ADDIS ABABA UNIVERSITY

COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR ENVIRONMENT AND DEVELOPMENT

Land use /Land cover change and its implications on Land Surface Temperature change in Addis Ababa and its surrounding area, Ethiopia

By Hewan G/Michael

Advisor: Dr. Ermias Teferi

A thesis submitted to the Center for Environment and Development Studies in Partial Fulfillment of the Degree of Master of Arts in Development Studies (Environment and Sustainable Development)

Addis Abeba University

February 2021

Addis Abeba, Ethiopia

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Declaration

This is to certify that thesis prepared by Hewan G/Michael, entitled Land use /Land cover change and its implications on Land Surface Temperature change in Addis Ababa and its surrounding area, Ethiopia. I declare that this thesis is an original report of my research, which has been written by me, and has not been submitted for any previous degree. The experimental work is almost entirely my work; the collaborative contributions have been indicated clearly and acknowledged. Due references have been provided on all supporting literature and resources. I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification.

Name Hewan G/Michael

Signature______________

Date ______________

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

Advisor: Dr. Ermias Teferi

Signature ________________

Date ________________

STATEMENT OF APPROVAL

Addis Ababa University

School of Graduate Studies

This is to certify that the project prepared by Hewan G/Michael, entitled Land use /Land cover change and its implications on Land Surface Temperature change in Addis Ababa and its surrounding area, Ethiopia. submitted in partial fulfillment of the requirements for the degree of Master of Arts in Environment and Sustainable Development complies with the regulations of the university and meets the accepted standards with respect to the originality and quality.

Signed by

Thesis Advisor	Signature	Date
Internal Examiner	Signature	Date
External Examiner	Signature	Date

Chair of Department or Graduate Program Coordinator

Acknowledgment

First, I would like to thank Almighty God for giving me the strength to accomplish this work. I would like to acknowledge those people who had a great contribution to this MA thesis. I cannot possibly cite them all but the most impactful contributor are here as follows, primarily my deepest appreciation and Gratitude goes to my Adviser Dr. Ermias Teferi, for his most valuable advice and guidance throughout this research. In addition to my advisor, Ato Molla Maru had helped me in motivating and was forwarding constructive comments that enhanced the quality of thesis. Second, I would like to acknowledge my family for their great moral and financial support. I would not accomplish and reach here without them.

Third, it is such a great pleasure for me to pass my deepest gratitude to Belete Tafese, Getachew Haile, Mehamed Ahmed and Tewodros Kassahun for their constructive comments and advise. I wish to express my genuine thanks to Geospatial Information Institute, Central Statistical Agency and Ethiopian Meteorology Agency for providing necessary data. Lastly, I would like to thank my closest and dearest friends for their great effort made.

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Acronyms and Abbreviations

CSA	Central Statistical Agency
DEM	Digital Elevation Model
EEFRI	Ethiopian Environment and Forest Research Institute
EFCCC	Environment Forest and Climate change Commission
ERDAS	Earth Resources Data Analysis System
FAO	Food and Agricultural Organization
GIS	Geographic Information System
LST	Land Surface Temperature
LU/LC	Land use/Land Cover
LU/LCC	Land use/Land Cover Change
NDVI	Normalized Difference Vegetation Index
RS	Remote Sensing
TIRS	Thermal Infrared Sensor
TOA	Top of Atmosphere
UHI	Urban Heat Island
UNEP	United Nations Environmental Program
USGS	United States Geological Survey

Abstract

Land surface temperature is increasing as compared from year to year, mainly due to Land Use/ Land Cover change. The research aimed to assess the Spatio-temporal change of Land surface temperature from 1990-2020 in Addis Abeba and the surrounding area. Rapid urbanization and unmanaged land-use lead to fast change in LU/LC classes and cause an increase in Land surface temperature. Land surface temperature is a key parameter as a showing of climate change and input for making planning and decision-making. Knowing the impact of change in the land surface temperature of an area characterized by different land use/ land cover, climate, topography, and vegetation serves to formulate land management and land-use strategies. Land Use/Land Cover, normalized difference vegetation index, and Land Surface temperature were extracted from Landsat TM (1990), Landsat ETM+ 2000, Landsat TIRS 2010, and Landsat 8 TIRS 2020 using geospatial tools. Land Surface temperature was calculated using the Split window algorithm technique. The supervised classification algorithm was used in Land use /Land cover change detection using Erdas imagine and ArcGIS software packages. The result of LU/LC of 1990 and 2000 showed that the dominant classes were farmland and shrub whereas in 2010 and 2020 years the largest portion was dominated by farmland, built up and grassland of the total area. The calculated NDVI result of 1990, 2000, 2010, and 2020 showed that the Entoto, Menagesha, and Yerer Mountain of the study area has a higher value and these are Central parts of the study area around Addis Abeba town and water body areas have relatively low NDVI values. The study indicated that the highest LST was recorded in 2020. The analysis from such images indicated that the LST value of the study period ranged from the lowest LST value in 1990 36.8 °C to the highest LST value 38.3°C in 2020. The study implies the LST of different land classes has increased from 1990 - 2020 as a result of the decrease in forest cover and vegetation cover in the study area. In the present study, the zonal statics of LU/LC and LST result shows Land Surface Temperature has an inverse relation with vegetation cover. Understanding the influence of LST on the environment possibly will serve to land management and planning strategies focused on land Surface temperature mitigation and the adaptation of study area to the challenges of climate change.

Keywords: Landsat, LU/LC, NDVI, LST, GIS, RS

CHAPTER ONE

1. INTRODUCTION

1.1.Background of the study

Now a day's Global warming is highly increasing because of massive land-use and land-cover (LU/LC) changes. The change in Land use /Land cover leads to environmental change, rainy season fluctuation, increase sea surface temperature (SST), and land surface temperature (LST). The increase needs of land for settlement and agriculture leads to significant land-use and land-cover change. The land cannot be changed when the number of populations increases because it is scarce (limited) natural resource. Land-use should be tie with land capacity and the environment (FAO/UNEP, 1999). The main driving force for land use changes is the human activity and it changes over time.

The human population is increasing and it causes the transformation of natural ecosystems into human landscapes. Human settlements, large urban and industrial areas significantly modify the environment. land surface temperature affected by changing in land use from permeable and moist to dry one, amount of evaporation, surface infiltration, runoff rate, drainage system, etc. (Guo *et al.,* 2012). The temporal and spatial land-use changes should be therefore critical matter and needs detailed information.

The land surface temperature can be defined as the temperature felt when the land surface is touched with the hands (www.ltrs.uri.edu/research/LST). According to Rajeshwari and Mani, (2014) the temperature emitted from the surface which measured in Kelvin is land surface temperature (LST). It was greatly affected by increasing greenhouse gases in the atmosphere. Land surface temperature and emissivity are key variables for explaining the biophysical processes which govern the balances of water and energy at the land surface (Schmugg *et al.*, 1998). The changes in land surface temperature were related to many factors including changes in land use, land surface parameters, seasonal variation, climatic condition, and economic development (Jing and Guangjin, 2010).

The physical features of the land surface and human socioeconomic activities influences the urban thermal. On the other hand, the way of land use and agricultural activities affects rural area. The thermal environment affects the urban ecosystem and considered as the most significant indicator for demonstrating the urban environment and vegetation (Yueet *et al.,* 2007). The combined approach of geographic information system (GIS) and remote sensing (RS) is important and plays a crucial role to study the impact of LU/LC dynamics on land surface temperature as well as in the analysis of Land use /Land cover change and NDVI.

According to Gottsche *et al.,* (2002) temperatures can be monitored and estimated through space-borne remote sensing sensors, which account for the top of the atmosphere (TOA) radiances in the thermal infrared (TIR) region radiance is the net radiance of the emitted radiance from the earth's surface upwelling radiance from the atmosphere, and down welling radiance from the sky. The brightness temperatures (also known as blackbody temperatures), can also be derived from the TOA radiance.

Increase land surface temperature leads to a decrease in crop production, health problem, and environmental impact. Addis Abeba and its Surrounding area have stress in rapid urbanization and population growth, which leads to unplanned land use. Addis Abeba is a center for economic, political, social educational activities. Besides, showing LST change with LU/LC change of the study area as such creates a better understanding of environmental change and its impact on sustainable development. Therefore, it is important to study the temporal change of land surface temperature and LU/LC change pattern of the study area. In the study area, LU/LC changes are at an alarming rate causes environmental change, and affect sustainable development. This study creates awareness about the LU/LCC influence on LST change and its impact on the environment as a general.

1.2. Statement of the problem

According to Naissan and Lily, (2016) global climate seems to be changing at shocking rate. There is warm temperature in both urban and rural areas and it is growing from time to time. There is a complex structure in the atmosphere of the earth, with several interacting constantly changing components such as physical, chemical, biological, and human (Emilio, 2008). One of the main factors that responsible for the increase of land surface temperature is Land use /Land cover change. Currently global warming and the environmental problem is a trouble for both developed and developing countries. This environmental problem is due to the urban expansion the rising need for land for agricultural activities. Environmental warming occurs due to unplanned land use for settlement, overgrazing, deforestation and other activities. Land surface temperatures are rising in Addis Ababa. (Hiwot, 2012) Therefore, a wide variety of applications that include information about land surface temperature and its effect on the climate as an input for planning and decision making are what signifies the importance of this research.

According to Aires, (2001); Sun (2003) In land surface practices, land surface temperature is a basic factor, serving not only as an indicator of climate change, but also as an indication of its regulation of upward terrestrial heat and, consequently, as a control of the sensitive and concealed temperature change exchange with the atmosphere on the surface.

Increasing land surface temperature leads to the environmental problem such as climate change and seasonal fluctuation. Environmental change leads to the displacement of people and a negative impact on the economy. Unless land for Settlements and farmland are properly managed, it can affect and harm the environment in general. Increment of LST accelerates the spread of infectious diseases and results in a decrease of soil moisture that makes the air temperature warmer consequently affect crop productivity. An increase in Land surface temperature raises underground and groundwater evaporation that water and food quantity and quality will decrease.

Some researchers have conducted a spatial and temporal change of LST and LU/LC in a different part of Ethiopia. However, those researches asses about LU/LC and LST change of a specific town. city alike Addis Abeba in one way or another affect economically, towns in nearby what makes this research different from other study is that it assesses LST and LU/LC change influence in Addis Abeba and its satellite town and this helps to know LU/LC change influence on LST change and to clearly understand its impact on the environment and development as well.

The basic argument why this research is carried out in the Addis Ababa and its surrounding area is characterized by rapid urbanization and rapid change in Land use /Land cover, various vegetation, climate, and topographic trends, and overall distinct Land use /Land cover. Addis Abeba is the most inter-connected city mainly with Sululta, Sendafa, Sebeta, and Dukem. In Ethiopia, different researches have been conducted about LST. Those researchers focus on a certain town only, does not include the specified town and its surrounding area. For the reason that those researches made a study on a specific town it’s hard to understand LU/LC implication on

LST clearly. Therefore, the present study focuses on this area to show LST and LU/LC change impact on environmental change. The study area contains different LU/LC types such as Farm land, Forest, Bare land, Grass land, waterbody, Wet land, Shrub land and Built-up elevation, diverse vegetation, environment therefore the study can provide information about the status of LU/LC change influence on LST change and contribute for environmental management.

1.3. Objectives of the study

1.3.1. General Objective

The general objective of this study is to analyze Land Use/ Land Cover change and its implications on Land Surface Temperature change from 1990-2020 in Addis Abeba and its Surrounding area.

1.3.2. Specific Objectives

The specific objectives of this thesis were

To detect changes in LU/LC for Addis Abeba city and its Surrounding area

To analyze the relationship between LST, NDVI and LU/LC over time.

To analyze the impact of Spatio-temporal change of LU/LC on land surface temperature

1.4. Research questions association

❖ What are the major LU/LC classes in the study area?

❖ What is the spatial and temporal change of Land surface temperature in the study area?

❖ What is the relation between land surface temperature and NDVI?

❖ What is the effect of LU/LC cover change on land surface temperature in the study area?

1.5. Scope of the study

The study focuses on evaluating Land use /Land cover change and its consequences on the change of Land Surface Temperature in Addis Ababa and its Surrounding area, Ethiopia. It includes spatial showing tools to show the pattern of LST and LU/LC. The study presents the relation between LST and LU/LC and its impact on the environment and sustainable development in general. Specifically, the study area covers up to a 20 km radius of Addis Abeba.

1.6. Significance of the Study

Land surface temperature is an important parameter required in the application of climatology, hydrology, and metrology. Land surface temperature data helps different organizations like defense, environmental protection, and agriculture and research institute. Land surface temperature helps to monitor vegetation and crop health condition, natural disaster, and the greenhouse effect. Land use /Land cover change affects Land surface temperature therefore, the relation between them must be studied further. (Aries *et al.*, 2001)

To understand the pattern of LU/LC change, the relationship of NDVI with land surface temperature, and the effect of LU/LC dynamics on LST change, it should be supported by research. Towns like Addis Abeba have pressure in need of land for settlement, industry, trade, recreation, and socio-economic activities as a result those pressures influence the surrounding towns resulting in rapid LU/LC change; therefore, the researcher found studying LU/LC implication on LST change of Addis Abeba including its satellite town is crucial to identify causes of environmental change. (Hiwot, 2012)

This study assessed the LU/LC change impact on the variation of LST in Addis Abeba and its Surrounding area. LST is a key parameter as an indicator of climate change. Besides, the study analyzes the relationship between LST and LU/LC over time and its impact on the environment and human health. Therefore, it is important to study both LU/LC and LST to overcome this problem; this study would contribute to decision-makers as information and identifying different factors for environmental change.

To mitigate Environmental changes and temporal change of land surface temperature impact on Addis Abeba and its satellite town, the study can provide information about the trend of LU/LC change and LST changes on the study area and driving factors also mentioned for better understanding of environmental changes which contributes to proper land use planning.

The purpose of this study is to develop ideas about LU/LC change implication on the of land surface temperature and to contribute to policymaking as an input. To contribute to the different organizations about the cause and influence of LU/LC change and its effect on Land surface temperature change and climate change as a general. Also, this study can contribute to further study of the temporal change of land surface temperature.

