994). Climate change refers to long term or permanent shift in climate of the area. Some of the evidence for climate change includes increased frequency of the occurrence of drought, global temperature rise, tropical cyclones, flood, and reduced annual rainfall reduction in glacial cover over mountain and rising sea levels (Alemayehu, 2008).

United States Environmental Protection Agency (USEPA, 2004), identified the general causes of LULCCs 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.

2.1.3. Land Use 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 LULC 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 LULC changes in different part of the country and the expansion of cultivated land at the expense of forestland and 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).

2.1.4. Remote Sensing

Remote sensing is the capability to gather information without being in direct contact with it. 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 (Lille sand 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 LULC change through time.

2.1.5. 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 relationship 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.

2.1.6. 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 LULC 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 LULC 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 LULC 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 LULCs 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.

2.1.7. 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 radioactive ability to reflect solar and infrared and also ability to emit infrared availability of surface moisture to evaporate and roughness of the surface (Voogt, 2000). Land-use/land-cover changes due to changes in surface temperature (ST) which makes both urban and rural managers to estimate the urban surface temperature and its surrounding rural area for urban planning as well land management in general (Becker *et al.*, 1990).

2.1.8. 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).

2.1.9. 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 LULCC 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 1ºC variation and increase in surface temperature of vacant land, built-up area and stream, while cultivated land and vegetation also had increases of 0.95ºC ,respectively. The influence of

LULC 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 it in Shanghai employed Landsat7 ETM+ data. The result shows that different LULC classes have significantly different impacts on LST and on vegetation index, calculated by ETM+ sensor in Shanghai urban environment.

2.1.10. 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 radioactive properties of the earth's surface that determine LST (Weng, 2004).

Previously, different researchers outside Ethiopia did researches in relation to the impact of LULC 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 center Addis Ababa; Ethiopia (ESRI Eastern Africa Education GIS conference which held from 23−24 September, 2016). The study mainly focuses on modeling LST of Addis Ababa city, which acquired Landsat 5 and 8 for the year 1985 and 2015 respectively. Finally, the results showed negative correlation was found between NDVI and LST. Moreover study indicates and suggested the need for urban greening and plans to increase vegetation 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).

2.1.11. 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 sub setting of the image based on the boundary of Adama 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 geo referenced-using boundary of the Woreda. During geo referencing and re projecting 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. Gap filling tool is also used to correct the strips in 2009 LST strips.

2.1.12. 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.

2.1.13. 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.

2.1.14. 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 LULC 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.

2.1.14.1. 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 LULC. After the training area assigned for each class classification activity was performed. For bare land, farmland, shrub land and settlement LULC types taken 20 training site, where as for plantation and water body LULC 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 LULC class (Coppin and Bauer, 1996).

Using Multispectral Band from band 1 to 5 and 7 for Landsat 5 TM 1999 and ETM + 2009 and OLI /TIRS 2016 1 to 7 and 10&11 Bands of the preprocessed images the land-use land-cover pattern mapped was by supervised classification with the likelihood classification algorithm of ERDAS Imagine 2015 software. In supervised classification, with the help of image processing techniques, the user specified type of the land use land cover classes. The seven major classes studied in Adama Woreda were bare Land, water body, agricultural land, built up area, forest land, wet land and range land. The description of each land use land cove and sources are listed in Appendix 2. 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.

2.1.15. Accuracy Assessment

The common way to represent classification accuracy is in the form of an error matrix. An error matrix is a square array of rows and columns and presents the relationship between the classes in the classified and reference data (Tesfaye, 2015). Sets of reference points have been taken to assess its accuracy. Error matrices were then designed to assess the quality of the classification accuracy of 1999, 2009 and 2017 LULC maps.

Overall accuracy is computed by dividing the total correct number of pixels (*i.e.* summation of the diagonal) to the total number of pixels in the matrix (grand total). Various standard threshold levels were applied to the lower and higher tail of each distribution in order to find the threshold value that produced the highest change classification accuracy (Tesfaye, 2015).

Producer's accuracy refers to the probability of a reference pixel being classified correctly. It is also known as omission error because it only gives the proportion of the correctly classified pixels. It is obtained by dividing the number of correctly classified pixels in the category by the total number of pixels of the category in the reference data. User's accuracy assesses the probability that the pixels in the classified map or image represent that class on the ground (Congalton, 1991). It is obtained by dividing the total number of correctly classified pixels in the category by the total number of pixels on the classified image.

The Kappa coefficient was also used to assess the classification accuracy. It expresses the proportionate reduction in error generated by a classification process compared with the error of a completely random classification (Congalton, 1991). The Kappa statistic incorporates the off-diagonal elements of the error matrices *(i.e.*, classification errors) and represents agreement obtained after removing the proportion of agreement that could be expected to occur by chance. Using hand held Global Positioning System (GPS) field survey was conducted in the study area and about 70 points i. e. ten points for each LULC identified. The field survey and Google Earth were used as a ground for validation the LULC classification accuracy.

2.2. Empirical Review

2.2.1. Estimation of LST by different studies employed different data and empirical methods.

In this study LST was generated using MODIS (31 and 32 bands) and ASTER data of same date and time for one of the semi-arid region in Iran. As the result shows, LST output of MODIS exactly matches with the ASTER output. Mono-window and single channel algorithm were used to estimate LST for Alashtar city, Iran. (Reference) NDVI was found for four different years in Kunsan city Chollabuk_do, Korea. Using NDVI threshold technique LST was derived. The output of LST was compared with the NDVI output and a positive correlation was found in between them. Changes over period was also assessed and found that LST was increasing. LST and NDVI were estimated using Landsat 7 image.

A correlation study was conducted between LST and NDVI data. The output revealed that there was a strong positive correlation between them and the methodology is more feasible to estimate NDVI and surface emissivity . Single Window algorithm for estimating LST was adjusted for Landsat 8 data for better accuracy. The basic inputs for SW algorithm were brightness temperature and Land Surface Emissivity (LSE). The adjusted Split window algorithm’s accuracy was estimated using MODTRAN 4.0 software.

This study was conducted in the northern Negev Desert, Israel. Sobrino and Mao methods were used individually for retrieving LST with MODIS data in Hebei and Shanxi, North China Plain. The maximum, minimum and mean of Sobrino and Mao LST methods were cross checked with the standard LST values and found that Sobrino output range greater while Mao method had less value than standard LST. Hence, a combined method of Sobrino and Mao was evolved as Sobmao method. It is as accurate as Sobrino and simple to use.

This study uses Split-Window, dual-angle and mixed structures algorithms to generate LST and Sea Surface Temperature (SST) in a part of New South Wales. The dual-angle algorithm has low sensitive to aerosol effects. Although, many researchers had estimated LST using satellite image. A number of algorithms were developed and adopted by them to estimate LST. Some of the frequently used algorithms are Split-Window (SW), Sobrino, Mao, Dual Angle, and Sobmao. Most of the studies were done for urban areas and arid and semi-arid regions and in many of the studies, single thermal band was used. In the present study LST was estimated for the entire district using two TIR bands and four OLI bands.

The major objectives of the study are to find the brightness temperature using band 10 and band 11 of TIR, calculate the LSE using NDVI threshold technique and estimate the LST of Dindigul district using Split-Window (SW) algorithm. estimate brightness temperature and OLI spectral bands 2, 3, 4 and 5 were used to generate NDVI of the study area. The district was covered in four tiles. Landsat 8 provides metadata of the bands such as thermal constant, rescaling factor value etc., which can be used for calculating various algorithms like LST.

CHAPTER THREE

3. Materials and Methods

3.1. Description of the study area

3.1.1. Location

Adama Woreda (study area), is located in East Shoa Zone of Oromia region, and it bounds a geographic coordinates ranging from 39^0 03'00” E to 39^{0}29'0” E and 8^{0}16'00” N and 8^{0}49'00" and the altitude ranges from 1329 to 2483 meters above Mean Sea Level (MSL).

Adama Woreda has 99,932.5 hectare (999.325 km^2) area coverage. It comprises Adama City, Wonji sugar factory and town, Koka Lake, and other rural Kebeles. It is bounded by Boset Woreda in the East, Lome Woreda in the North West, Dugda Bora in South West, Dodota sire Woreda in South and Shenkora and Minjar in North. It has varied topography which includes hills, plains and undulating landscapes with lakes and the rift valley escarpment.

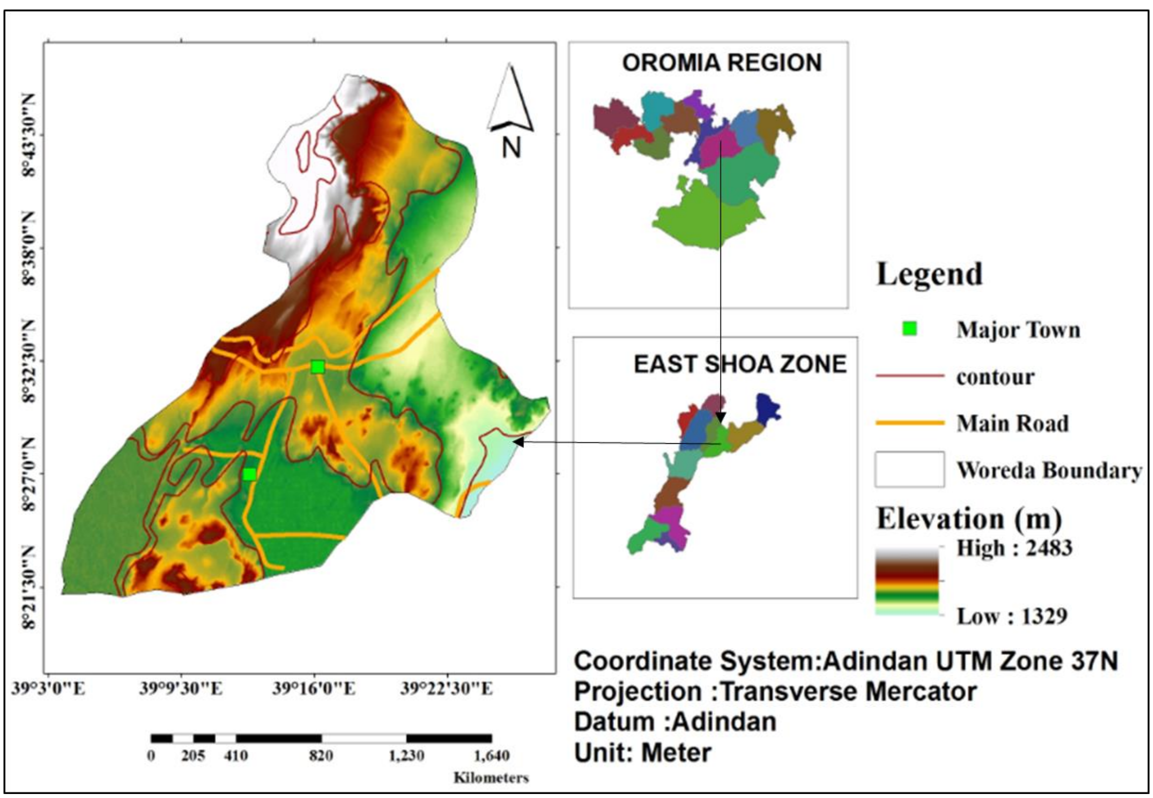


Figure 3. 1: Location of the Study Area.