1.7. Limitation of the study

Despite the researcher, efforts to collect the relevant information as much as possible there were some limitations. As the Landsat is an optical sensor, accessing LST data taken in all weather is very difficult. Therefore, the Landsat LST data is taken at a much specified time considering the absence of cloud cover. This may result in a lack of accessing actual high LST value.

Concerning the scope (coverage) of the study, particular emphasis was given to Addis Ababa and its satellite town. Inadequate data of soil temperature of meteorological data was a limitation to the study for which would use to validate the Landsat data. The researcher tried to validate the LST with the sentinel image but the same date image of a sentinel was not available as that of the Landsat acquired to date. Modis image resolution was also another limitation for the validation of Landsat LST value.

1.8. Organization of the thesis

The thesis is structured as follows: Chapter 1 commences with an abstract view of the study and continues with a discussion of the significant parts of the study process such as the statement of the problem, objective, and methodology of the study. Chapter 2 presents a discussion and review of some related works of literature. Chapter 3 discusses a description of the study area, methods, and data used in the study. Chapter 4 explains the result of some general data issues as well as a description and analysis of the data that has been used in this study. In this section, it describes the major driving factors for the dynamics of LST of the area pattern of LU/LC of the study area and the correlation between LU/LC and LST. Chapter 5 presents the discussion and Chapter 6 deals with the conclusion and recommendation it deals with the implications of findings and possible improvements that could be made to the analysis.

CHAPTER TWO

2. LITERATURE REVIEW

2.1.Land use / land cover change

Changes is Land use and land cover (LU/LC) induced by human or natural processes drive bio-geo chemistry of the Earth influencing the climate at global as well as regional scales. With the decrease in vegetation and water bodies as a result of changes in nature due to human activities, dramatic changes in land cover increase heat emissions from the land surface and atmospheric temperatures Increased land surface temperature (LST) is mainly due to increase in concentrated human activities, paved land cover or barren lands.

The techniques of the Geographic Information System and remote sensing have been extensively used worldwide to study sequential shifts in the LU/LC (Land Use/Land Cover) and Surface temperature of land (LST). Increase in land surface temperature (LST) of growing urban areas in the current global warming scenario is a cause of concern for city planners.

Human activities continuously decrease the vegetation cover of the earth's surface to cause environmental changes, especially the terrestrial ecosystem at local, regional, and global scales

Improper planning and uncontrolled management of LU/LC changes in the urban areas will have a great impact on the climate and local environment, which can contribute to the development of urban heat islands. Therefore, previous studies on LU/LC changes, in particular areas, can help to understand the spatial extent and the degree of changes, as well as other human-related environmental changes (Buyadi *et al.,* 2013; Kikon *et al.*, 2016).

In the evaluation of the influence of urbanization on Land surface temperature, remote sensing systems have been effective, particularly in reducing the time for urban expansion analysis. Remote sensing is an important tool for obtaining spatial and temporal information with in small time frame; this method has proven itself to be one of the methods for studying change detection.

2.2.Land surface temperature

The land surface temperature (LST) is the temperature of the surface of the land, which can be acquired from the satellite data or direct measurements. Land Surface temperature is the radiometric surface temperature emitted by the land surfaces and observed at instant viewing angles by a sensor (Prata *et al*., 1995). This is an accurate measurement tool for indicating the energy exchange balance between the atmosphere and the Earth.

The degree of land surface temperature (LST) is affected by the surface attributes, which are significantly influenced by the elevation, slope, and aspect. However, the topography is one of the factors that control the soil moisture distribution and exerting an additional influence on the land surface temperature. (S. Youneszadehaet *et al*., 2015)
Land Surface temperature gives a precise indicator of the balance of energy exchange between the Earth and the atmosphere (Zhengming *et al*., 1989).

High spatial heterogeneity is shown by LST. The degree of LST is influenced by the attributes of the land surface. Which are significantly influenced by altitude, slope, and feature, which exert direct control on the incoming solar radiation (Dubayah, 1990). Besides, the topography is one of the factors that control the soil moisture distribution, thus exerting an additional influence on land surface temperature. Variation in LST also may be subject to seasonality, time of day, sea breeze, surface air temperature, humidity, wind speed, and land use (Keramitsoglou *et al.*, 2011).

A study in Greece indicated that evapotranspiration can cool air temperature by up to 3.1°C, while the canopies of trees, and directly obstruct solar radiance, forms shading areas to reduce the air temperature (Georgi and Dimitriou, (2010)

2.3.Impact of Land use /Land cover on land surface temperature

Spatial and temporal change of Land surface temperature offers details on the variance of the earth's surface energy change from time to time. That is the main factor for monitoring climate and vegetation in impermeable area.

Land surface temperature is an important climate variable associated with environment change and is an indication of the surface energy balance as it is a central parameter in the physics of land surface processes (James and Mundia 2014). The methods of remote sensing and GIS are used to detect changes in land use and its effect on the temperature of the land surface (Buyadi *et al*.2013).

Rapid urbanization causes numerous environmental problems such as extreme change of Land use /Land cover. Urbanization changes the natural surface into an impervious area which leads to urban heat islands. Some studies examined the effect of LU/LC on land surface temperature, which was found to be positively correlated with impervious surface. (Jiang, Jing &Tian, Guangjin. 2010)

LU/LC is the interface between the atmosphere and biosphere for material and energy exchange and has a clear influence on LST. Currently, a wide consensus has been reached on the influence of LU/LC change on regional climate through various processes, such as water and heat flux between land and air, surface wind speed, and boundary layer turbulence. LU/LC change directly causes changes in the physical characteristics of the land surface, which affects a variety of factors that determine regional climate, such as radiation, heat, and water vapor exchange. LU/LC change also alters the composition of surface attachments such as vegetation type and vegetation density. Street vegetation and urban forestry help to reduce the land surface temperature that’s important for the well-being of human as well as for the environment. Tree shades support the reduction of dehydration of soil and groundwater decrease.

Urban forest management is important to increase the benefits gained from the urban forest ecosystem and improve the urban environment for people. Such benefits may include refining air quality and the thermal environment (Dwyer, John.*et.al*., 1992).

Besides, LU/LC change has associated effects such as demographic changes and changes in regional chemical composition. This relationship has led to changes in terrestrial carbon stocks and their fluxes, resulting in a variety of outcomes, including changes in atmospheric greenhouse gas levels (Jie Tan *et al.*, 2020).

According to Anantharaj, V. G., (2006) The consequences of these LU/LC shifts are most noticeable in areas with higher population density, industrialization, urbanization, deforestation, agricultural diversification, and so on. Changes in the LU/LC, which modifies the surface energy balance, in turn influences the surface temperature, altering the region's microclimate, are thus the most noticeable consequence of anthropogenic activities regionally and locally.

Generally, the environment is affected by Land surface temperature increase which leads to a lower living standard for a human being because it affects health, environment, and sustainability of development.

2.4.LU/LC and LST impact on Climate change

According to Berg, P.*et al.,* (2013) Climate change has gotten a lot of attention in the last two decades, particularly from governments and scientists. The relationship between the land surface and the environment includes various processes and feedback, all of which can change at the same time, and land surface temperature is an important part of the climate system. Changes in vegetation type have been shown to alter the characteristics of regional air circulation and large-scale external moisture fluxes.

As a result, any changes in surface energy budgets caused by land surface change can have a significant impact on the global environment. (Knight, J.; Harrison.*et al.,* 2012)

According to Paul, S. *et al.,* (2016) Heat/cold waves, clouds, and rainfall patterns are all influenced by shifts in LU/LC. Furthermore, changes in LU/LC have been related to atmospheric aerosol emissions which can alter surface temperature through both direct and indirect effects, thereby modulating rainfall, which can result in droughts or floods through changes to severe events under some favorable circumstances.

As a result of anthropogenic climate change, global surface temperatures are rising. However, it is well understood that observed shifts are a result of climate forcing as well as a variety of other feedbacks, including LU/LC. The LU/LC can change in response to climate change and serve as a feedback mechanism. There are additional aspects related to anthropogenic behaviors in addition to these normal pushing and feedback cycles. As a consequence, the LU/LC is further updated, as are the meteorological responses. (Fu, P. & Weng, Q. 2016)

2.5.Normalized Difference Vegetation Index

The Normalized Difference Vegetation Index (NDVI) is an index of plant “greenness” or photosynthetic activity and is one of the most used vegetation indices. The vegetation index has based on the observation that different surfaces reflect different types of light differently. While the near infrared reflecting light, photosynthetic allies absorbs much of the red light that strikes Vegetation that is dead or stressed reflects more red lights and less near-infrared light. Likewise, non-vegetated surfaces have a much more even reflectance across the light spectrum. Satellites Landsat spot and sentinel produce near-infrared and red images.

In agriculture, professionals use NDVI for precision farming and to measure biomass. Whereas, in forestry, foresters use NDVI to compute forest supply and leaf area index. NDVI is usually used to examine drought, forecasting fire zones, and estimate agricultural production. Moreover, NASA states that NDVI is a good indicator of drought. When water limits vegetation growth, it has lower NDVI and density of vegetation.

NDVI is a common and widely used remote sensing index (Bhandari, Kumar, & Singh, 2012). NDVI is calculated as the ratio between TOA reflectance of a red band (ρred) around 0.66 μm and a near-infrared (NIR) band (ρnir) around 0.86 μm. The NDVI of a densely vegetated area will tend toward positive values, whereas water and built-up areas will be represented by near-zero or negative values. Formally, NDVI is given by Braun and Herold (2004).

$$\text{NDVI calculated as } NDVI = \frac{\text{NIR}-\text{RED}}{\text{NIR}+\text{RED}}$$

The result of this formula generates a value between -1 and +1. If we have low reflectance (low values) in the Red channel and high reflectance in the NIR channel, this will yield a high NDVI value and vice versa. Overall, NDVI is a standardized way to measure healthy vegetation. When we have high NDVI values, you have healthier vegetation. When we have low NDVI, we have less or no vegetation. Generally, if we want to see the vegetation change over time, then we will have to perform the atmospheric correction.

When you have negative value, it is likely water. On the other hand, if you have NDVI value close to +1, there's a high possibility that it's dense green leaves. However, when NDVI is close to zero, there are no green leaves and it could even be an urbanized area.

The distribution of land Surface Temperature (LST) is influenced significantly by vegetation cover. Using Landsat satellite images, the current study examines the relationship between the Normalized Difference of Vegetation Index (NDVI) and Land Surface Temperature in the Mashhad urban area. This clearly shows that the LST is both strongly and negatively associated with the NDVI.

As a result, regions with the least vegetation have higher ground surface temperatures. The highest temperature was found in suburban areas with bare earth, and the lowest temperature was found in vegetative areas such as parks, according to LST photographs. The negative correlation between NDVI and LST, as well as the regression coefficient from NDVI to LST, implies that where NDVI is lower, land surface temperature is higher, and where NDVI is higher, land surface temperature is lower. Except for a few parks with high NDVI values, the built-up or core urban areas of Mashhad have relatively low NDVI values and little vegetation. Mahdi Panahi, (2013)

Yuan and Bauer, 2007 research indicated in Shangai that the lowest LSTs are usually located in areas with the highest NDVI. For urban climate research, the negative correlation between NDVI and LST is useful.

2.6.Urban Heat Island (UHI)

Urban heat island is referring to a city experience more temperature than the nearby rural areas. Heat is created by energy from all the people, cars, trucks, and trains in big cities. The sun's heat and light reach the city and the country in the same way. The difference in temperature between urban and less developed rural areas has to do with how well the surfaces in each environment absorb and hold heat. (Twan Rovers, 2016)

According to the environmental protection agency, heat islands form as a result, of several factors such as urban material properties, urban geometry, and heat generated from human activities, weather and geography reduced natural land scope in urban areas.

There are many reasons for UHIs. When houses, shops, and industrial buildings are constructing close together, it can create a UHI. Building materials are usually very good at insulating, or holding in heat. This insulation makes the areas around buildings warmer.

"Waste heat" also contributes to a UHI. People and their tools, such as cars and factories, are always burning off energy, whether they're jogging, driving, or just living their day-to-day lives. Urban areas are closely populated, implicate there are many people in a small space. Nighttime temperatures in UHIs remain high. This is because buildings, sidewalks, and parking lots block heat coming from the ground from rising into the cold night sky. Because the heat is trapped on lower levels, the temperature is warmer.

According to Environmental protection Agency Structures such as buildings, roads, and other infrastructure absorb and re-emit the sun's heat more than natural landscapes such as forests and water bodies. Urban areas, where these structures are highly concentrated and greenery is limited, become "islands" of higher temperatures relative to outlying areas. Annual air temperature of a city with 1 million people can be 1-3°C warmer than its surroundings. Urban heat islands are one of the easiest ways to see how human influence can change the globe.

2.7.Geographic Information System (GIS)

A GIS is a system of hardware, software, and procedures to facilitate the management, manipulation, analysis, modeling, representation, and display of geo-referenced data to solve complex problems regarding planning and management of resources (Kemp,1997).

Geographic information systems have emerged in the last decade as an essential tool for urban and resource planning and management. Their capacity to store, retrieve, analyze, model, and map large areas with huge volumes of spatial data has led to an extraordinary proliferation of applications.

Geographic information systems are now used for land use planning, utility management, Ecosystem modeling, landscape assessment and planning, transportation and infrastructure planning, market analysis, visual impact analysis, facilities management, tax assessment, real estate analysis, and many other applications. GIS allows the creation of maps through automated mapping, data capture, and surveying analysis tools (F. Escobar, 2009).

The abundance of urban vegetation is known to greatly influence the urban thermal environment and the development of the UHI. Vegetation can reduce LSTs and atmospheric temperatures through evapotranspiration (Yuan and Bauer, 2007; Ramachandra and Kumar, 2010), a process by which heat from the air results in the evaporation of water (EPA, 2009c). Evapotranspiration is believed to be able to cause a reduction in peak summer temperatures within urban environments by as much as 1 – 5°C (EPA, 2009b).

Vegetation abundance, sun intensity, LU/LC characteristics affect Land surface temperature; this means that the LST of "discontinuous low-density urban fabric" is more radically affected by NDVI than the other residential LU/LC types (Andrew, 2012).

2.8.Remote sensing

The science of acquiring information about the earth using instruments those are remote to the earth's surface, usually from aircraft or satellites. Instruments may use visible light, infrared, or radar to obtain data. The Digi map states that remote sensing offers the ability to observe and collect data for large area relatively quickly, and is an important source of data for GIS.

According to Punyatoya, (2016) remote Sensing includes all techniques of obtaining pictures or other forms of electromagnetic records of Earth's surface from a distance, and the dealing and processing of the picture data. Remote Sensing then in the widest sense is concerned with detecting and recording electromagnetic radiation from the target areas in the field of view of the sensor instrument. This radiation may have originated directly from separate components of the target area; it may be solar energy reflected from them, or it may be reflections of energy transmitted to the target area from the sensor itself.

Remote sensing of the environment by geographers usually done with the help of mechanical devices known as remote sensors. These tools have a greatly improved ability to receive and record information about an object without any physical contact. Often, these sensors are positioned away from the object of interest by using helicopters, planes, and satellites. Most sensing devices record information about an object by measuring an object's transmission of electromagnetic energy from reflecting and radiating surfaces.

Remote sensing imagery has many applications in mapping land-use and cover, agriculture, soil mapping, forestry, city planning, archaeological investigations, military observation, and geomorphologic surveying, among other uses. For example, foresters use aerial photographs for preparing forest cover maps, locating possible access roads, and measuring quantities of trees harvested. Specialized photography using color infrared films has also been used to detect disease and insect damage in forest trees.

2.8. Conceptual framework

The conceptual framework of the study provides information about Land Surface temperature increase causes and its influence on the environment and health. The framework tries to show the association between land surface temperature and Land use /Land cover and NDVI and driving factors that affect LST change such as LU/LC, NDVI, and Elevation and Seasonal variation. LU/LC change affects Land surface temperature consequently LST increase causes much impact on climate change, health, food and water quality and supply, economic growth, and public goods. Land Surface temperature impact on Environment cerate obstacle for Sustainable development. Generally, Proper land use management, afforestation, planned settlement, and promoting better technology and innovation are vital mitigation measures.

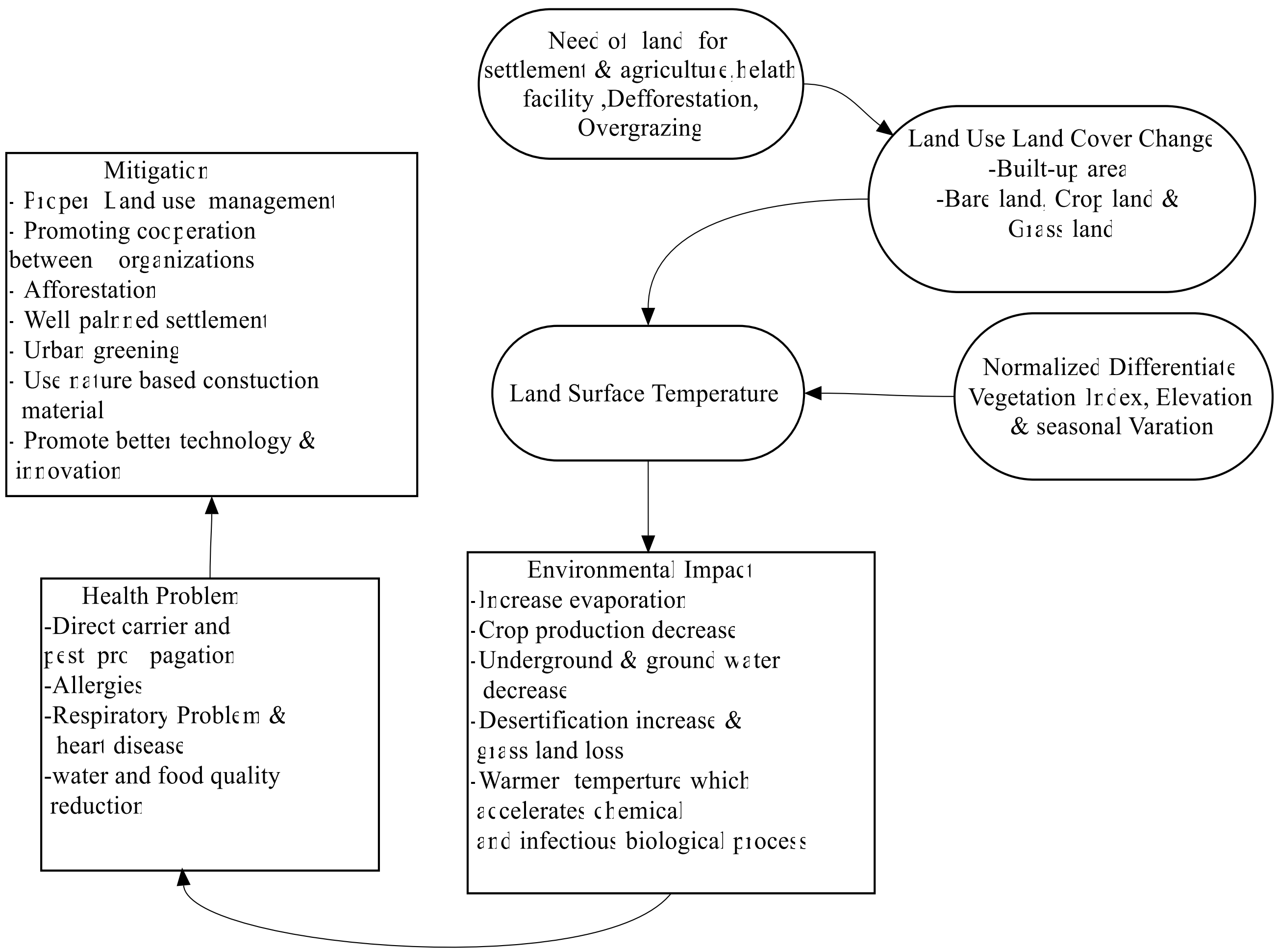


Figure 2. 1 Conceptual framework

CHAPTER THREE

3. Material and methods

3.1. Description of the study area

3.1.1. Location

Addis Abeba is located at 9º 1'48''N, 38º 44' 24''E. Addis Abeba has a central location with greater distance from the periphery. Addis Abeba city elevation lies at 2405 above sea level. The trend shows generally a gentle Decreasing pattern with an undulating terrain from the northern Mt. Entoto pick to the southern lowest parts of the city, where the lowest point is found around Bole Airport. Four Mountains are surrounding the city in near and mid-far distance: Mt. Entoto in the north, Mt, Wechecha. In the West, Mt. Yarer in the east, and Mt. Furi in the southwest. The study area has a total area of 3448.8 sq. Km. According to the 2013 E.C population projection of CSA population of the city is expected to be Addis Abeba 3, 603, 000, Sululta177, 774, Holeta 44, 713, Sendafa 21,988, Sebeta 88,246 in July 2019. The study area is chosen because; researcher focus only on a certain town which does not include the specified town connected with Addis Ababa. The study area specifically covers Addis Abeba up to a 20km radius.

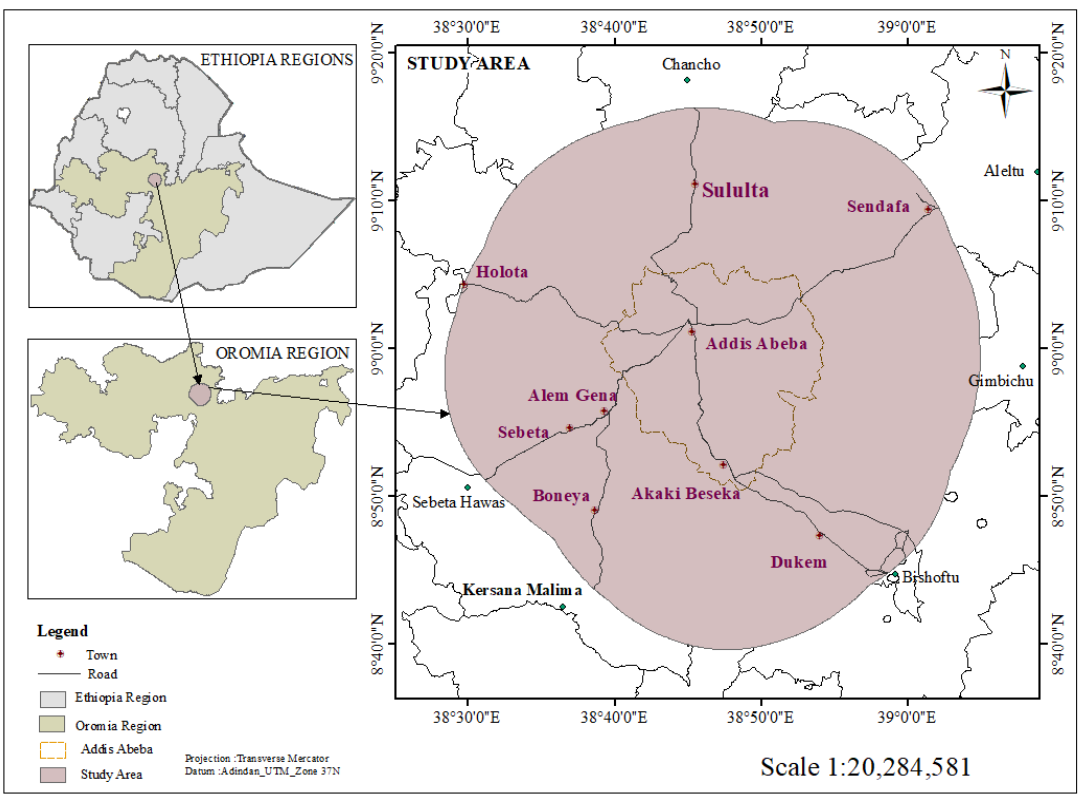


Figure 3. 1 Location map of the study area

3.1.2. Topography

The topography is the study and description of the physical features of earth; it contains mountains, rivers, hills valleys, or the representation of these features on the map. Addis Abeba is the largest city in Ethiopia. It is located on a well-watered plateau surrounded by hills and mountains, in the geographic center of the country. The study area's altitude is between 1795 m and 3388 m above sea level. Addis Abeba and the surrounding area has highland and flat area. The slope of the study area ranges from 0 - >75 %. The highest altitude is located at the North and northwest part of the study area. The slope of the study area and elevation map indicated as following (figure 3.2.)

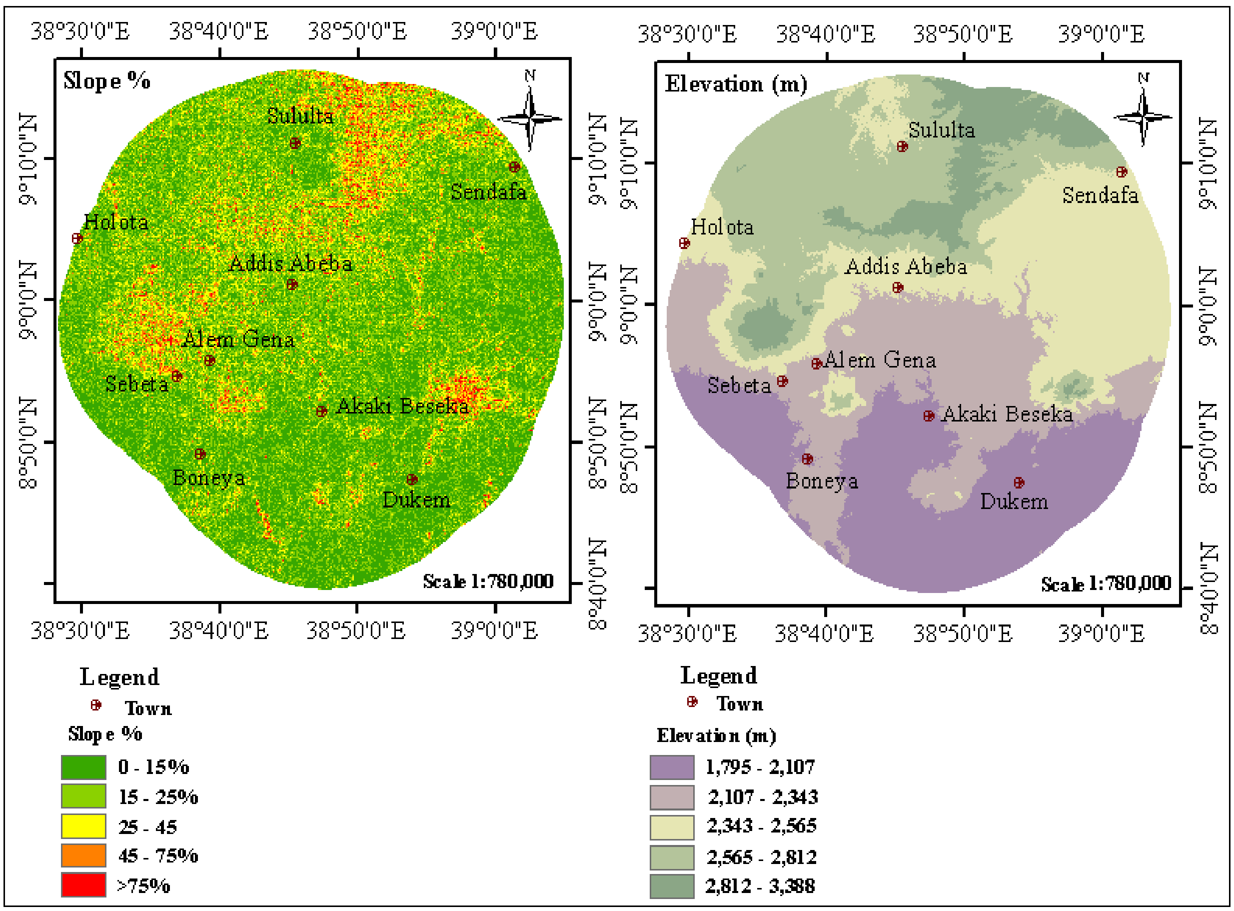


Figure 3. 2 Slope and Elevation map of the study area

3.1.3. Climate

3.1.3.1.Rainfall

Figure 3.3 depicts 35 years (from 1986 to 2019) record of the average monthly rainfall of 9 stations found in the study area. Accordingly, the highest monthly average rainfall (.mm) is recorded in

Sululta followed by Sendafa and Aleltu. The lowest monthly average rainfall (.mm) is also recorded in Bonya and Addis Ababa in January. The highest monthly average rainfall for all stations is recorded during June, July, and August. On the other hand, the lowest average rainfall is recorded in November, December, and January.