3.1.2. Topography of Adama Woreda

The Adama 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.

3.1.3. Climate ***and*** Vegetation

A. Rainfall

A long-term rainfall record from1999 to 2017 at the Adama meteorological station shows a total annual rainfall was 844. 20 mm and the maximum monthly average rainfall was 229.767 mm in the month of July. The wet rainy months in the study area are March, May, June, July, August and October. Whereas, the dry month are January, February, April, September, November and December. The warmest months are May and June and coldest month is July. Among all month, the driest month is November and December.

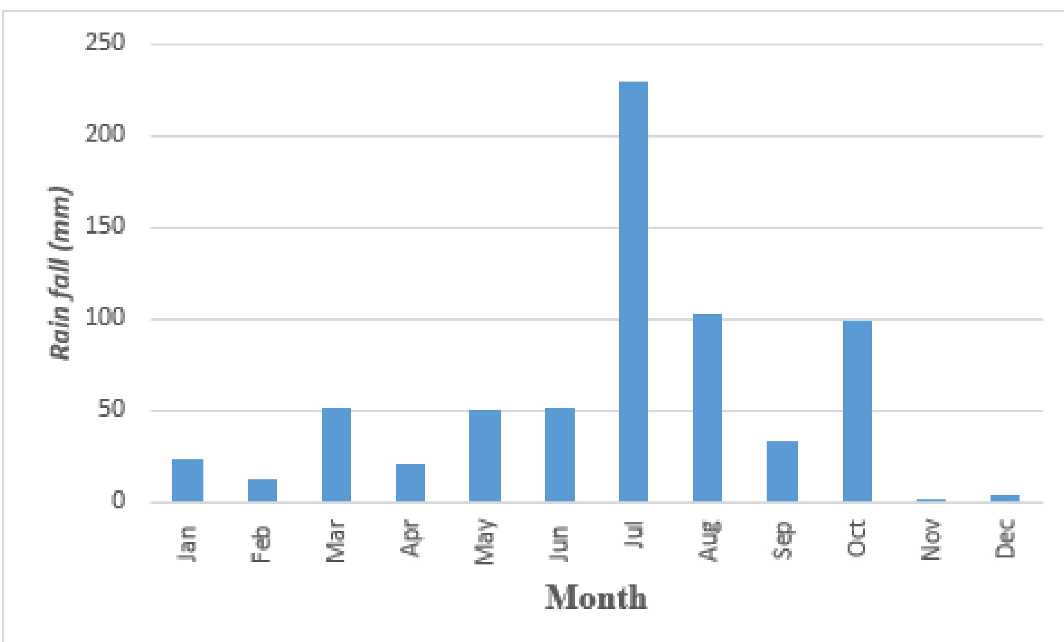


Figure 3. 2: Monthly average rainfall distribution of the study area. Source from National Metrological Agency.

B. Temperature

The mean annual temperature of the Adama Woreda is 27.7^{0}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 30.863 was June. The monthly maximum, minimum and mean temperature of Adama Woreda is presented in Figure 3. 3.

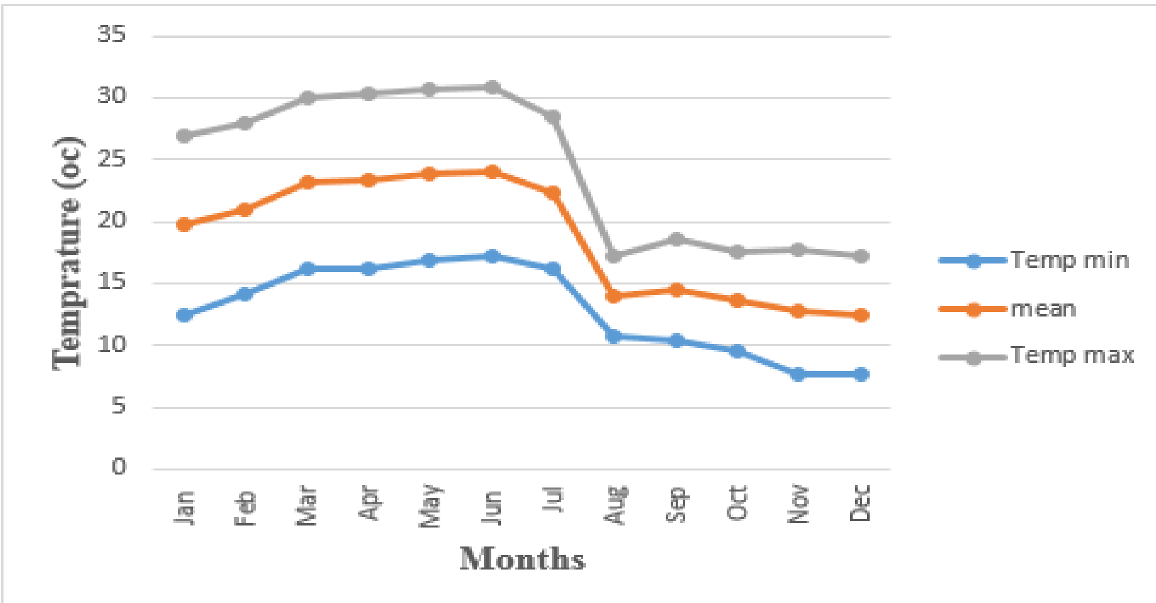


Figure 3. 3: Maximum, minimum and mean monthly Temperature during 1999–2017. Source from National Metrological Agency.

C. Vegetation

The vegetation distribution is mainly dependent on the climate condition of the area. The climatic 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 in the area which 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 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 237844 are men.

3.2. Data and Software

Data used for this research comprise both primary and secondary. 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

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. Field data was used for accuracy assessment based on ground truth. The primary data includes Landsat satellite image (Landsat data): Landsat 5 TM (1999), Enhanced Thematic Mapper Plus (ETM+) 2009, and Operational Land Imager/Thermal Infrared (OLI/TIRS) 2017 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 were used.

3.2.2. Secondary Data

Secondary data used in this study comprises meteorological data such as average monthly temperature (1999, 2009 &2017). In addition to this, the other data used in this study were population data from CSA to understand the status of the population of the study area (CSA, 2007).

3.2.3. Remote Sensing Data Acquisition

One scene of Landsat5 TM (1999),Landsat7 ETM+ (2009) and Landsat 8 OLI/TIRS (2017) 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 the open data source (https://libra.developmentseed.org). Remote sensing images used to calculate LST, NDVI and LULC in Adama Woreda are shown in Table 3. 1.

Table 3. 1: Remote sensing data used in the study.

Acquisition-date	Satellite	Sensor	Multispectral lband	Thermal Band	Source
3/Dec/1999	Landsat5	TM	1 to 5 and 7	6	USGS
6/Dec/2009	Landsat7	ETM^{+}	1 to 7 and 9	6	USGS
10/JAN/2017	Landsat 8	OLI/TIR	1 to 7 and 9	10&11	USGS

Source: website of earth explorer. usgs.gov, United States Geological survey (USGS)

3.2.4. Data Description and Source

Primary and ancillary data that used in this study was collected from different sources as indicated in Table 3. 2.

Table 3. 2: Data description and source of data

GIS data layer	Data description	Data source
Vector (polygon)	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	USGS 1999, 2009 &2017.
	▪ 1999 Landsat 5 TM	
	▪ 2009 Landsat 7ETM+	
	▪ Landsat 8 OLI/TIRS	
Ground truth	Ground truth 2017	Field survey

3.2.5. Software and Materials Used

Software and material packages used for this study were ArcGIS 10.3 for image analysis; calculate LULC, LST, NDVI and map preparation, ERDAS (Earth Resources Data Analysis System) Imagine 2015 for RS application in order to process satellite images including image enhancement, pre-processing and for LULC classification. As describe above these materials are very purposeful for the attainable of the aim of the research on time and effectively.

Table 3. 3: List of Software and materials used.

NO	**Software**	Remark
1	ERDAS IMAGINE	Version 2015
2	ArcGIS	Version 10.3
3	Google earth (as supportive tool)	
4	MS-Office word and MS-Excel	Version 2013
	Materials	
1	Hand held GPS	Magellan
2	Digital camera	

3.3. Methodology

In this study, the methods used to achieve the objectives of the research were begun with acquisition of Landsat imagery for the year 1999, 2009 and 2017 from website of earth explorer (USGS). Figure 3. 4 show the general methodological flow chart of the study.

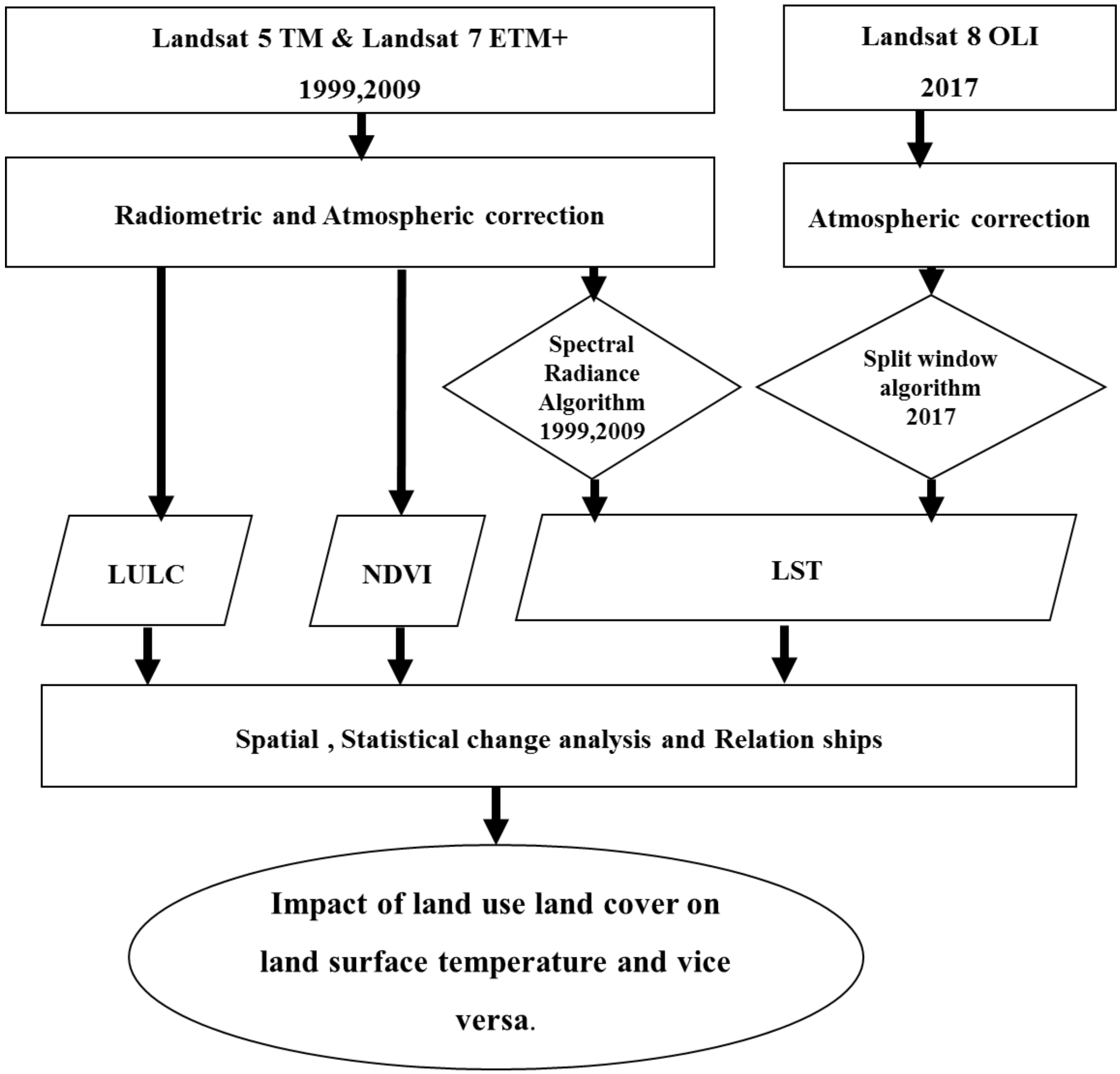


Figure 3. 4: Technical scheme of the study.