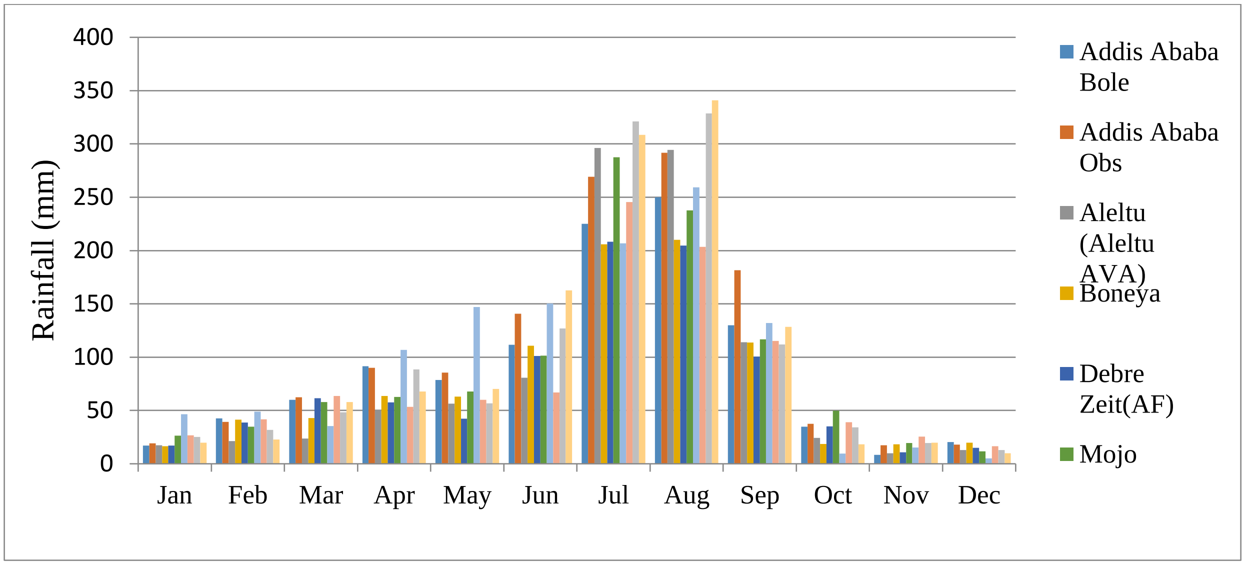


Figure 3. 3 Monthly average rainfall of study area

3.1.4. Climate

Figure 3.4 indicates the monthly average maximum and temperature recorded over 30 years for seven stations found within the study area. Mojo station has the highest monthly average record of maximum temperature, followed by Nazeret and Debre Zeit and Sululta has the lowest record. The highest monthly average maximum temperature for all stations recorded during March, April, and May. On the other hand, the lowest monthly average maximum temperature is recorded in July, August, and September.

Figure 3.4 indicates the monthly average minimum temperature (^{0}c) recorded over 30 years for seven stations found within the study area. Mojo has the highest average record of minimum temperature (.^{0}c), whereas Sululta station has the lowest record.

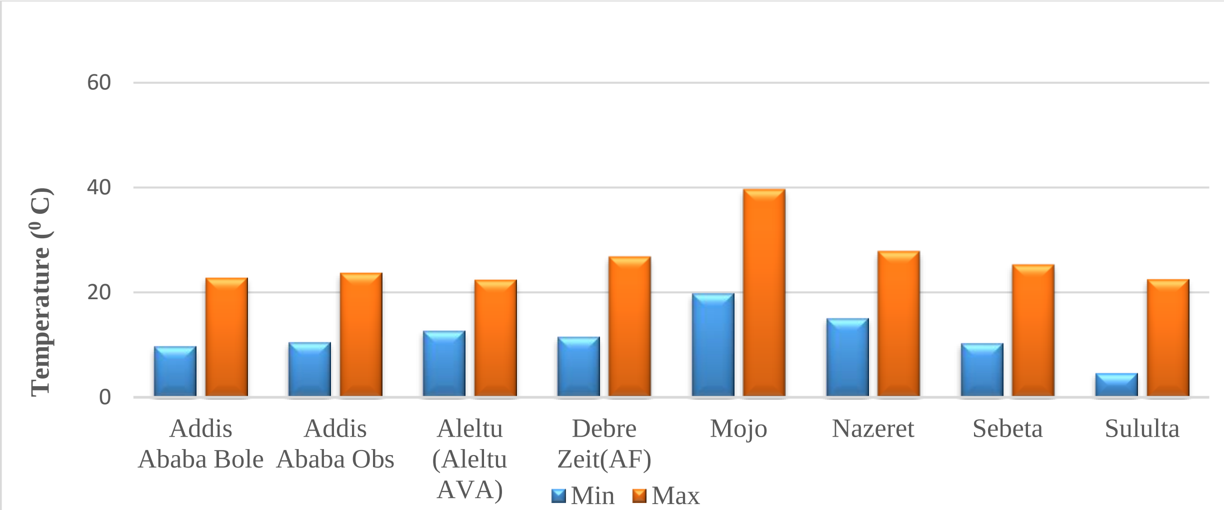


Figure 3. 4 Monthly average Maximum and Minimum temperature of the study area

3.2.Data Source and Software Application

3.2.1. Primary data

To achieve the above-stated objectives data collected and organized from primary and secondary sources. One of the primary data collected from USGS and land use / land cover (LU/LC) map of the area was produced from Landsat image, for 1990, 2000, 2010 and 2020. Landsat images and Modis image are the other primary data was downloaded from the Earth Explorer website. From https://libra.developmentseed.org, Usgs.gov and Landsat 8. In addition to the Landsat image 20-meter DEM data used to analyze the slope of the area.

Table 3. 1 Data source

GIS data layer	Description	Data Source
Vector (point)	Major Town	Ethio-Gis
Vector (line)	Road	Ethio-Gis
Vector (polygon)	Boundary	Ethio-Gis
Raster	Elevation & slope	DEM 20 SRTM
Attribute Table	Temperature & Rainfall	National Meteorological Agency
Attribute Table	Population	CSA
Raster	Satellite Image	Landsat 1990,2000,2010 & 2020, Modis LST 2020

3.2.2. Secondary data

The secondary data are those published and unpublished documents from various websites and organizations. National Meteorological Agency is the main source of rainfall and temperature data. Demographic characteristics, as well as other important data for the study, were gathered from Central Statistical Agency (CSA).

3.2.3. Remote sensing data acquisition

One scene 1990, 2000, 2010, and 2020 With Path and row 168/54) were downloaded from USGS global visualization viewer website. The acquired data from the different sources have adjusted to the Ethiopian projection system. In line with this, the projection is Universal Traverse Mercator Zone 37 and Datum Adindan, Spheroid name Clarke 1880 projection is used. The data acquired years chosen is because the cloud-free image is available for the duration of the dry season and Ten years' time interval for four decades.

Table 3. 2 Remote sensing data used in the study

Acquisition date	Sensors	Number of Bands	Path	Row	Spatial resolution	Forma t
01-19-1990	TM	1 to 5 &7	168	54	30	Tiff
01-05-2000	ETM+	1 to 5 &7	168	54	30	Tiff
01-10-2010	OLI & TIRS	1 to 5 &7	168	54	30	Tiff
01-19-2020	OLI & TIRS	1 to 7 &9,10 11	168	54	30	Tiff

For data analysis and map preparation, the software packages used for this study are ArcGIS 10.5, and ERDAS Imagine 2015 for the processing of satellite images, land use / land cover classification (LU/LC), land surface temperature (LST) and normalized vegetation difference index (NDVI), Microsoft office used to create word documents, analyze spreadsheets, and manage databases and presentation and data management. In addition to this above software, Google Earth has used to check and compare the result with ground truth accordingly.

The methods for this research include the following: data collection, data preprocessing, classification of Land sat satellite image for Land use /Land cover change (LU/LCC) map and land surface temperature (LST) map, analysis, and comparison of spatial and temporal change. Besides these above activities, this study incorporated verification compared using Google Earth. The for63mat is satellite images that have been acquired from Landsat satellite sensors for three selected years. Generally, in this research, different remote sensing processing methods have been used to carry out the research.

3.2.4. Image classification

The objectives of image classification procedures are automatically categorizing all pixels in an image into land-use/land-cover classes. In this study, supervised classification has been used to identify land-use/land cover classes in the study area.

Table 3. 3 Land cover classification scheme

LU/LC classes	Description
Bare land	Rocks, exposed soil, mines degraded land and dunes
Built-up	Area covered by buildings, houses, roads, concrete, industries & other services
Farmland	Areas used for growing crop, plantation, growing, breeding something
Scrubland	A woody plant which is smaller than the tree, bushes, shrubs with some grasses & less dense than forests
Grassland	An area that is covered by grasses & used for grazing
Forest	Area covered by dense trees
Waterbody	Area covered by the sea, lake, the river it can be natural or man-made like ponds or dams
Wetland	An area that is swampy or marshy land

3.3. Supervised classification

With supervised classification, land cover types have been identified. The image processing soft wares were used to develop a statistical characterization of the reflectance for each information class. This stage is often called "signature analysis" and may involve developing a characterization as simple as the mean or the range of reflectance on each band. Once a statistical characterization has been achieved for each information class, the image is then classified by examining the reflectance for each pixel and deciding about which of the signatures it resembles most.

In supervised classification, the user can identify types of land-use land-cover classes with the aid of image processing techniques. The eight LU/LC classes that were studied in Addis Abeba and its satellite town were, forest, shrubs, grassland, built up, wetland, Farm Land water body, and bare land. The advantage of the supervised classification is the growth of information classes, self-assessment using sites for training. Information classes may not, however, match spectral classes, the homogeneity of the signature, and the uniformity of information classes possibly will vary. Maximum likelihood Classification It is a criterion of statistical conclusion to assist in classifying overlapping signatures are given; the highest probability class are given to pixels. The maximum likelihood classifier is considered to give more results that are “accurate”.

3.3.1. Validation

In the study area, a validation was carried out in which various LU/LC groups were checked. Farmland, shrub land, water body, bare land and settlement include the observed LU/LC (urban and rural settlement). With reference of google Earth, site data used for image classification were acquired. For all land classes, 160 points have employed, for each LU/LC class stratified sampling method was employed.

3.3.2. Accuracy Assessment for Image Classification

Accuracy assessment is an important part of any classification task. It compares the classified image to another data source that is accurate or ground truth data assessing the accuracy of the classification requires that some initial data or previous information about certain parts of the terrain be obtained, which can then be contrasted with the derived classification map. Using Erdas software about 160 points were created. Google Earth was used as a ground for evaluation of the LU/LC classification accuracy. Prior awareness of the area is important for determining and classifying the LU/LC of the study area. Eight LU/LC major classes were identified in the study area.

The overall classification accuracy reported by the LU/LC accuracy assessment for the year 2020 is 91.25 percent. The total number of Kappa figures for 2020 is 0.8781. Detailed information on the producers and the accuracy of the consumers is given in table 3.4.

Table 3. 4 Statistical information of accuracy assessment for the year 2020

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Wetland	4	4	4	100.00%	100.00%
Bare land	2	2	2	100.00%	100.00%
Shrub	20	15	15	75.00%	100.00%
Grass land	24	28	24	100.00%	85.71%
Waterbody	2	1	1	100.00%	100.00%
Forest	5	6	4	80.00%	66.67%
Built up	34	28	27	79.41%	96.43%
Farm land	69	76	69	100.00%	90.79%

The detection of Land-Use-Land-Cover changes was carried out by including images from 1990, 2000, 2010, and 2020. The process of cross-operation of LU/LCC mapping began with the mapping of the latest satellite imagery for 2020, then looking back time to map imagery for 1990, 2000 & 2010. Post classification is one of the most commonly used approaches for the detection of changes (Chen, 2000). Technical integration procedures using the software techniques of ArcGIS were involved in the analysis of LU/LCC maps. The following equations have been used.

$$\text{Percentage Change} = \frac{observed\ change}{Sum\ of\ area} \times 100 \qquad \text{Eq. (3.1)}$$

3.4. Derivation of Normalized Vegetation Index and Land surface temperature

3.4.1. Normalized Vegetation Index Derivation

NDVI is a standardized way to measure healthy vegetation. When we have high NDVI values, we have healthier vegetation. When we have low NDVI, we have less or no vegetation.

According to Wardlow, 2007 low NDVI values indicate moisture-stressed vegetation and higher values indicate a higher density of green vegetation. It is also used for drought monitoring and famine early warning. NDVI was acquired from measurements of spectral reflectance in the visible in the ArcGIS environment, the (RED) and near-infrared regions (NIR).

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

NIR= is the near infrared band 4, R= is the red band 3. For the measurement of NDVI for the TM 1990, 2000, 2010 and OLI 2020 sensors, Equation 3.2 is used. But, in the case of Landsat 8, Band 5 is the NIR and Band 5 is the band 4 is a red band. (Weng*er et al.*, 2004).

The Fractional Vegetation Cover (FVC) calculation is achieved by following Eq. 3.3 was used.

$$\mathrm{FVC} = \frac{\mathrm{NDVI-NDVIs}}{NDVIv-NDVIs} \qquad \text{Eq. (3.3)}$$

FVC=Fractional Vegetation cover

NDVI= Normalized Difference Vegetation Index

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

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

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

$$\mathrm{Pv = NDVI\text{-}NDVI\ min/\ NDVI\ max\text{-}\ NDVI\ min)^2} \qquad \text{Eq. (3.4)}$$

Eq. (4) 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

3.4.2.1 Radiometric correction

Radiometric correction involves the conversion of a digital number for remote sensing to spectral radiance values and comparison results. Image processing methods used to correct errors, convert values of a digital number (DN) to radiance and then reflectance were known as radiometric Correction (Prata, A.J., and Caselles, 1995). To change digital numbers to spectral radiance there was an equation (5) used.

$$L\ \lambda = \mathrm{Lmin} + (\mathrm{Lmax} - \mathrm{Lmin}) * D\ N/255 \qquad \text{Eq. (3.5)}$$

Where L λ=spectral radiance

Lmin=spectral radiance of DN value 1

Lmax=spectral radiance of DN value of 255

DN=Digital Number Equation

The above methods were used to transform the number into spectral radiance

3.4.3. Conversion of radiance into brightness temperature

Using the thermal constants provided in the Metadata file, thermal infrared data can be translated from atmosphere reflectance (Lλ) to effective sensor brightness temperature (TB). The thermal band of remote sensing data (Landsat imagery) that is band 8 on thematic mapper and enhanced thematic mapper plus must be transformed from spectral radiance at the sensor to the TB equation, 8 was used (Rajeshwari and Mani, 2014).

TB=$K2\ LnK1L\lambda + 1$Eq. Eq. (3.6)

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

K2=calibration constant 2

Lλ=natural logarithm

K1=calibration constant 1

$L\lambda$=spectral radiance at sensors aperture

Generally, to calculate LST for the sensor TM subtracting 273.15 from the existed result that is performed from effective at satellite temperature formula in degree Celsius.

1. Calculation of TOA (Top of Atmospheric) spectral radiance.

$$TOA\ (L) = M_L * Q_{cal} + A_L \quad \text{Eq. (3.7)}$$

Where:

Q_{cal} = corresponds to band 10

A_L = Band-specific additive rescaling factor from the metadata (RADIANCE_ADD Band, where x is the band number).

TOA = 0.0003342 * “Band 10” + 0.1

2. TOA to Brightness Temperature conversion

$$BT = (K_2 / (\ln (K_1 / L) + 1)) - 273.15 \qquad \text{Eq. (3.8)}$$

Where:

K_1 = Band-specific thermal conversion is constant from the metadata (K1_CONSTANT_BAND_x, where x is the thermal band number).

K_2 = Band-specific thermal conversion is constant from the metadata (K2_CONSTANT_BAND_x, where x is the thermal band number).

L = TOA

Therefore, to obtain the results in Celsius, the radiant temperature is adjusted by adding the absolute zero (approx. -273.15°C).

BT = (1321.0789 / Ln ((774.8853 / %TOA %) + 1)) – 273.15

3. Calculate NDVI (using the formula; refer Eq. 3.2 on page 33) Eq.(3.9)

Note that it is necessary to measure the NDVI since, subsequently, the proportion of vegetation (P_v), which is highly related to the NDVI, and emissivity (ε), which is related to the P_v must be calculated.

4. Calculate the vegetation proportion P_v

$$P_v = \text{Square} ((NDVI - NDVI_{min}) / (NDVI_{max} - NDVI_{min})) \qquad \text{Eq. (3.10)}$$

Normally, it is possible to view the minimum and maximum values of the NDVI image directly in the image (both in ArcGIS & Erdas Imagine), otherwise you have to open the raster properties to get those values.

P_v = Square ((“NDVI” – 0.216901) / (0.632267 – 0.216901))

5. Calculate Emissivity ε

$$\boldsymbol{\varepsilon} = 0.004 * P_v + 0.986 \qquad \text{Eq. (3.11)}$$

Simply add the formula to the raster measure, the value of 0.986 corresponds to the equation's correction value.

6. Calculate the surface temperature of the land using the LST equation to obtain the surface temperature

$$\mathrm{T} = TB/(1 + \left(\mathrm{L} * \frac{\mathrm{TB}}{\mathrm{C2}}\right) * \ln{(e)} \qquad \text{Eq. (3.12)}$$

Formulas used in this thesis are from equation 3.6 up to 3.12

3.4.4. Verification of the result for land surface temperature

The direct relationships were demonstrated by the soil surface temperature obtained from the Landsat thermal band of the study region and the Modis Land surface temperature obtained from the earth explorer. n this analysis, though, the LST pattern achieved was from Landsat imagery acquired during dry weather conditions and crop gathering time. The spatial distributions of the LST have validated the current Modis image resolution and acquired time of Landsat. The land surface temperature was verified using the same time Modis LST data of daytime temperature. Modis LST data was prepared based on the Modis data obtained from USGS earth explorer and Clipped image by the study area. There is a strong relationship between Landsat LST value and Modis LST value, which have extracted temperature value from each image using Extract value by a point from each pixel. The correlation between the two images LST was directly related and the values were proximate. The R2 value is 98 % which shows the Landsat LST value is positively correlated with the Modis LST. In characterizing and forecasting spatial-temporal trends of atmospheric temperature, the remotely sensed LST is most useful. LST is, therefore, often used as an ambient temperature measure. Because air and surface temperature area directly related. The Landsat ranges from 12.85 up to 38.33 and Modis LST ranges from 21.95 up to 48.15. The southern and northeast part of the study area has the highest LST value in both images and the lowest LST value recorded in the high lands of the study area LST Correlation graph of Landsat LST and Modis LST value are given below in figure 4.23.

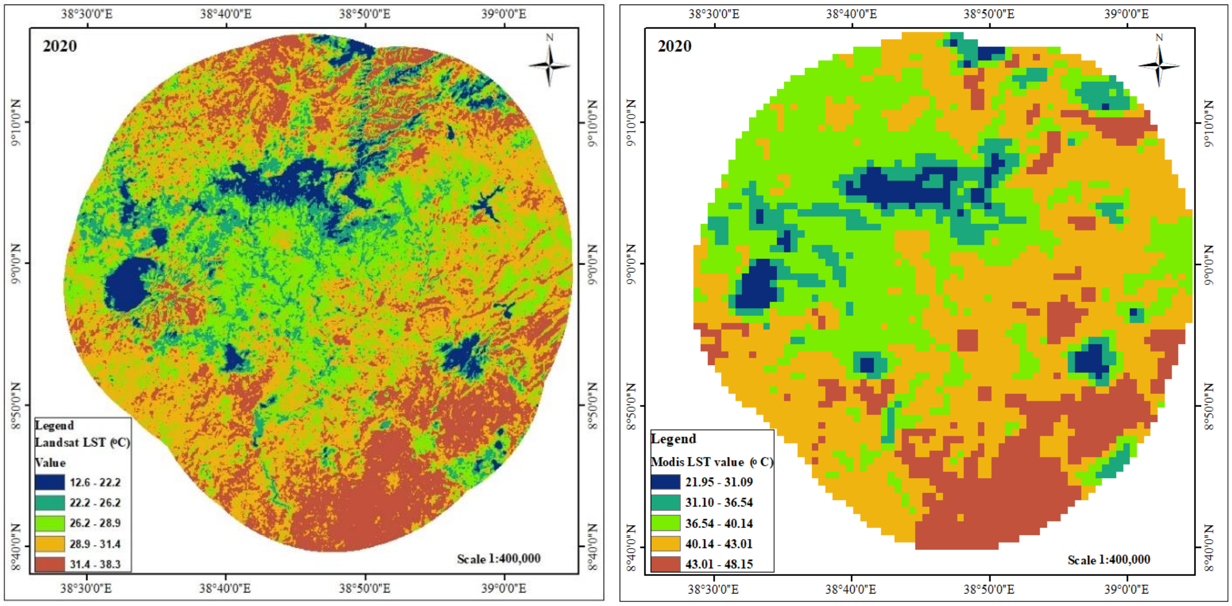


Figure 3. 5 Modis and Landsat Land Surface Temperature maps of 2020

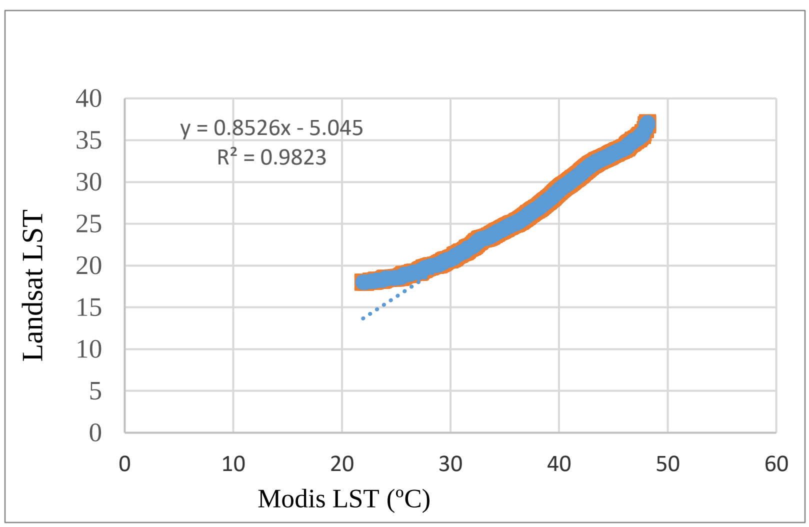


Figure 3. 6 Modis and Landsat Land Surface Temperature graph of 2020

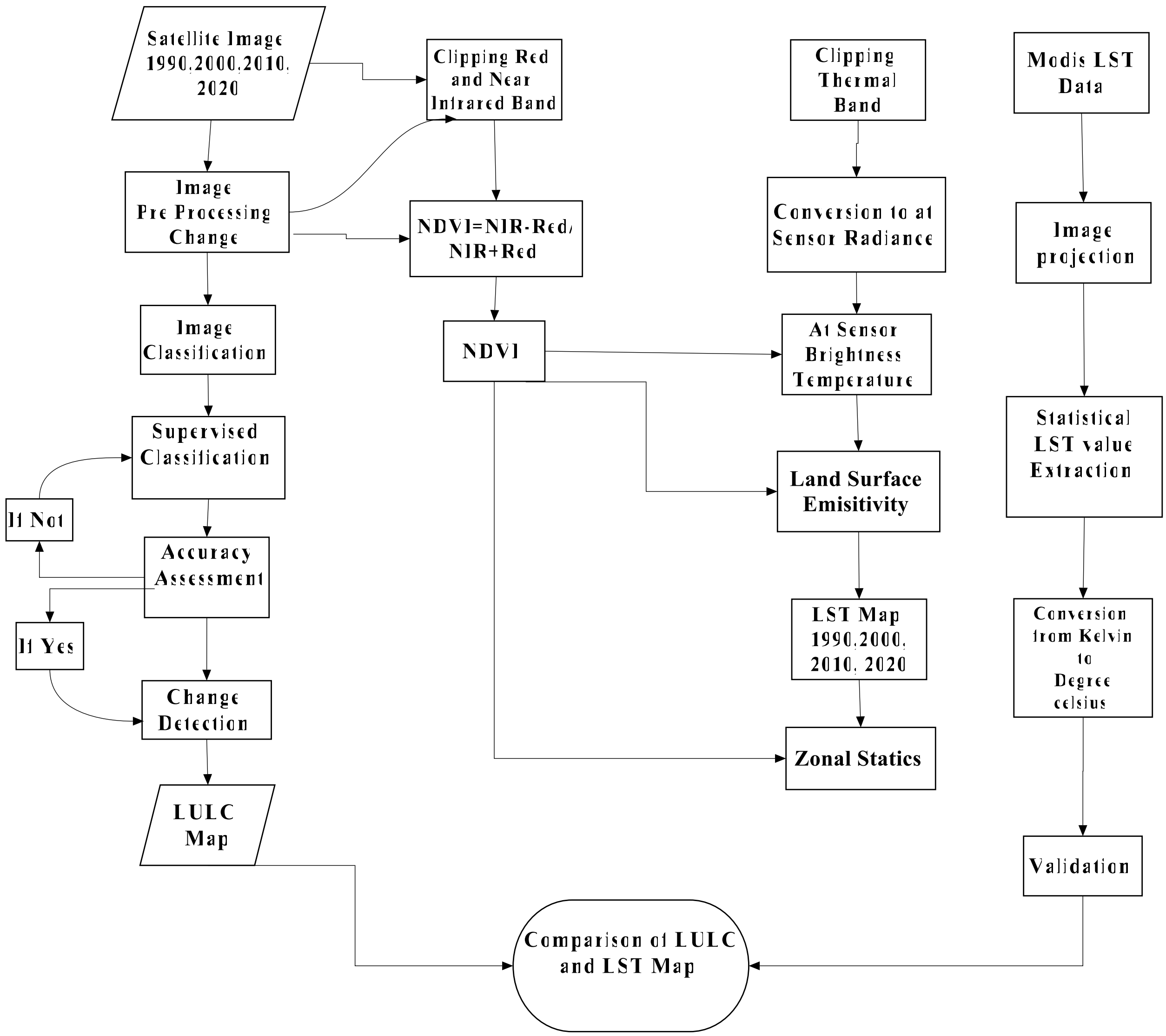


Figure 3. 7 Flow chart of the methodology

3.4. Zonal statics

A zone is defined as all area with the same value input. A role of zonal statics inside the zones of raster or vector, it summarizes the value of a raster and reports the results as a table and figure. For the years 1990, 2000, 2010, and 2020 maps of LU/LC, LST and NDVI were prepared. The result was summarized using the zonal statics method of ArcGIS 10.5 to analyze the spatial difference of LST according to varying LU/LC. One of the important methods used to analyze the association between LU/LC and LST is Zonal statistics as a table and figure.