3.3.1. Land Use Land Cover Change Detection

Land use land cover change detection was done by involving images of 1999, 2009 and 2017. Using GIS techniques thematic image was compared. The cross operation process of mapping LULCC over time began with mapping the recent 2017 satellite imagery, then looking back in time to map the 1999 imagery. Post classification is among the most widely used approach for change detection purpose (Chen, 2000). The analysis of LULCC 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 1999, 2009 and 2017 measured against each LULC classes. Therefore, to calculate LULCC in percentage equation 3.1 were used (Lambin *et al*, 2001).

$$\text{Percent Change} = \frac{Observed\ Change}{Sum\ Area} * 100 \qquad Eq.\,(3.1)$$

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 -1and 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.

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

Where, NDVI=Normalized Difference Vegetation Index, NIR= is the near infrared band 4, R= is the red band 3. Equation.2 is used to calculate NDVI for the sensor ETM+ 1999, Landsat 5 TM and OLI 2017.

Equation 3.3 was used to calculate Proportion of Vegetation that helps in calculating Landsat 8 land surface emissivity (LSE).

$$\mathrm{PV} = (\mathrm{NDVI} - \mathrm{NDVI_{min}}/\mathrm{NDVI_{max}} - \mathrm{NDVI_{min}})2 \qquad Eq.(3.3)$$

Where, PV =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. 4.

Table 3. 4: Emissivity constant value of Landsat 8 OLI/TIRS**.**

Emissivity	Band 10	Band 11
εs	0.971	0.977
εv	0.987	0.989

Source: Skokovic et al, 2014; Sobrino et al, 1996; 2003; Shaouhua Zhao et al, 2009.

The following equation 5, 6 and 7 used to compute Land surface Emissivity, mean of LST and change of LSE of Band 10 and 11, respectively.

$$LSE = 0.004PV + 0.986 \qquad Eq.(3.4)$$

$$Mean\ LST = \frac{(LST_{10} + LST_{11})}{2} \qquad Eq.(3.5)$$

$$Difference\ of\ Land\ Surface\ Emissivity(LSE) = LSE_{10} - LSE_{11} \qquad Eq.(3.6)$$

3.4.3. Radiometric Correction

Radiometric correction requires converting a remote sensing digital number to spectral radiance values and data for comparisms. Image processing procedures that are used to correct errors, converting digital number (DN) values to radiance and then reflectance was categorized as a Radiometric correction (Parente, 2013). To perform the conversion of digital number to spectral radiance equation 3.7 was used. (Mehebub et. al, 2016).

$$L_\lambda = L_{min} + (L_{max} - L_{min}) * DN/255 \qquad Eq. (3.7)$$

Where, L_λ =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 3.8 was used to perform the conversion at sensor spectral radiance or satellite data scaled into 8 bits.

$$L_\lambda = \frac{(L_{max\lambda} - L_{min\lambda})}{(Q_{Calmax} - Q_{Calmin})}(Q_{Cal} - Q_{Calmin}) + L_{min\lambda} \qquad Eq. (3.8)$$

Where,

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

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

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

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

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

Q_{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 3.9 was used to compute TOA.

$$P\lambda = \frac{\pi * L_{\lambda} * d^2}{ESUN_{\lambda} * \cos\theta_s} \qquad Eq.(3.9)$$

Where,

P_{λ} = planetary top of atmosphere (TOA) reflectance, which has no unit or it is unit Less.

∏=mathematical constant approximately equal to 3.14159. It is also unit less.

L_{λ}=spectral radiance at the sensors aperture.

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

$ESUN_{\lambda}$=mean Exo Atmospheric solar irradiation (from Meta data).

Ɵ= Solar zenith angle.

3.4.6. Conversion of Radiance into Brightness Temperature

Thermal infrared data can be converted from atmosphere reflectance (L_{λ}) 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 a sensor spectral radiance to effective at sensor brightness temperature. Brightness temperature is the radiance travelling upward from the top of earth atmosphere. To convert Lλ (spectral radiance) to TB (brightness temperature) equation 3.10 was used Rajeshwari and Mani, 2014).

$$TB = \frac{K_2}{(\ln \frac{K_1}{L_\lambda}) + 1} \quad Eq.(3.10)$$

Where,

TB=effective at satellite brightness temperature (unit in Kelvin), K2=calibration constant 2.

Ln=natural logarithm, K1=calibration constant 1, λ=spectral radiance at sensors aperture.

Table 3. 5. Shows the calibration constant used during performing the formula for brightness temperature.

Table 3. 5: Thermal band calibration constant of Landsat 8 OLI/ TIRS.

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

Source: website of earth explorer. usgs.gov, United States Geological survey (USGS)**.**

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 in1975. As follows eq.3.11.

$$LST = TB_{10} + C_1(TB_{10} - TB_{11}) + C_2(TB_{10} - TB_{11})2 + C_0 + (C_3 + C_4W)(1 - m) + (C_5 + C_6W)\Delta m \quad Eq.(3.11)$$

Where,

LST=Land Surface Temperature, C_0 up to C_6=Split Window Coefficient Value

TB_{10}=Brightness Temperature of band 10, TB11=Brightness Temperature of band11.

m=Mean Land Surface Emissivity of thermal infrared bands (mean of band 10 and band11)

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

Δm=Difference in Land Surface Emissivity (LSE)

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

Table 3. 6: Split window algorithm constant value.

Constant	**Value**
C_0	-0.268
C_1	1.378
C_2	0.138
C_3	54.3
C_4	-2.238
C_5	-129.2
C_6	16.4

[Source: Skokovic *et al*, 2014; Sobrino *et al*, 1996; 2003; Zhao *et al*, 2009]

The calibration constant for Landsat 5 and Landsat 7 is different from Landsat 8. For the case of Landsat 5 and Landsat 7 the following values

Table **3.** 7**:** were used.

Table 3. 7: Thematic mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) thermal band calibration constant.

Satellite	**Sensor**	**Constant**	**Value**
Landsat 5	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 obtained result, which was in degree Kelvin.

Therefore, to convert degree Kelvin into degree Celsius the following formula was used Eq.3.12.

$$C = K - 272.15 \qquad Eq.(3.12)$$

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 LULC, NDVI and LST were prepared for the year 1999, 2009 and 2017. To examine the spatial difference of LST according to varies LULC; the result was summarized using the zonal statistics tool of the ArcGIS 10. 3. Subsequently, summarized LULC, 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.

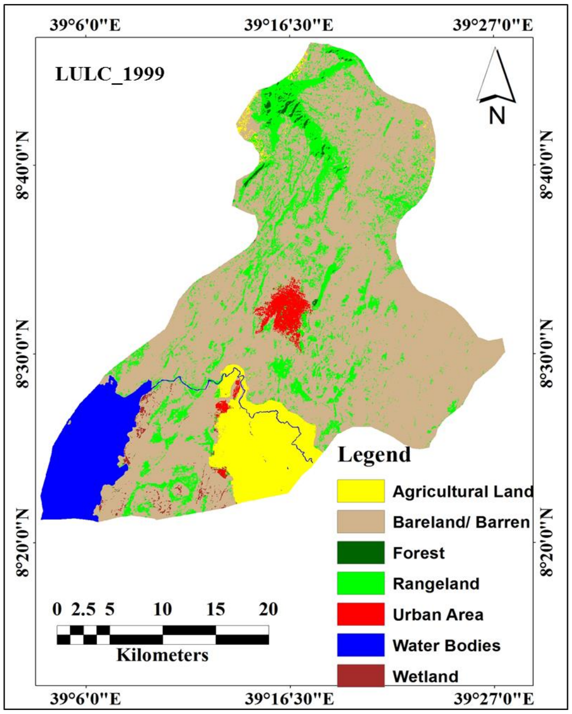
CHAPTER FOUR

4. Results and Discussion

4.1. Land Use Land Cover Change Analysis.

4.1.1. Land Use Land Cover Status in 1999

Seven types of land cover classes have been identified in the analyses process in Adama Woreda. These are Water body, forest, range land, urban areas, wetland, bare land and agricultural land. The Spatial and statistical distribution and proportion of land use coverage of Adama Woreda in 1999 has been analyzed (Figure 4.1). The total area of Adama Woreda is 99,932.4 hectare and its large coverage is bare land which covers 65.7 % of the total area, and shares the area of fallow lands. Agriculture (crop) land covers 8.4% of the area. The agriculture land concentrates in Southern part of Adama Woreda around Wonji Town and some private agricultural practice are shown. The area covered by wet land is follows the water containing areas. The wet land coverage of area is 0.56%. The land use coverage of urban area is 1.64%, it sparse mainly in Adama City and Wonji area. Because of Adama is the capital of Oromia Region there is influx of migrants from remote areas to the City that is why urban expansion is largely concentrated on the City which is anthropogenic factor for encroaching other lands and resulting expansion of urban. In the study area range land coverage is 15.03% and water body coverage of Adama Woreda is 8.16% of the total area, it concentrated on Lake Koka around Wonji Town. The remaining 0.5% of the area is covered by forest.



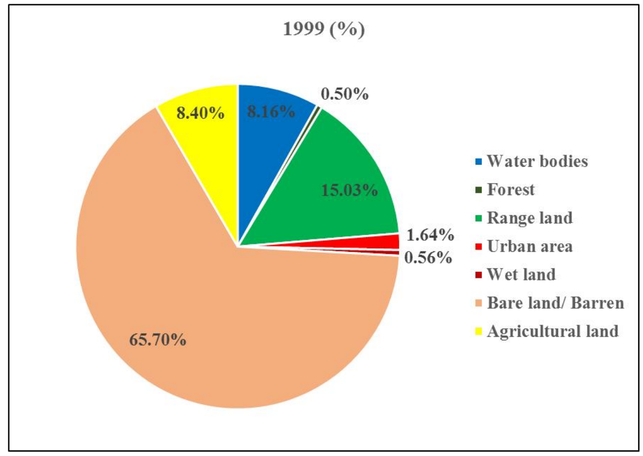


Figure 4. 1: spatial distribution of LULC in 1999 with their respective area (%) coverage in 1999.