CHAPTER FOUR

4 Land use /Land cover Changes & its implication on Land surface temperature

4.1. Land-use/land-cover trend in 1990, 2000, 2010 and 2020

The 1990 land-use/land-cover classification outcome suggested that farm land, shrub land, and forest were the dominant LU/LC groups. 345161.77 ha from the total area, farmland accounted for 186964.6 ha, which is 55.8 %, shrub land, accounted for 63432.9 ha 18.38%, and forest accounted for 10447.74 ha, which is 3.12 %. Built-up accounted for 10823.49 ha this is 3.23 %. Grass land, bare land, wetland and water body are counted 63275.94 ha and 18.9 % of the total area. Compared to other LU/LC groups, water bodies covered the least area. Study of 2000 images reveals that agricultural land and shrubs are with the amount of 184559.31ha (48.3 and 51612.93 ha (13.5 percent) respectively), the largest share of land in the study region is accounted for. Other LU/LC groups together accounted for 146247.66 ha (38.2 percent) of the total area, such as grassland, water body, built-up, bare land, wetland, and forest. Similarly water body cover in 2010, contained the smallest area of all the other LU/LC categories. However, from 2000, the extent of farmland reduced by 38816.42 ha in 2010. In 2020, the largest area accounted for 134832.66 ha, which is 39.1 % of the total area. Farmland is typically the main LU/LC of the study area, followed by shrub and built up in terms of area coverage. The temporal analysis of the LU/LC map is presented in table 4.1.

Table 4. 1 Land use /Land covers classes and area coverage of 1990, 2000, 2010 & 2020 in the study area

Class Name	1990		2000		2010		2020	
	Area(ha)	Area %	Area(ha)	Area %	Area(ha)	Area %	Area(ha)	Area %
Wet Land	11953.8	3.57	9972.45	2.61	33654.6	9.75	8773.02	2.54
Farm Land	186964.56	55.82	184559.31	48.26	145,742.89	42.52	134832.66	39.06
Bare Land	22408.38	6.69	48121.65	12.58	8454.87	2.45	3709.71	1.07
Water Body	1268.46	0.38	1835.64	0.48	1336.68	0.39	1873.35	0.54
Shrub	63432.9	18.94	51612.93	13.5	35173.53	10.19	32756.4	9.49
Forest	10447.74	3.12	21365.82	5.59	19393.74	5.62	13775.94	3.99
Built up	10823.49	3.23	19354.5	5.06	45996.59	13.33	89600.16	25.96
Grass Land	27645.3	8.25	45597.6	11.92	54388.62	15.76	59840.46	17.34
Total	345161.7	100	345161.7	100	345161.7	100	345161.7	100

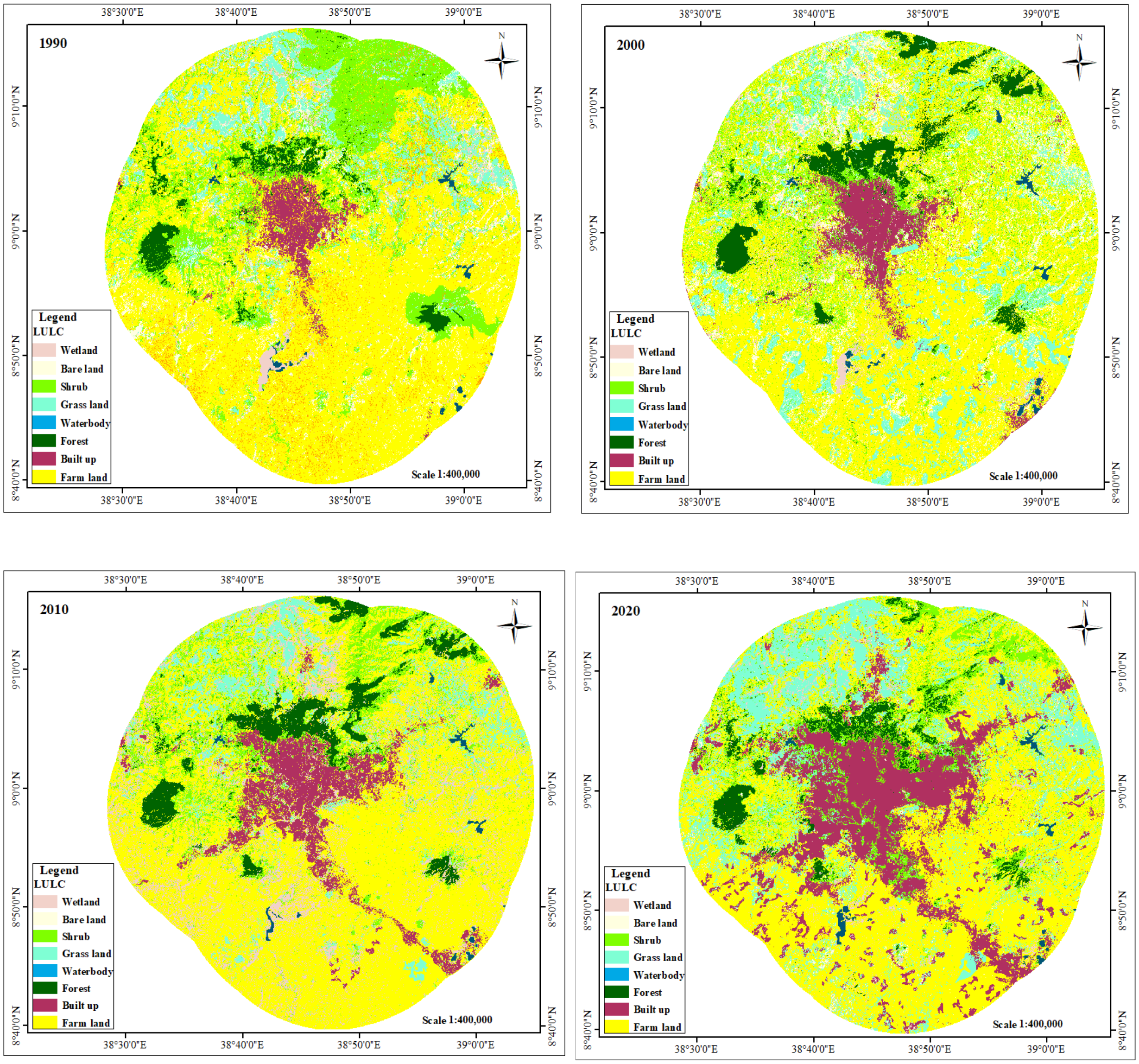


Figure 4. 1 Land use /Land cover map of the study area for the year 1990-2020

Farmland and shrub as land use had the largest extent of all LU/LC in the study area during 1990 & 2000.on the other hand the largest area of the LU/LC for the year 2010 & 2020 was built up and grassland.

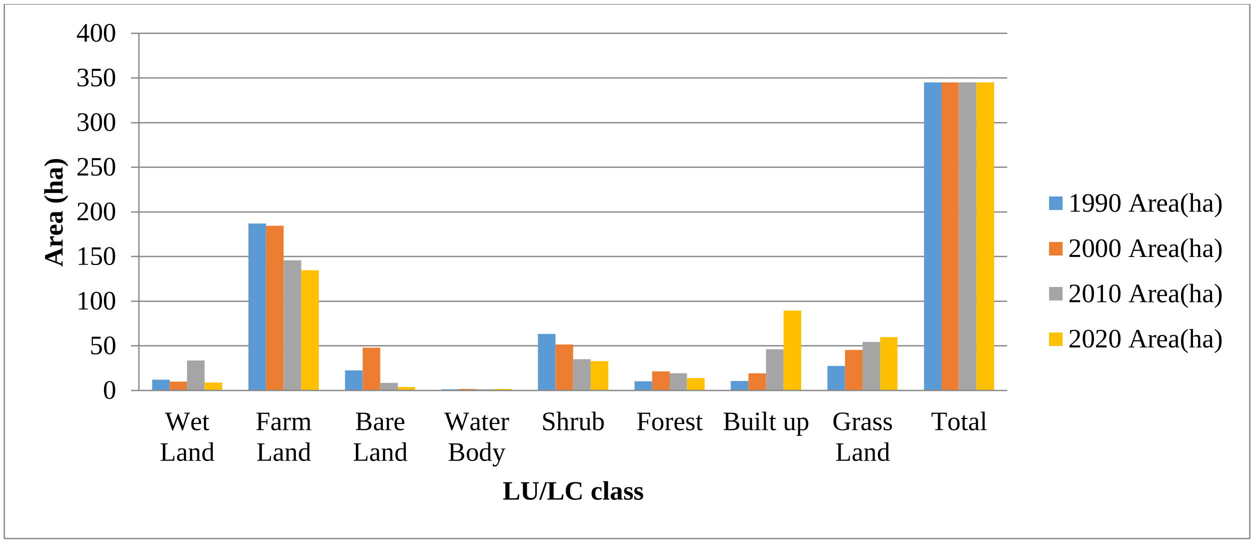


Figure 4. 2 Land use /Land cover changes in the study area during 1990 – 2020

4.1.1. Spatial extent and change in land-use/land-cover

Land-use/land-cover patterns in the study area have significantly changed in the area between 1990 and 2020. Among the eight major LU/LC classes, farmland covered more than 39 % of the area in all the study years. The built-up area has been increasing continuously from 1990 to 2020. It has increased from 8531.01ha in 2000 to 26642.09 ha by 2010 to 43,604.01ha by 2020. Shrub had decreased in 2000 by 11819.97 ha and 16439.4 in 2010, 2417.13ha by 2020. Scrubland has been decreasing from1990 to 2020. Shrub and farmland were the most decreased land cover during the 40 years covered by this study.

Table 4. 2 1990, 2000, 2010& 2020Land use /Land cover net changes in the study area

Class Name	2000-1990	2010-2000	2020-2010	2020-1990
	Area (ha)	Area (ha)	Area (ha)	Area (ha)
Wet Land	-1981.35	23682.15	-24881.58	-3180.78
Farm Land	-2405.25	38,816.42	10,910.23	-52131.9
Bare land	25713.27	-39666.78	-4745.16	-18698.67
Water Body	567.18	-498.96	536.67	604.89
Shrub	-11819.97	-16439.4	-2417.13	-30676.5
Forest	10918.08	-1972.08	-5617.8	3328.2
Built up	8531.01	26642.09	43,604.01	78,776.67
Grass Land	17952.3	8791.02	5451.84	32195.16

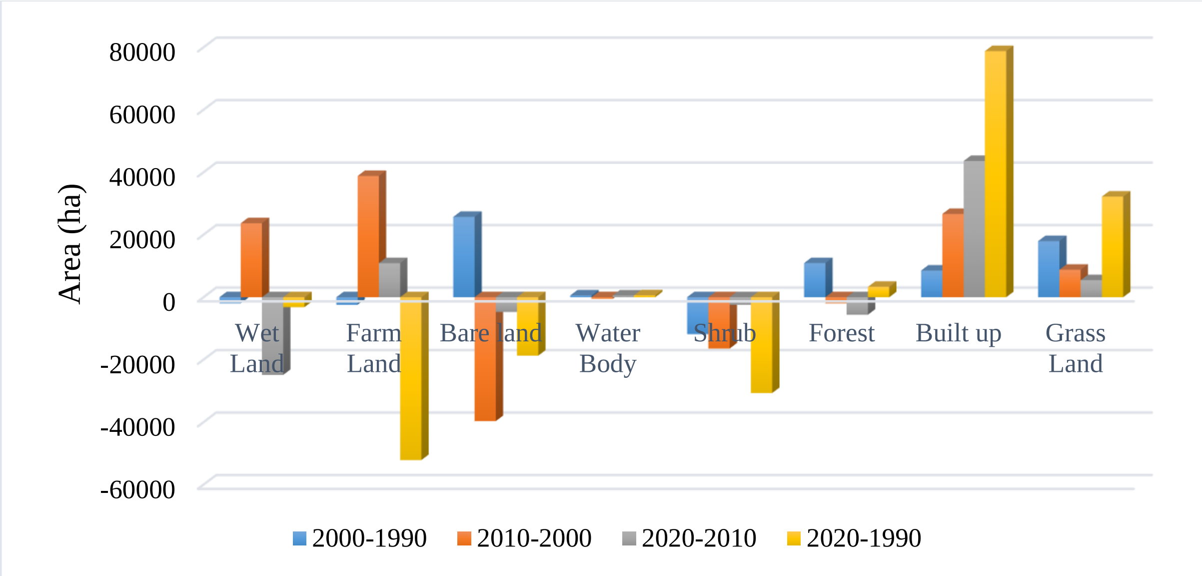


Figure 4. 3 1990, 2000, 2010 & 2020 Land use /Land cover changes in the study area

4.1.2. Built-up area expansion

On the satellite images overlays on the study obtained during 1990 up to 2020.In different part especially on the city periphery of the study area farm land, shrub land and bare land was changed to built-up area. The built-up area increase shows significant change in Addis Abeba and its satellite town 40 years cover of the study.

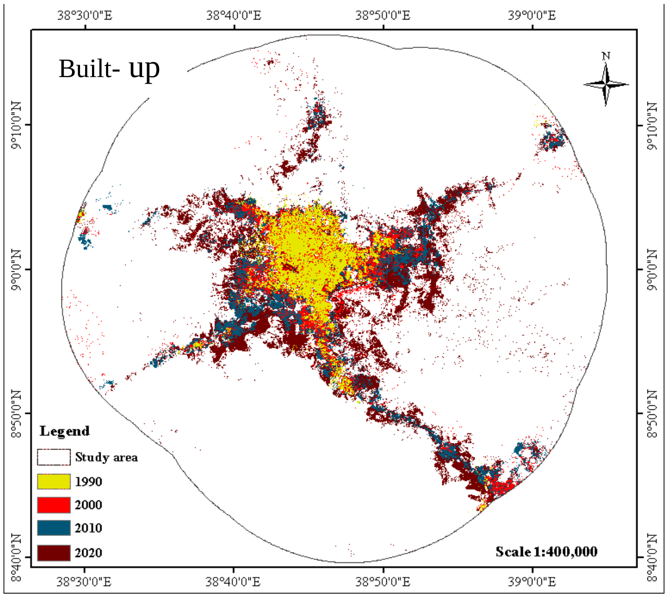


Figure 4. 4 The trend expansion of built-up area from the year 1990 to 2020 in the study area

4.1.3. Accuracy assessment

The overall classification accuracy reported by the LU/LC accuracy assessment for the year 2020 is 91.25 percent. The total number of Kappa figures for 2020 is 0.8781. Detailed information on the producers and the accuracy of the consumers is given in table 4.3.