4.1.2. Land Use Land Cover Status of 2009.

Slight diminish in area is observed on barren land in this year compared to 2009, even though it is still the dominant land use type which covers about 61.51%. It is also observed that the range land is dominant in northern parts and sparsely distributed to south east and south west of the Woreda in this year which shares 17.75% of the geographical area. In case of agricultural land, it is concentrated mostly in south east of the Woreda which shows sugar cane production for sugar industry and sparsely distributed around northern parts of the Woreda which practice traditional farming system for other crops that covers about 7.56% of Woreda in land use land cover. Most of the area is covered by bare land specially the north east is extremely dominated by bare land which accounted 61.51% geographical area whereas forest land coverage fall in northern parts and almost there is no forest coverage in the rest of parts of Woreda and accounts 0.82% area. The urban area increases nearly by double in ten years between 1999 and 2009. The urban area of the Woreda concentrated around South East and central parts of the Woreda as well as sparsely distributed in North West which accounted 3.26% land coverage. And also both the water bodies and wet land found in south west of the Woreda which covers 8.06 % and 1.03% geographical area of the Woreda respectively. Figure 4. 2 Shows spatial and statistical coverage under different LULC classes of 2009.

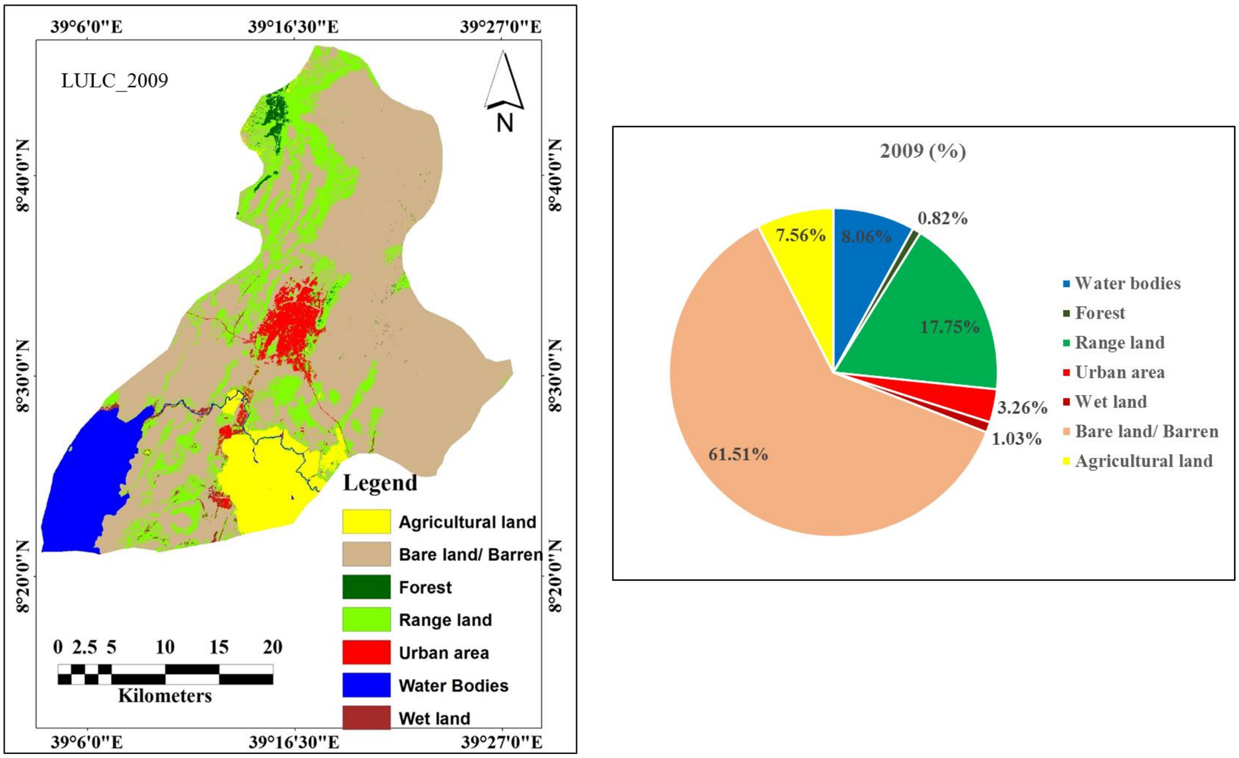


Figure 4. 2: Spatial distribution of LULC in 2009.

4.1.3. Land Use Land Cover Status for 2017

As indicated in Figure 4. 3 the latest LULC status of Adama Woreda currently, bare land is still a dominant among all other classes which occupies 67.23 % of the total area. The agricultural area covers 9.02 %. The agricultural area covers largely in southern part of Adama City and partially in northern parts. The area covered by wet land is near water bodies which covers an area about 2.30 %. The forest covers a least shares in area which is about 0.16 % and highly concentrated on the northern part of the Woreda. The range land covers 8.01 % of the total area. The built up occupies 5.13 % of the area, since the expansion of urban is near to the main road that is dominant over Adama Town and South West part of Wenji Town. Still the only water bodies covers 8.15 % and no other new water bodies found in the study area.

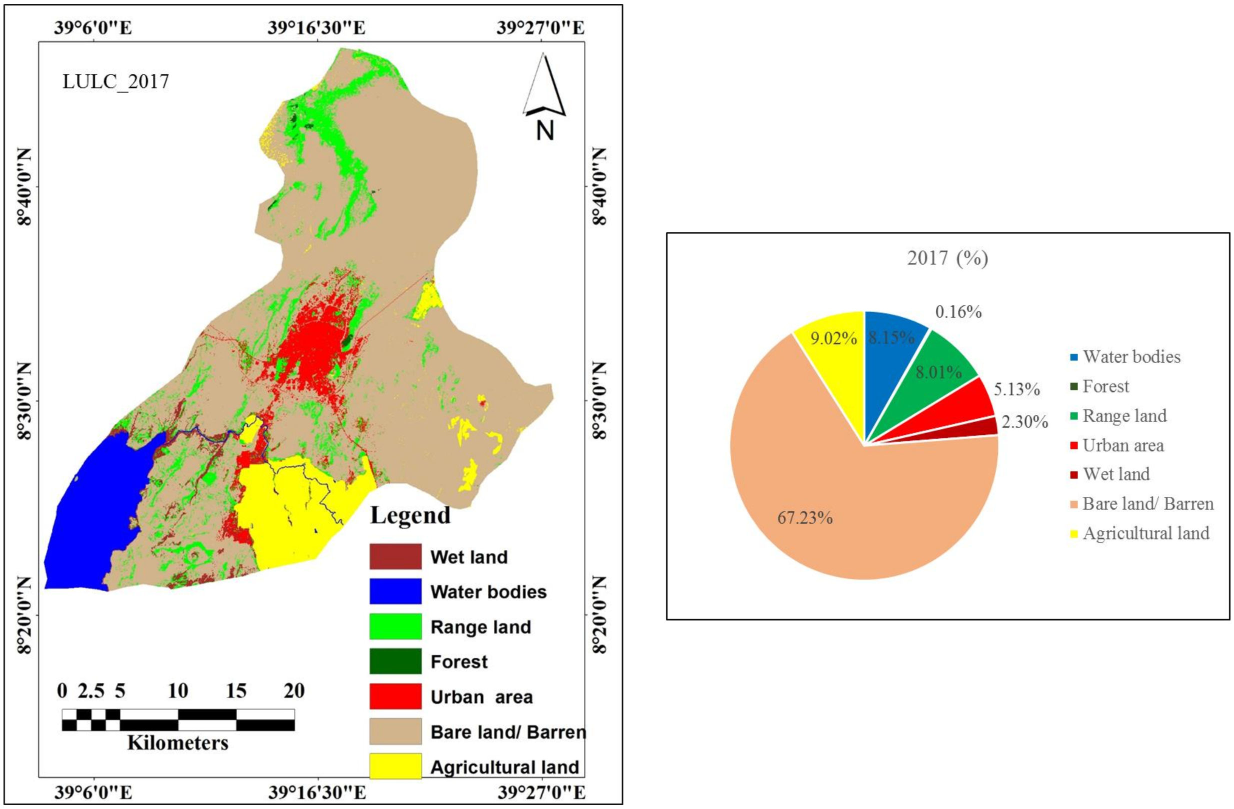
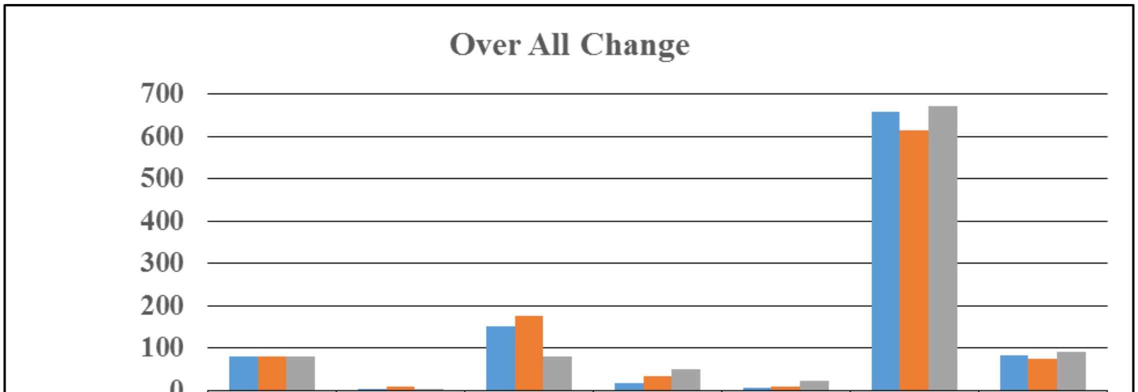


Figure 4. 3: spatial distribution of land use land cover in 2017 with their respective Area (%) coverage in 2017.

4.1.4. Statistical Change of Land Use Land Cover in 1999, 2009 and 2017.

Almost in land cover type's changes has been observed. However the rate of change in different land cover varies. The range land coverage in 2009 was 177.36 km^2 whereas it decreased in 2017 which is now 80.01 km^2. Drastic Change has been analyzed in urban expansion after 1999(Figure 4. 4). Forest area has been increased significantly in study area and less variation in forest, has been noticed during the whole study. As per the statistical information and spatial distribution of pixels, it has been noticed that urban area, wet land, bare land and agricultural land are the main classes which expanded continuously over the period from 1999 to 2017.



	Water body	Forest	Range land	Urban area	Wet land	Bare land	Agricultural land
Area 1999	81.58	4.99	150.21	16.38	5.64	656.54	83.94
Area 2009	80.52	8.23	177.36	32.59	10.29	614.71	75.59
Area 2017	81.44	1.6	80.01	51.31	23.01	671.78	90.14

Figure 4. 4: Over all statistical change of land use land covers.

4.1.4.1 LULC Change Rate from 1999 to 2009.

The graph indicates that agriculture land, bare land, and water bodies are decreased by 8.35 km^2, 41.83 km^2, and 0.006 km^2 respectively whereas, wet land, urban area, range land and forest land have increased by 4.65 km^2, 16.21 km^2,27.15 km^2 and 3.24 km^2 respectively.

The urban area is expanded by 1.62% and this increment of urban area between 1999 and 2009 due to a rapid increase in population, migration of rural citizens to the city and towns for finding job opportunities, and also location of higher institutions such as University, Polytechnic colleges and other colleges at Adama city. In this some parts of the bare lands changed into urban area. Moreover, range lands increased by 2.72% this is due to the government regulation of reforestation of bare lands.

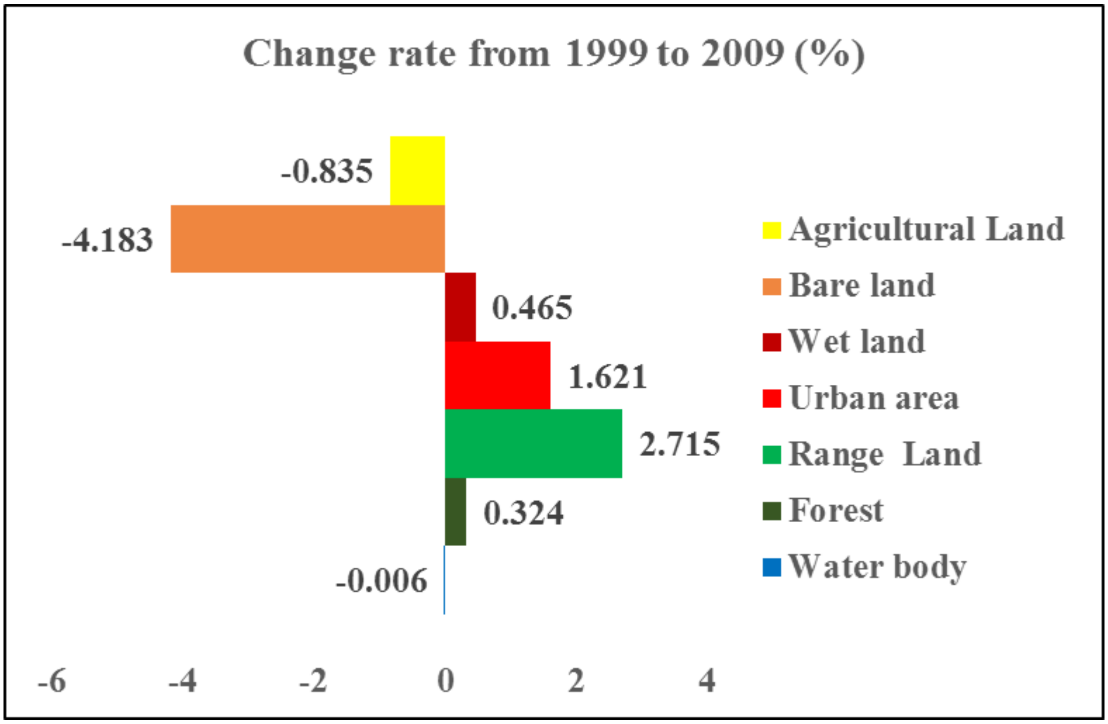


Figure 4. 5: Land Use Land Cover Change from 1999 to 2009(%).

As has been noticed in classified map that agricultural lands are suddenly changed from the area of range land and wet lands. Around Wonji some urban has been expanded and totally it expended 1.62% from 1999 to 2009 (Figure 4. 5 and Table 4. 1).

Table 4. 1: LULC change from 1999 to 2009 area (km^2) and percent.

Class Name	Area change 1999 to 2009	Change rate from 1999 to 2009 (%)
Water body	-0.06	-0.006
Forest	3.24	0.324
Range land	27.15	2.715
Urban area	16.21	1.621
Wet land	4.65	0.465
Bare/Barren land	-41.83	-4.183
Agricultural land	-8.35	-0.835

Forest area has increased by 3.24km^2 in one decade. This is because the government regulation of planting two trees by every individual instead to cut one tree. So, some of the range lands are transformed to forest lands. As clearly shown by the graph that wet lands are increased by 0.47% from 1999-2009. This increment occurred due to some part of water body (lake Koka) is changed to wet land where as water bodies are constantly decreased by 0.01%. There is dramatic changes occur on the bare lands. Most of its class is changed to range land and the rest converted to urban area which is decreased by 4.18%.

4.1.4.2. LULC Change Rate from 2009 to 2017

The forested areas do not contribute significance for the increase in urban areas. From the calculated change rate, it can be seen that the rate of degradation of range land has increased over time, whereas area under range land is increasing due to the conversion of forests into range land. According to Figure 4. 6 and Table 4. 2 range land also shows negative growth rate from 2009 to 2017 due to the degradation of forested areas. It is found that highest positive changes are recorded in bare land and built-up category followed by wetland and water. Forest land and range land reported an insignificant declined in area.

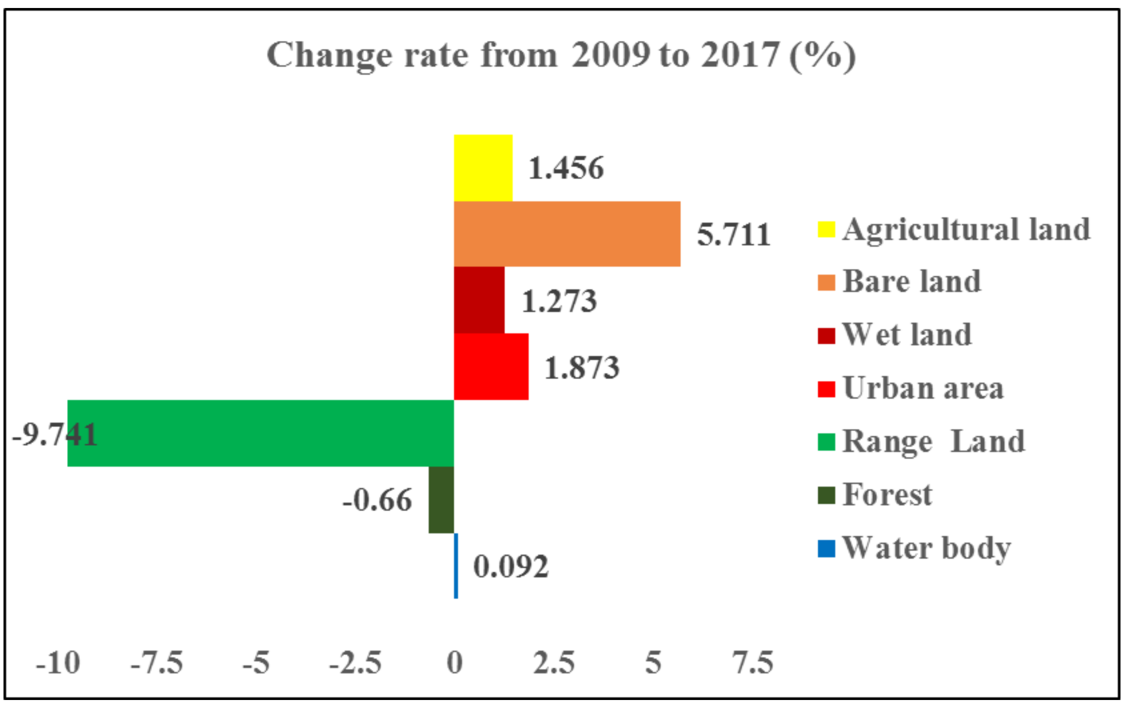


Figure 4. 6: Land Use Land Cover Change from 2009 to 2017 (%).

Table 4. 2: LULC change from 2009 to 2017 area (km^2) and percent.

Class Name	Area change 2009 to 2017	Change rate from 2009 to 2017 (%)
Water body	0.92	0.092
Forest	-6.6	-0.66
Range land	-97.35	-9.741
Urban area	18.72	1.873
Wet land	12.72	1.273
Bare land	57.07	5.711
Agricultural land	14.55	1.456

The Figure 4. 6 implies positive growth 1.87% in urban area between 2009 and 2017. The consequences of expansion are the migration of population from rural to urban, business center and etc. Agriculture and bare lands plays vital role for the expansion of the built up area of the Woreda.

Most changes have occurred in forest area which was 8.23 km^2 in 2009 and currently exists only 1.61 km^2 as per 2017. It implies that area coverage of Woreda is extremely decreased due to artificial and natural factor for instance deforestation, firing, flooding, landslides are the factors for negative growth of the forest land. The range land covered 177.36 km^2 during 2009 whereas in 2017 it is 80.01 km^2 that indicates negative growth from 2009 to 2017.

4.1.5. Accuracy Assessment

Supervised image classification conducted to extracted information from 1999, 2009 and 2017 Landsat imagery and evaluation was made by using contingency evaluation system**.**

This evaluation classifies all of the pixels in the selected area of interest and compares the results to training sample- (in ERDAS Imagine 2015). The pixels of each training sample are not always so homogenous that every pixel in a sample is actually classified to corresponding class. Each sample pixel only weight the statics determine the class. However, if the signature statics for each sample are distinct from those of other sample, then a high percentage of each sample pixel is classified expected. Contingency matrix of 1999, 2009 and 2017 containing the number of pixels that are classified were found to be presented in appendix. Interestingly it is we found that overall accuracies are 85.15 %, 91.25 % and 90.13% for the year 1999, 2009 and 2017 respectively. According to the Anderson (1970) classification, accuracy values should be above 85 % and the results are shows the accuracy above it which is acceptable for international standards. Among the 70 points that are collected on the field using a hand GPS 57 points lie on the exact class but 13 points lie wrongly. And it gives an accuracy of 81.43 %.

4.2. Normalized Difference Vegetation Index (NDVI) analysis.

In this study, it has been observed that the vegetation health was good and its cover was more in 1999 and 2009 with maximum NDVI of in 2017 with the NDVI value of 0.566 (Figure 4. 7). The vegetation index results of 1999, 2009 and 2017 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. As indicated in Figure 4. 7, vegetation cover has decreased and non-vegetated area has been increasing gradually over the study period. However, in 2017 Agricultural land, has slightly increased due to the expansion of Wonji Shewa Sugarcane Plantation. Table 4. 3 showed statistical information of NDVI value for the year 1999, 2009 and 2017.

Table 4. 3: Statistical information of NDVI value for the years 1999, 2009 and 2017.

Year	Min	Max	Mean	Std.
1999	-0.382	0.800	0.253	0.208
2009	-0.416	0.738	0.200	0.188
2017	-0.233	0.566	0.165	0.131