Table 4. 3 Statistical information of accuracy assessment for the year 2020

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Wetland	4	4	4	100.00%	100.00%
Bare land	2	2	2	100.00%	100.00%
Shrub	20	15	15	75.00%	100.00%
Grass land	24	28	24	100.00%	85.71%
Waterbody	2	1	1	100.00%	100.00%
Forest	5	6	4	80.00%	66.67%
Built up	34	28	27	79.41%	96.43%
Farm land	69	76	69	100.00%	90.79%

4.1.4. Normalized difference vegetation index of the study area

In this analysis, vegetation cover was found to be higher in 2000 than in 2010, with a maximum NDVI of 0.614 and 0.566, respectively. High vegetation reflects the maximum value. The vegetation cover decreased to NDVI value of 0.459 for the year 2020. Figure 4.5 below shows NDVI findings for the years 1990, 2000, 2010 and 2020. Results of NDVI 1990, 2000, 2010 and 2020 presented that the Entoto, Menagesha, and Yerer Mountain have the maximum NDVI value of the study area and those are the Central part of the study area around Addis Abeba town and water body areas have comparatively low NDVI values. As shown in Figures 4.5 vegetation cover has reduced and the constructed area has been growing gradually in the study years.

Table 4. 4 Statistical information for NDVI value for the study years

Year	1990	2000	2010	2020
Min	-0.17	-0.61	-0.19	-0.08
Max	0.56	0.59	0.57	0.49
Mean	0.14	-0.06	0.14	0.17
Std	0.09	0.12	0.09	0.06

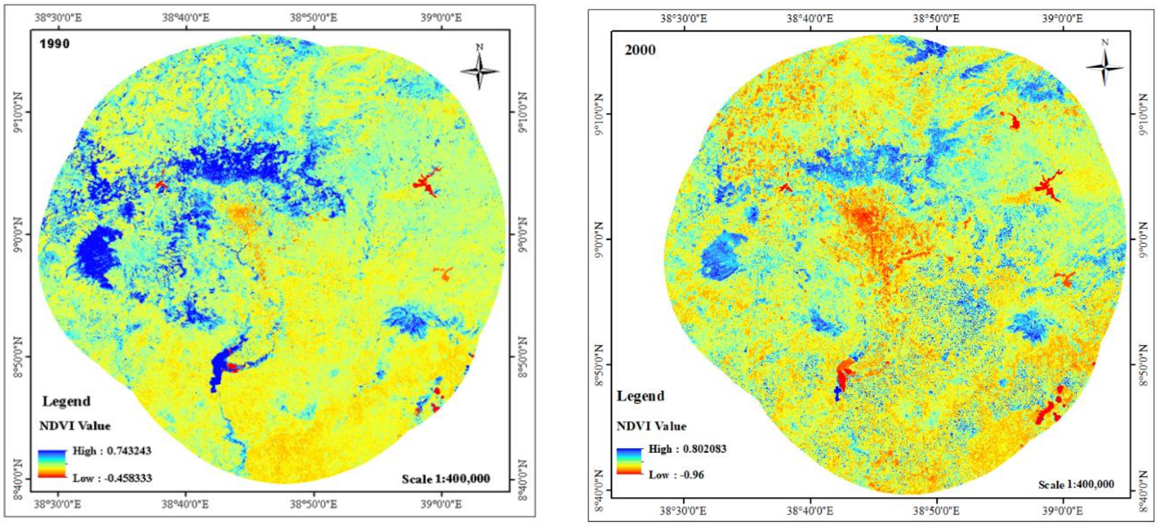
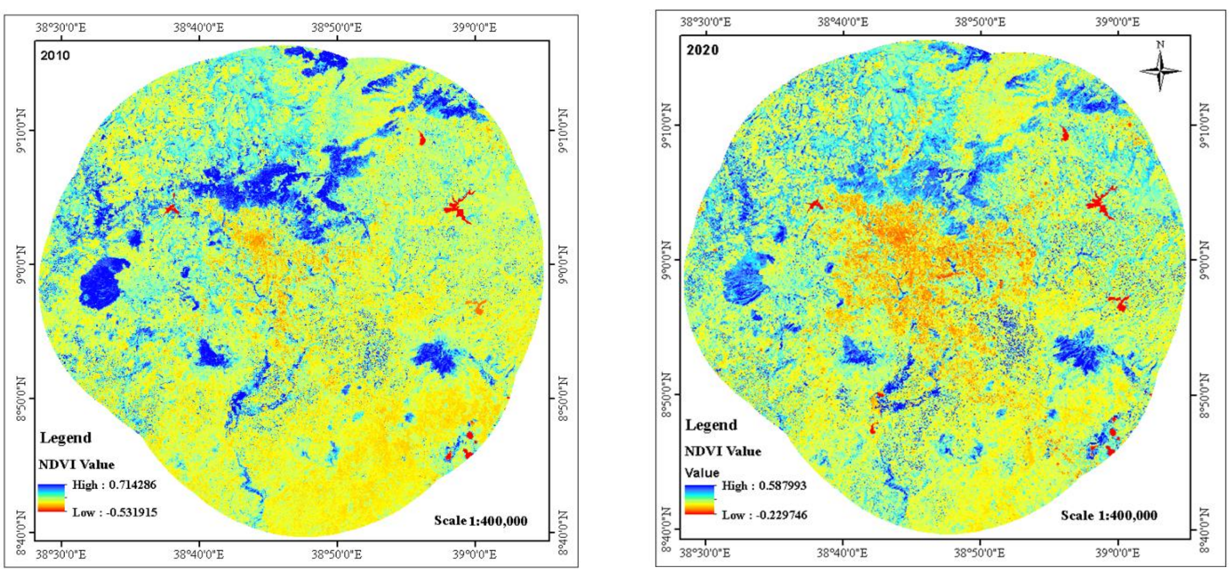


Figure 4. 5 (a)Normalized Difference Vegetation Index map of the study area of the year 1990-2020



(b) Normalized Difference Vegetation Index map of the study area of the year 1990-2020

4.1.5. The relationship between land-use/land-cover types and NDVI

Normalized differential vegetation index maps obtained from the study periods' near-infrared and red-bands showed that different NDVI values have different LU/LC. The value varies from area to area depending on the degree of vegetation potency, as NDVI have a value related to the vegetation condition. Forests and shrub land have relatively the highest NDVI value than the other groups. The graph displays that the blue line indicates the NDVI of 1990, the red line indicates the NDVI of 2000 and, the green lines indicate the NDVI of 2010 and the purple lines indicate that the NDVI of 2020 respectively. The graph shows the recent year 2020 have the lowest NDVI value.

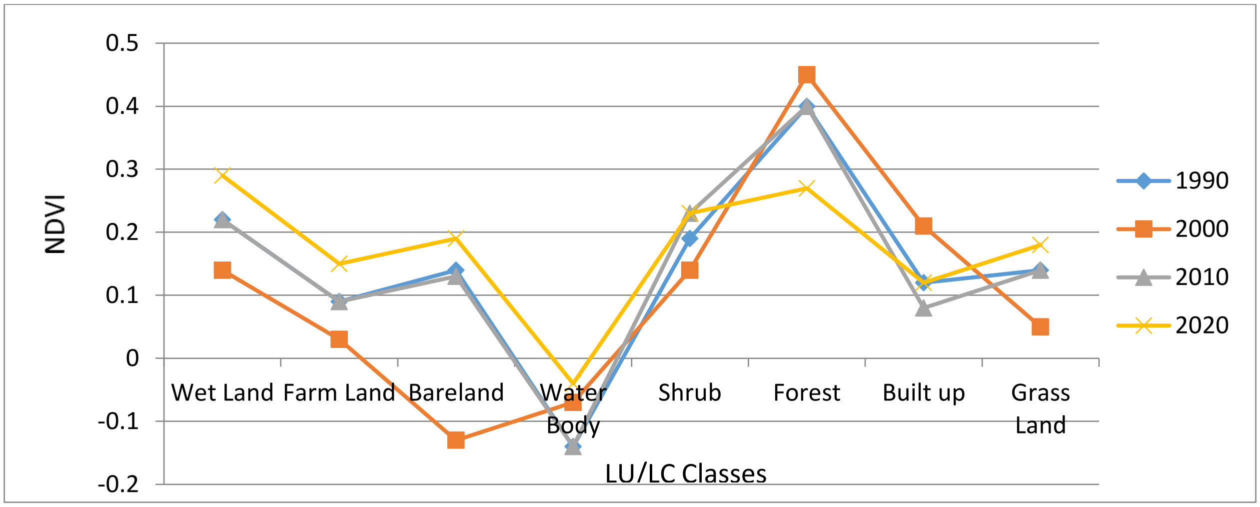


Figure 4. 6 Zonal Statistical description of NDVI in 1990, 2000, 2010 & 2020 over different LU/LC classes

4.2. The spatial pattern of Land Surface Temperature (LST) in the study area

Landsat TM 1990, ETM+ 2000, OLI/TIRS 2010, and Landsat 8 2020 OLI/TIRS thermal bands were used to obtain and quantify the LST from the study area. Analysis of such images found that the LST value of the study period differed from the LST value of the study period. The study period ranged LST value from 6.98 °C to 38.33°C highest LST value. As has been observed from the thermal images processed, there were relatively high temperatures in the south, southwest, and some southeastern parts of the study area. This is largely due to forms of height, slope, and LU/LC. Then again, the central parts and surrounded by mountains and the city area holds huge buildings, vegetated areas, and eucalyptus, and different trees that provide shades and lower the LST. In addition to that built-up portion of the study area is on the highland. Entoto, Yerer, and Menagesha area exhibited relatively low LST values.