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

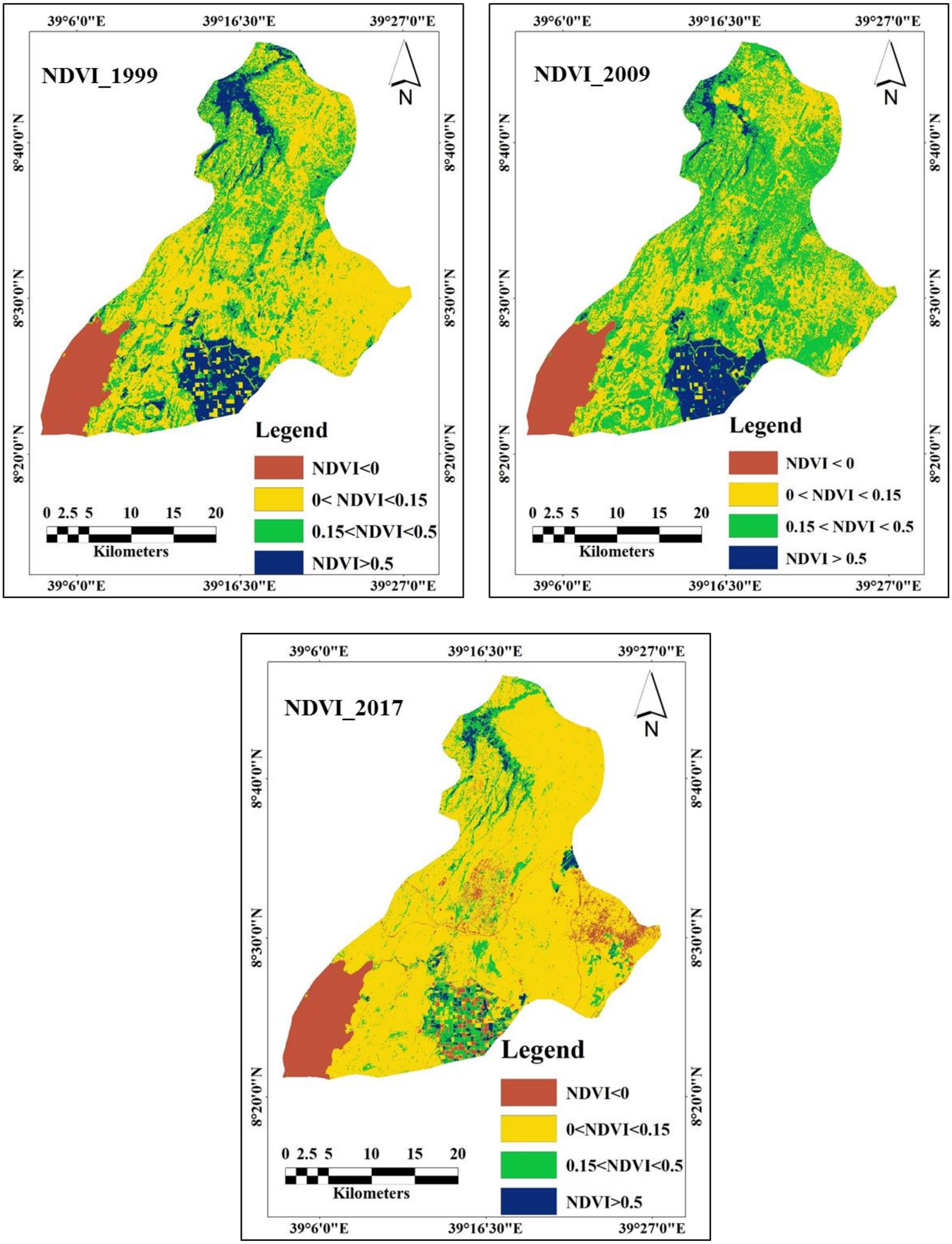
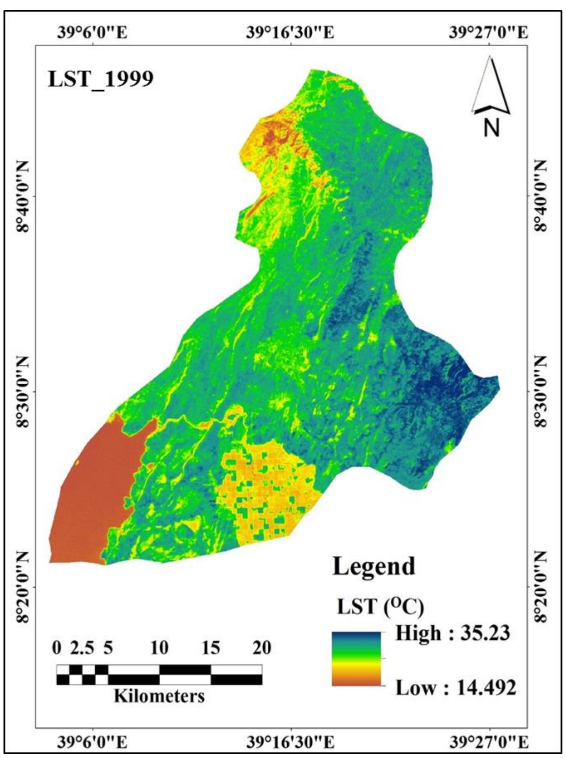
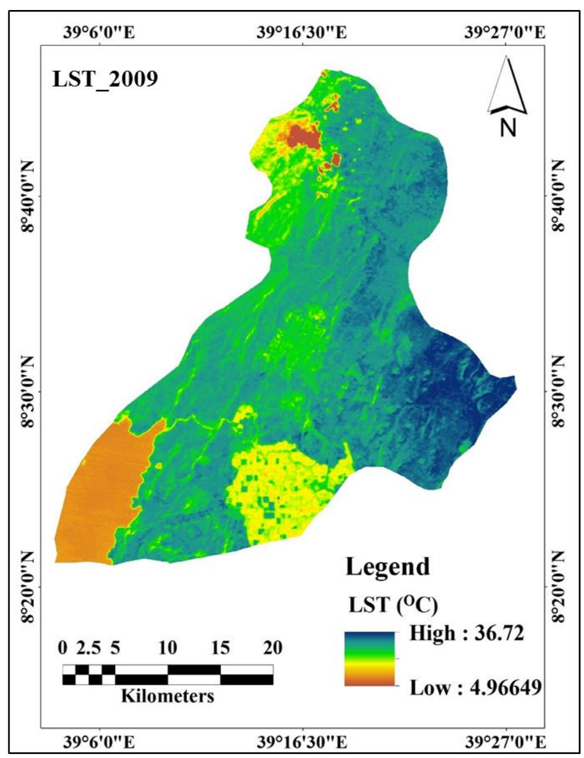


Figure 4. 7: NDVI maps of the study area (1999, 2009 and 2017).

4.3. Spatial Variation of Land Surface Temperature (LST).

The spatial distribution of LST of the study area was extracted and quantified using Landsat 5 TM of 1999, ETM+ of 2009 and OLI/TIRS of 2017 data employed thermal bands following the methodology procedures presented in chapter three. The analysis from such images indicated that the LST value of the study period ranged from 14°C to 37.15°C. . The highest and lowest values of LST increases from time to time. The highest LST is 35.23°C, 36.72°C and 37.15°C respectively in 1999, 2009 and 2017.All indicates the increasing trend. Similarly, the lowest LST in the study area was 14.49°C, 14.96 °C and 16.3°C respectively within same period. As it was observed from the processed thermal images, that the East, Northeast and South-East parts of the study area exhibited relatively high temperature because it has barren and bare land covers that emitted more heat. This is mainly due to altitude, slope and LULC types. On the other hand, Northwest part and Wonji 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 is increasing gradually as its distribution is reflecting the increasing trend in Figure 4. 8.





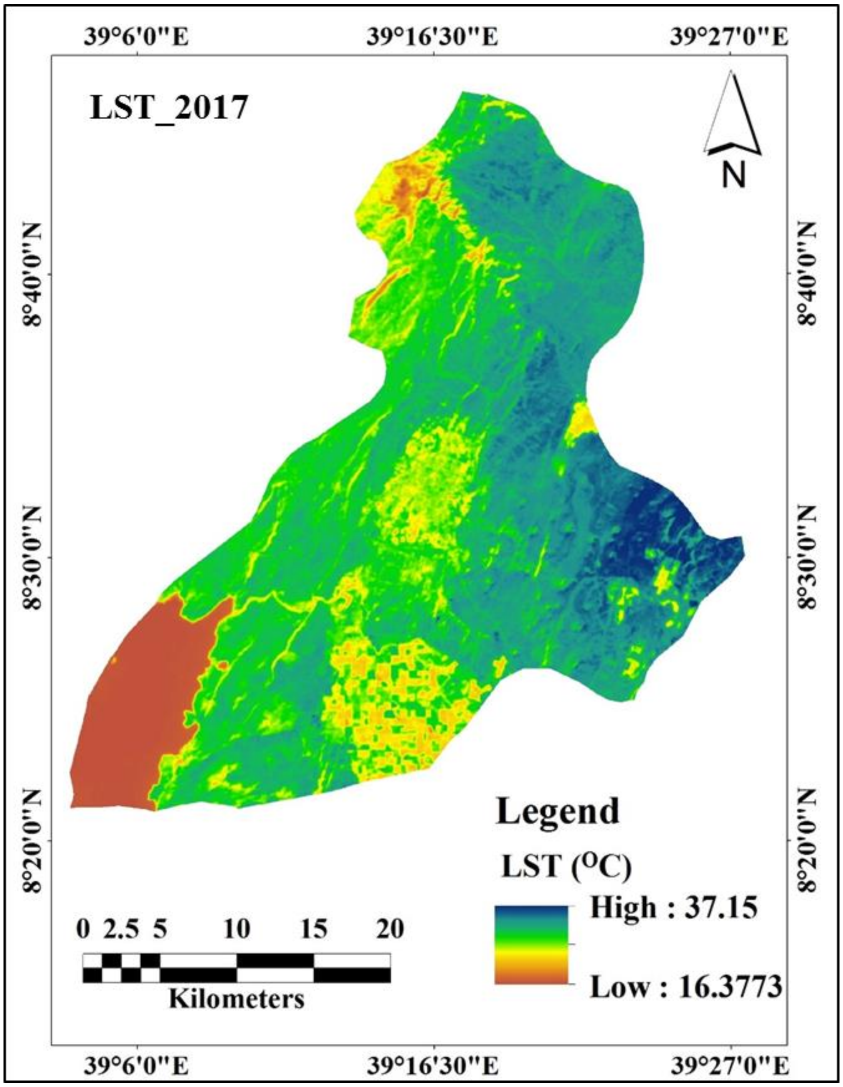


Figure 4. 8: land surface temperature (LST) maps of the study area (1999, 2009 and 2017).

4.4. Relationship between Land use land cover and Normalized Difference Vegetation Index.

Normalized difference vegetation index maps extracted from Near Infrared (NIR) and Red-bands of the study periods indicated that different LULC has different NDVI values (Figure 4. 9) which were identified by pixel classifier and were used to consider as pervious and impervious surface. As NDVI is related with the vegetation condition, the value varies from area to area based on vegetation intensity of the sites. Agricultural land, Rangeland and forest have the highest NDVI value than other classes. The mean value of impervious (urban/built-up) features was 29.02°C and 31.05°C in 1999 and 2017, respectively. At the same time these values were measured 22.58°C and 23.92°C in pervious surface. The changes in mean values are almost similar but noted more in impervious surface than pervious surface which have been calculated through NDVI classified value based on the literature suggested.

Year	Wet. L	Water. B	Barren	Urb.A	Rang.L	Forest	Agri.L
NDVI_1999	-0.27	-0.312	0.223	0.201	0.697	0.659	0.71
NDVI_2009	-0.325	-0.299	0.169	0.215	0.316	0.528	0.692
NDVI_2017	-0.187	-0.226	0.165	0.114	0.37	0.372	0.461

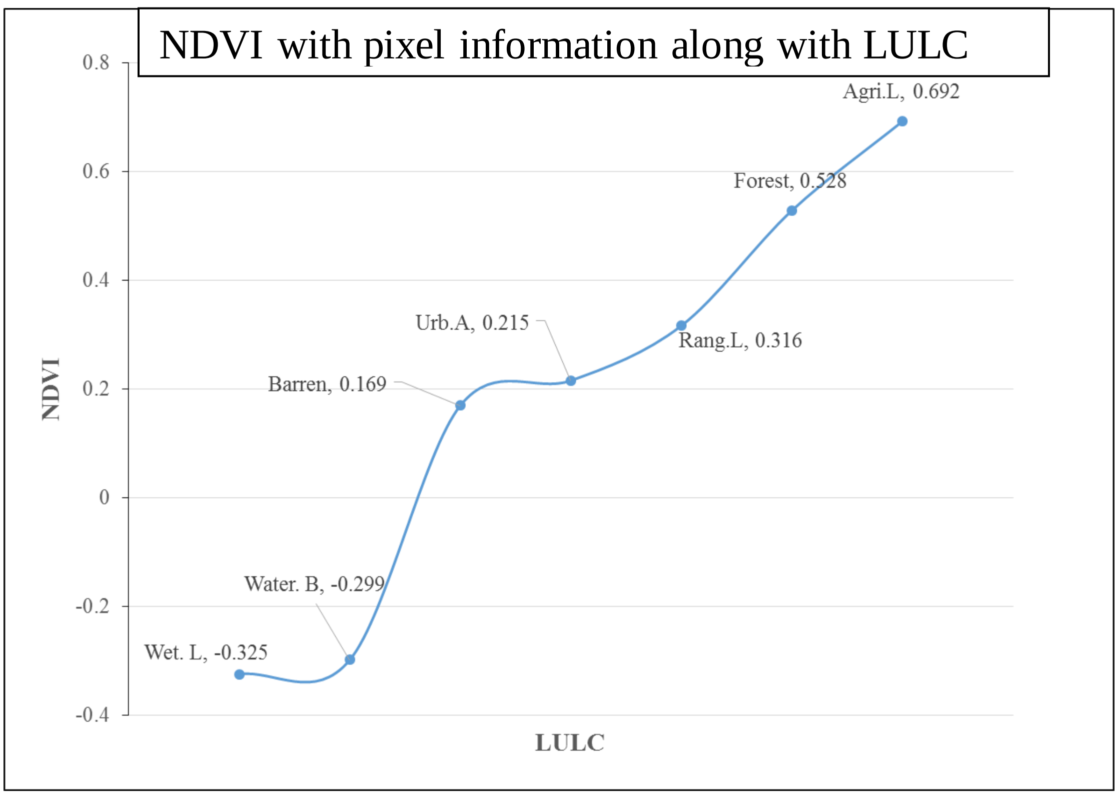


Figure 4. 9: Relationship between LULC vs. NDVI.

4.4.1. 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 surface temperature have changed during the study period. Land use land cover categories with pixel value of minimum temperature was water body, Wetland and vegetative area, respectively. Water body and Vegetated area played crucial role in regulating 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.

From 1999 to 2017, the mean LST of Adama Woreda has increased by 2.25 °C. Table 4. 4 indicates that all major LULC categories have recorded increase in the LST over the study period. The highest mean of LST was recorded in bare land and urban area. Whereas, the lowest mean LST was recorded in water body, wetland and vegetative area. Comparisons of mean LST with LULC classes for the study period are indicated in Figure 4. 10.

Table 4. 4: Mean LST status in 1999, 2009, 2017 and changes in temperature during 1999−2017 in the study area.

LULC Classes	1999 Mean	2009 Mean	2017 Mean	1999-2009 Change in (°c)	2009-2017 Change in (°c)	1999-2017 Change in (°c)
Agricultural land	25.67	26.48	27.92	0.81	1.44	2.25
Bare land	32.95	33.31	34.38	0.36	1.07	1.43
Forest	21.33	22.79	23.11	1.46	0.32	1.78
Range Land	28.97	29.49	30.21	0.52	0.72	1.24
Urban area	29.02	30.47	31.05	1.45	0.58	2.03
Water bodies	17.58	18.47	17.41	0.89	-1.06	-0.17
Wetland	20.7	21	22.9	0.3	1.9	2.2

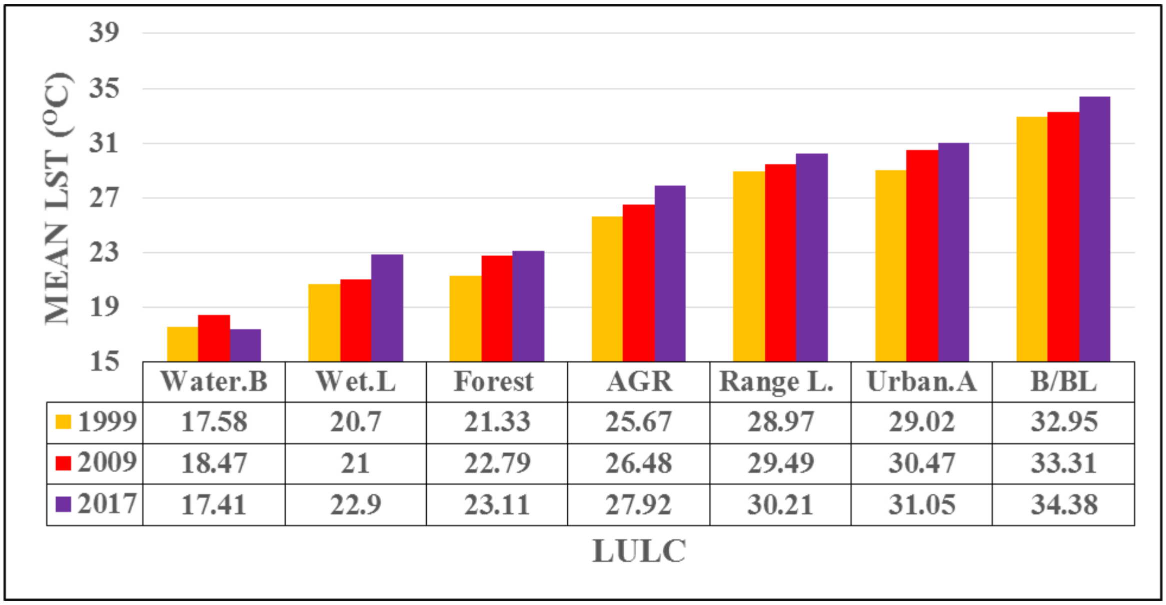


Figure 4. 10: Comparisons of mean LST in different LULC.

4.5. Impact of Land Use Land Cover Change on Land Surface Temperature and its relationship.

Land-use land-cover dynamics has an impact on land surface temperature. The changes LULC resulted in alteration of land surface temperature, particularly in the urban, agricultural land and bare land. The reason behind agricultural land of high LST was that the image used during harvesting time and dry weather condition for the analysis was taken. For each of LULC classes LST value varies from place to place because of vegetation and climate condition. The conversions of agricultural land and other types of LU into urban area also contributed to the increase of LST. Expansion of urban area from the year 1999 to 2017 has increased from 1.64% to 5.13%, especially the northern and southern parts of Adama Town and along the main gate of town (Addis Ababa, Wonji Shewa, Asella and Metehara). Therefore there is strong relationship of LULC changes on LST as per the spatial variation. Almost all LULC classes have been recorded increase in temperature from 1°c to 3 °c (Table 4. 5).

Table 4. 5: Statistical description of LST in 1999, 2009 and 2017 over different LULC Classes.

LULC Classes	1999				2009				2017			
	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std
Agricultural land	16.77	33.64	27.44	3.31	10.47	35.45	25.48	2.19	19.46	40.32	27.92	3.09
Bare land	15.86	43.94	32.95	2.84	4.96	43.2	34.31	2.88	18.93	43.93	33.38	2.85
Forest	14.49	34.83	21.33	3.13	5.47	36.25	22.79	5.58	17.01	36.4	23.11	5.32
Range Land	15.41	40.59	28.97	3.29	4.96	40.92	30.49	4.47	17.37	42.53	30.21	3.76
Urban area	21.21	36	29.02	1.37	18.47	37.04	30.47	1.7	19.88	40.17	31.05	2.4
Water. B	14.95	36	17.58	1.28	17.1	32.64	18.47	1.46	16.37	31.53	17.41	1.65
Wetland	19.45	36.77	29.84	2.43	17.56	38.6	29	3.9	17.14	36.86	28.9	2.89

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

4.6. Comparisons of LST distribution during 1999, 2009 and 2017

The results of the study indicated that throughout all the study period the LST value increased drastically. Land surface temperatures were classified into seven groups ranging from 14ºC-37.15ºC.The LST distribution statuses during study period are given in Table 4. 6.

Table 4. 6: Trends of land surface temperature distribution during the study period in Adama Woreda during 1999–2017.

LST(^{O}C)	**Area coverage during study period(km^2)**		
	1999	**2009**	**2017**
<23	84.53	58.83	68.23
23-26	83.62	58.17	63.40
26-29	85.79	94.45	86.46
29-32	98.26	104.55	93.36
32-34	152.91	158.58	144.04
34-35	192.88	201.98	213.03
>35	301.37	322.80	330.84
Total	**999.35**	**999.35**	**999.35**

The trend of increase in LST shows that in Adama Woreda LST was increasing from year to year. A comparison between LST distributions of the selected years are given in Figure 4. 11.

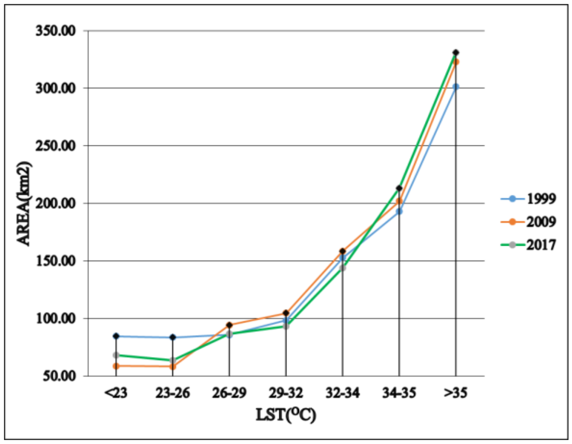


Figure 4. 11: Comparisons between LST distributions of the years 1999, 2009 and 2017 in Adama Woreda.

CHAPTER FIVE

5. Discussion

5.1. Land Use Land Cover Status of Adama Woreda

The land use land cover change in Adama Woreda is an indication of population dynamics, mainly resulted from the need for urban land for settlement and agricultural land for food production. When the land cover characteristics of this area is modified because of these changes, it is not leave the environment as it is but forces to be changed. Houghton (1994) revealed that human population growth, economic development, technology and environmental changes are major factor responsible for LULC variability. According to FAO (1999), LULC 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 which are exacerbated by anthropogenic factors.

The present study revealed that during the study period there were drastic changes in LULC. In 1999, the urban area was 16.38 km^2 (1.64%) and then it reached 51.31 km^2 (5.13%) in 2017. It is one of the evidences for the increasing needs of urban land. The extent of agricultural land also increased from 83.94km^2 (8.40%) in 1999 to 90.14 km^2 (9.02%) in 2017 and bare land increased from 656.54 km^2 (65.70%) in 1999 to 671.78 km^2 (67.23%) in 2017 and also wet land increased from 5.64 km^2 (0.56%) and then it reached 23.01 km^2 (2.3%). Range land, water body and forest decreased from 150.21 km^2 (15.03%) in 1999 to 80.01 km^2 (8.01%) in 2017, 81.58 km^2 (8.16%) in 1999 to 81.44 km^2 (8.15%) in 2017 and 4.99 km^2 (0.50%) in 1999 to 1.6 km^2 (0.16%) in 2017 respectively. In general, the classified satellite image indicates that there is a change in LULC. The need for urban land is increasing in alarming rate, especially in Adama Town, which is the capital with high economic activities undertaken. Because the town is the economic corridor and center for the central Ethiopia and connects main routes. The town is crossed by major roads which connects other parts with the capital of the country. The huge investments, which need huge human capital, are established in and around Adama. As a result many people live in the town to get a job, which increases the need for urban land in the area. The previous places which were covered by bushes and to some extent by farmlands are now getting converted to settlements.

5.2. Land Surface Temperature of Adama Woreda

A thermal band of Landsat image was important in quantifying the LST of the area. In the present study agricultural land, urban area and bare land have high LST. The main reason behind less NDVI and high LST values in the area of agricultural land LULC 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, agricultural land, bare land and urban areas 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, and urban area and agricultural land classes. However, in the case of agricultural and range land, the values were relatively high. To evaluate the thermal status of land surface by satellite, it is important to find the relation between LULC 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 LULC categories except in the case of water body. Water body LULC class has low NDVI and LST value. Vegetation condition (NDVI value) and types of LULC have impacts on LST value. However, it does not mean that the type of LULC is the only factor for the increase of LST. There are a number of contributing factors for increasing or decreasing the LST value.

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 LULC, 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 LULC 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 LULC changes in the study area, with the expansion of urban area, agricultural land and bare land, the range land and forest land have highly declined. This is clearly observed, especially at Adama Town area. In this area, due to the expansion of urban area, small-scale farmers moved and start too settled in bare land and range land. Thus, the study area is highly degraded and exposed to natural disasters such as soil erosion. However, sometimes LULC has a positive impact on environment. For instance, the conversion of open space/bare land/ to agriculture LULC type. This might help to control increasing LST.

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 seven major LULC classes and for each class LST value varies. Water body, agricultural and range land have relatively low LST than urban area, Agricultural land and bare land LULC class. Spatial and temporal distribution of LST during 1999, 2009 and 2017 revealed that during the study period there was drastic changes took place in the area. In 1999, the distribution of LST was 14.49 ºC and 35.23ºC, minimum and maximum, respectively, where as in 2009 and 2017, the minimum and maximum LST ranges were 14.97ºC–36.72ºC and 16.38ºC–37.15ºC, respectively.

CHAPTER SIX

6. Conclusions and Recommendations

6.1. Conclusions

LANDSAT Satellite data with different sensors are useful for applications such as LULC change detection, pervious, impervious and surface temperature changes and their relationships. Landsat imageries have great potential to examine the LULC dynamics and vegetative and non-vegetative changes relation to analyze the spatio-temporal distribution of LST. The present study has used Landsat TM 5, ETM+7 and Landsat OLI/TIRS images to evaluate and analyze the impact of LULC changes on LST. Land surface temperature and LULC derived from such data provides important information to monitor human activities and environmental changes. It reveals that Landsat images are very useful in quantifying and mapping LULC change, NDVI and LST in Adama Woreda. The LULC pattern of the study area has attributed to socio-economic and natural factors and their exploitation in time and space. Water body, wetland and forest classes have recorded lowest LST, whereas urban, bare land and range land class have highest LST. The mean LST value of urban areas were measured 29.02°C, 30.47 °C, and 30.21 °C in 1999, 2009 and 2017 respectively that shows the increasing trends in temperature. In the present study, the mean NDVI values were found 0.201, 0.215 and 0.114 in 1999, 2009 and 2017 respectively. This changes of indices shows that the vegetation health and growth is poor from 1999 to 2017 that ultimately contributes the spatial changes in land cover from pervious to impervious surface. These pattern has shown direct impact on the LST values which has been discussed with their statistical information.

In 1999, the distribution of minimum and maximum LST was 14.49 ºC and 35.23ºC respectively, whereas in 2009 and 2017 these variation with its spatial locations were measured 14.97ºC–36.72ºC and 16.38ºC–37.15ºC, respectively. The findings of this study showed that LST of Adama Woreda has increased during period of 1999, 2009 and 2017. The land surface temperature of the Woreda indicated a high variation in LST between different LULC types because of minimum and maximum LST has increased. The derived NDVI values from satellite data also somehow a good indicator of LST status of the study area. The results of study found that the LULC change, vegetation growth and changes in pervious and impervious surface has direct relationship on temperature and vice-versa increasing temperature may alters the natural vegetation. Therefore such studies are really important to monitor the changes in micro climate and urbanization that leads to the climate change of any region which ultimately affects the human life.

6.2. Recommendations

The focus of this study was to analyze the impact of LULC changes on LST in Adama Woreda based on Landsat imagery of 1999, 2009 and 2017. The study showed that the conversion of LULC types to another type of LULC types such as from vegetation area to Agricultural land, Agricultural land to urban and the value of LST was different for each LULC 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 LULC.
- Conservation activities have to be taken on both rural and urban green areas of the study area and it is recommended to plant trees and delineate green area, especially at high urban and bare land areas Trees and vegetation lower surface and air temperatures by providing shade and through evapo-transpiration. Shaded surfaces may be 20–45°F cooler than the peak temperatures of unshaded materials. Evapotranspiration, can help reduce peak summer temperatures by 2–9°F.
- Land managers and environmental experts should control LULC 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 LULC changes on environmental issues.

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APPENDICES

Appendix 1: GPS point with their Remark and coordinate.

sample pt.	Easting	Northing	Description	Remark
1	532408	944487	Forest	Ok
2	532642	944540	Forest	Ok
3	532817	944308	Forest	Not
4	532888	944297	Range land	Ok
5	533009	944472	Range land	Ok
6	533124	944766	Range land	Ok
7	533363	944775	Barren land	Ok
8	533497	944861	Barren land	Ok
9	533895	944840	Barren land	Ok
10	534595	945610	Barren land	Ok
11	534184	945107	Barren land	Ok
12	534078	944906	Urban area	Ok
13	534649	945752	Urban area	Not
14	532349	943484	Urban area	Ok
15	529434	943967	Urban area	Ok
16	531329	939296	Urban area	Not
17	531755	938360	Urban area	Ok
18	538680	943798	Urban area	Ok
19	531479	938962	Barren land	Ok
20	531417	938728	Barren land	Not
21	531320	938633	Barren land	Ok
22	531404	938373	Barren land	Ok
23	531387	938313	Range land	Not
24	525839	942397	Range land	Ok
25	532202	949174	Barren land	Ok

26	532361	949505	Barren land	Ok
27	532778	949968	Range land	Not
28	532808	950331	Wet land	Ok
29	529098	944660	Urban area	Ok
30	530477	945276	Urban area	Ok
31	531787	946037	Range land	Ok
32	530468	947008	Urban area	Ok
33	533337	959230	Range Land	Ok
34	533707	959071	Range Land	Ok
35	532807	955684	Range Land	Ok
36	512159	935745	Water body	Ok
37	514302	936063	Water body	Not
38	516684	936698	Water body	Ok
39	516049	935190	Water body	Ok
40	511127	934555	Water body	Ok
41	513270	933681	Water body	Ok
42	514779	932808	Water body	Ok
43	507476	923918	Water body	Ok
44	512794	926379	Water body	Ok
45	51163	930983	Water body	Not
46	539898	948170	Agriculture	Ok
47	539845	949387	Agriculture	Ok
48	540374	948382	Agriculture	Ok
49	544925	938275	Agriculture	Ok
50	546195	937375	Agriculture	Not
51	545878	936423	Agriculture	Ok
52	533654	932930	Agriculture	Not
53	529632	931713	Agriculture	Ok
54	528786	927850	Agriculture	Ok

55	525346	928591	Agriculture	Ok
56	517356	935893	Wet land	Ok
57	521906	936507	Wet land	Ok
58	514293	926606	Wet land	Ok
59	514095	926606	Wet land	Ok
60	516542	935072	Wet land	Ok
61	522092	936562	Wet land	Ok
62	519169	936448	Wet land	Ok
63	528045	962669	Forest	Ok
64	528733	962034	Forest	Ok
65	528415	963103	Forest	Ok
66	527992	965209	Forest	Ok
67	530791	967008	Forest	Not
68	531537	961978	Forest	Ok
69	529791	961346	Forest	Not
70	528583	961634	Forest	Ok

Appendix 2: Description of land use land cover classes and sources.

No	Land use land cover classes	Description of classes	Source
1	Agricultural Land	Lands that are covered by the crop at the time of imagery i.*e*. study has not included the pasture (agricultural fallow land).	Geological Survey Professional Paper 964.
2	Water body	The Streams and Canals category includes rivers, creeks, canals, and other linear water bodies.	Geological Survey Professional Paper 964
3	Wetland	Wetlands are those areas where the water table is at, near, or above the land surface for a significant part of most years.	Geological Survey Professional Paper 964
4	Rangeland	Rangeland historically has been defined as land where the potential natural vegetation is predominantly grasses, grass like plants, forbs, or shrubs and where natural herbivore was an important influence in its pre-civilization state.	Geological Survey Professional Paper 964
5	Urban Area	Urban or Built-up Land is comprised of areas of intensive use with much of the land covered by structures. Example: transportation, industrial, residential, commercial	Geological Survey Professional Paper 964

		and service.	
6	Bare/barren land	In general, it is an area of thin soil, sand, or rocks. Vegetation, if present, is more widely spaced and scrubby than that in the Shrub and Brush category of Rangeland.	Geological Survey Professional Paper 964
7	Forest	Forest Land generally can be identified rather easily on high-altitude imagery, although the boundary between it and other categories of land may be difficult to delineate precisely.	Geological Survey Professional Paper 964

Appendix 3: Error Matrix table and over all Accuracy Assessment, 1999.

Class name	Water	Agriculture	Forest	Rangeland	Urban	Wetland	Bare land	Row Total
Water	26039	5	0	0	0	10	0	26054
Agriculture	38	39177	0	236	310	369	0	40130
Forest	0	32	358	243	0	13	0	646
Rangeland	0	3320	10	5189	563	307	29	9418
Urban	46	1476	0	140	10722	839	35	13258
Wetland	1	3786	0	98	3065	18093	268	25311
Bareland	0	302	0	25	923	1650	4497	7397
Column Total	26124	48098	368	5931	15583	21281	4829	122214

Over all Accuracy Assessment = Diagonals/Total area*100
= 104075/122214*100
= **85.158**%

Appendix 4: Error Matrix table and overall Accuracy Assessment, 2009.

Class name	Water	Agriculture	Range land	Forest area	Urban	Bare land	Wetland	Row Total
Water	23100	117	320	390	20	110	690	24747
Agriculture	15	3500	90	35	28	10	15	3693
Range land	11	305	50	35	15	52	15	483
Forest area	9	15	190	450	0	0	7	671
Urban	15	7	0	2	662	20	0	706
Bare land	10	15	50	10	130	2000	8	2223
Wetland	34	53	0	19	2	0	151	259
Column Total	23194	4012	700	941	857	2192	886	32782

Over all Accuracy Assessment =Diagonals/Total area*100

=29913/32782*100.

= **91.248**%

Appendix 5: Error Matrix table and overall accuracy assessment, 2017.

Class name	Water	Agriculture	Urban	Wet land	Bare land	Range land	Forest	Row Total
Water	18000	844	118	100	67	130	132	19391
Agriculture	0	1667	80	140	131	3	1	2022
Urban	0	7	445	4	140	41	20	657
Wet land	50	3	2	153	5	4	21	238
Bare land	0	22	55	0	274	0	0	351
Range land	0	32	4	0	0	131	55	222
Forest	6	13	0	50	5	4	242	320
Column Total	18056	2588	704	447	622	313	471	23201

Over all Accuracy Assessment =Diagonals/Total area*100

=20912/23201*100.

= **90.134**%

Appendix 6: GPS point data map.