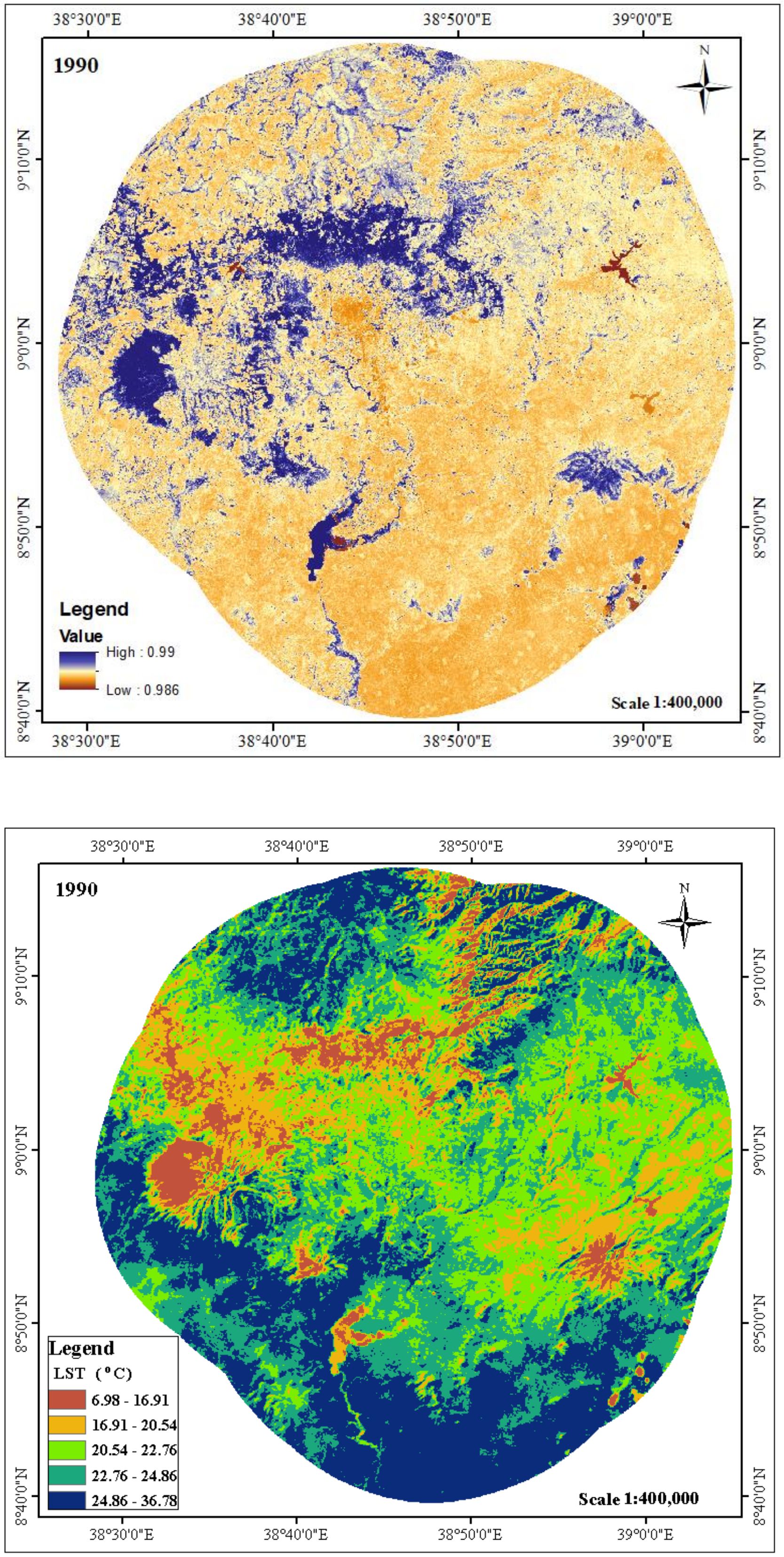


Figure 4. 7 (a) Emissivity and (b) LST map of the study area for 1990

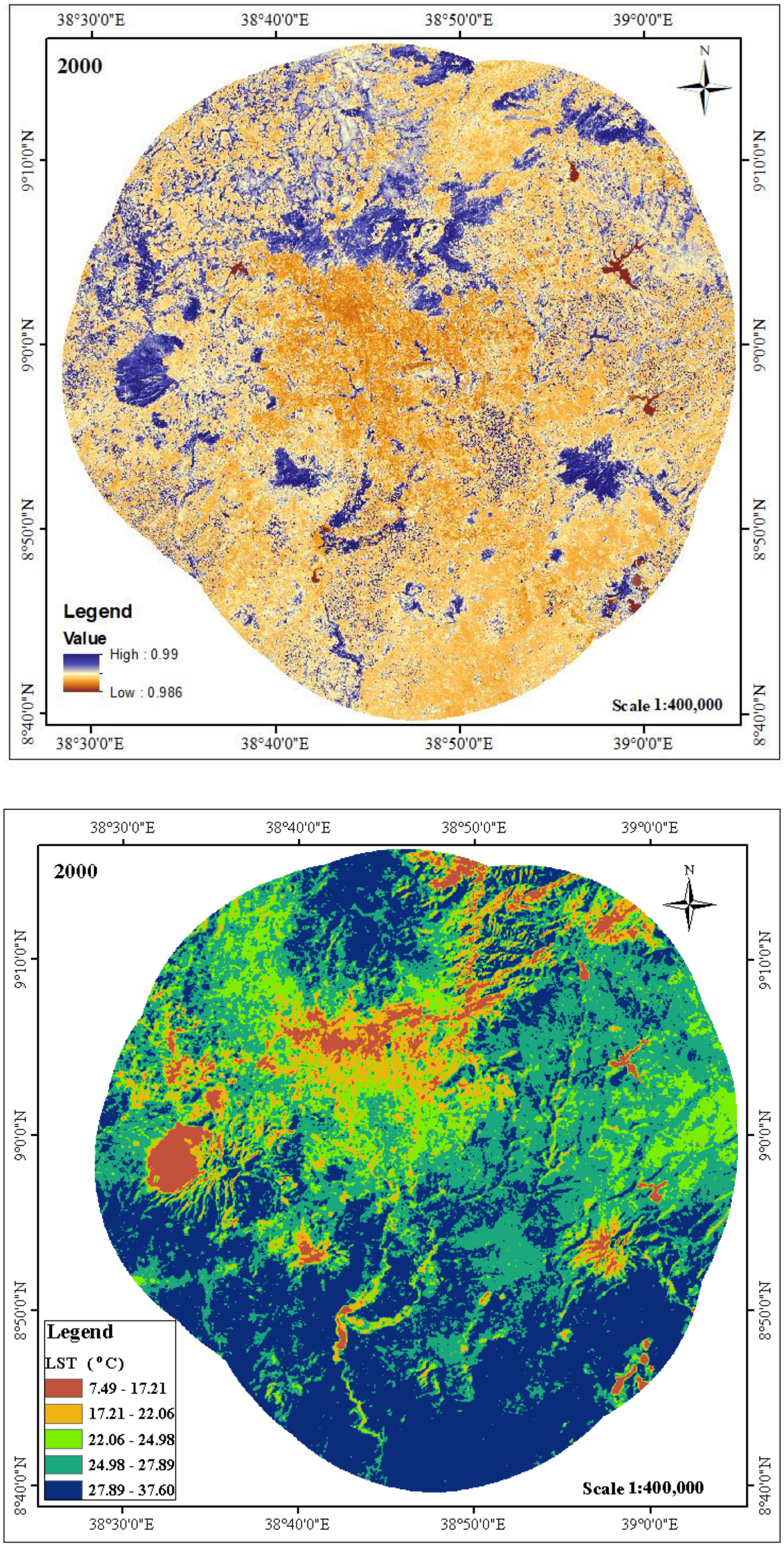
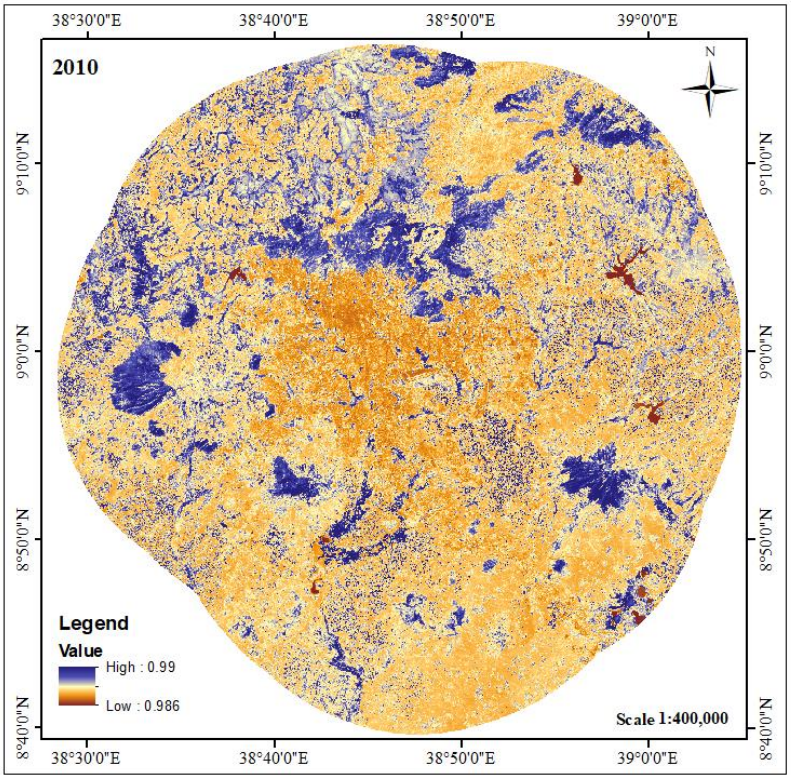


Figure 4. 8 (a) Emissivity and (b) LST map of the study area for 2000



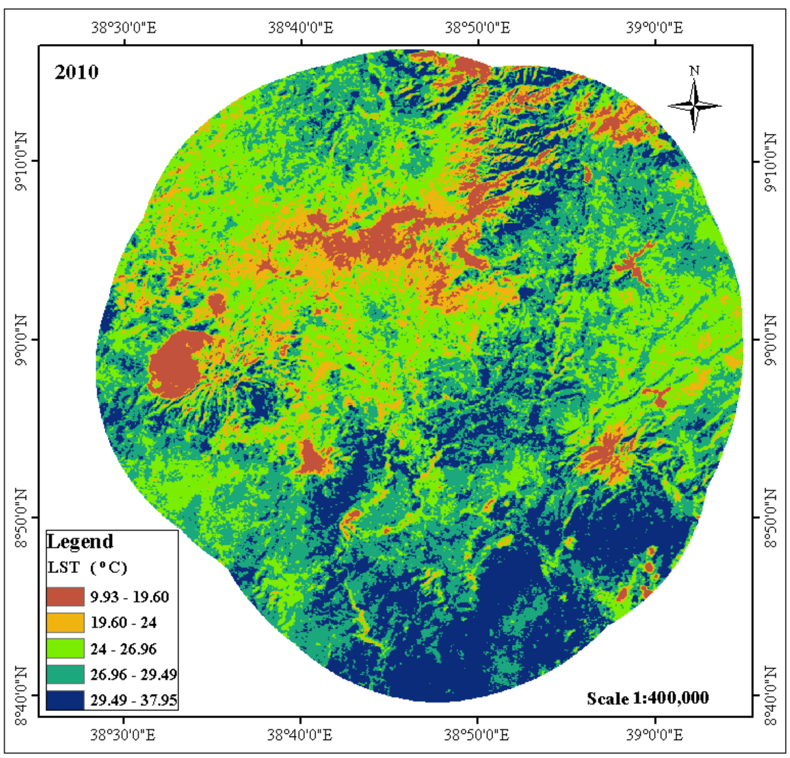
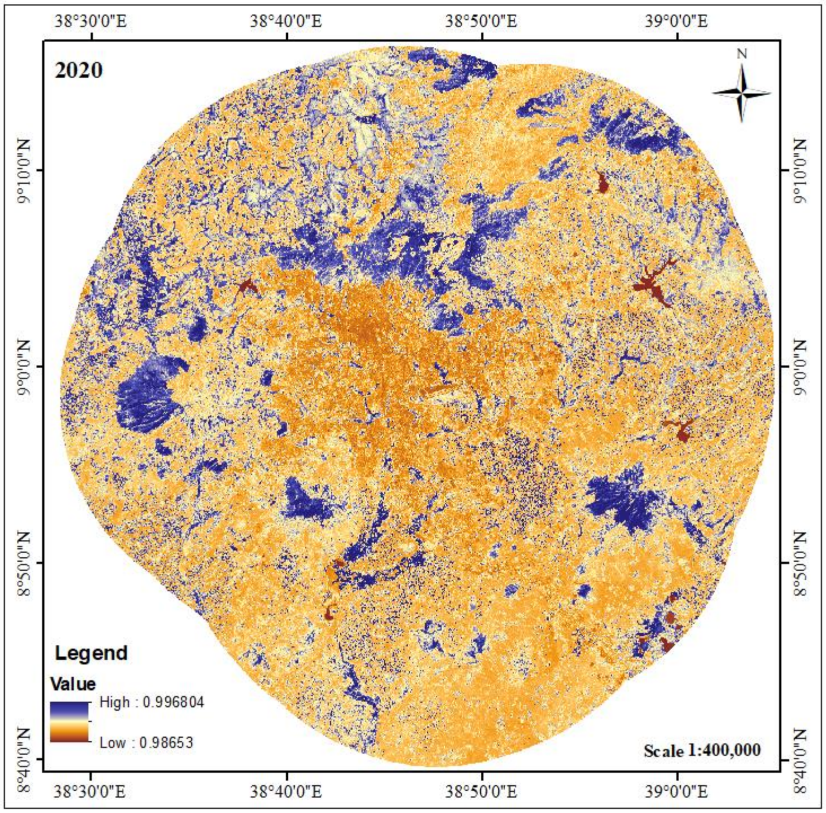


Figure 4. 9 Emissivity and LST map of the study area for 2010



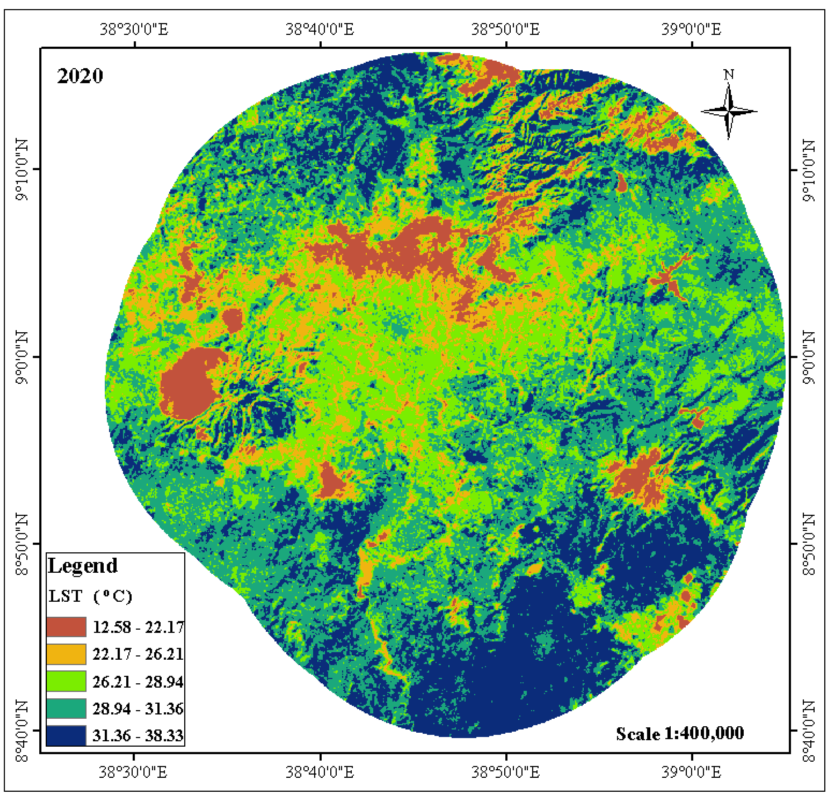


Figure 4. 10 Emissivity and LST map of the study area for 2020

4.2.1. Impact and relationship of land-use/land-cover change on land surface temperature

Land use /Land cover changes have an effect on land surface temperature. The changes in LU/LC resulted in difference in land surface temperature, particularly in the built-up area, farmland (after harvest), and bare land. The explanation behind farmland LU/LC classes of high LST was that the Landsat image used for the analysis were employed after the harvesting period and dry weather conditions. For each of the LU/LC classes, the LST value varies from one place to another place because of abundance of vegetation, sun intensity, altitude of an area and climate condition. The conversions of farmland, bare land, and other types of LU into settlement areas also contributed to the increase of LST. As observed in Figure 4.5 (Expansion of settlement area from the year 1990 to 2020), the built-up area has highly increased especially in the central, northern, and southern parts of the study area. In addition to that, the built-up area has increased in smaller towns located in the study area.

The types of land-use/land-cover and LST map of the study area showed how during the study period the categories and corresponding surface temperature of the land changed. Waterbody and Scrubland were respectively land-use/land cover categories that reported minimum temperature. In minimizing the LST, the waterbody and vegetated regions played a vital role. In another part of the city, vegetated areas and eucalyptus trees provide shade, which helps lower ground surface temperatures and reduce air temperature by evapotranspiration, in which plants release water into the ambient air. Relatively, on bare land, farmland, and built-up area has been registered the highest LST value. The LST value was maximum in bare land and farmland during the acquisition time of the image.

Table 4. 5 Mean temperature of 1990, 2000, 2010 & 2020 in the study area

Class Name	1990	2000	2010	2020
	Mean	Mean	Mean	Mean
Wet Land	22.45	25.1	26.33	28.1
Grass Land	23.33	27.58	27.11	30.5
Bare Land	23.68	27.16	28.24	30.84
Water Body	14.75	16.65	19.14	22.45
Shrub	21.02	24.24	24.23	26.01
Forest	15.09	17.38	18.04	20.19
Farm Land	23.46	27.07	27.96	30.13
Built up	21.32	25.28	25.52	27.99

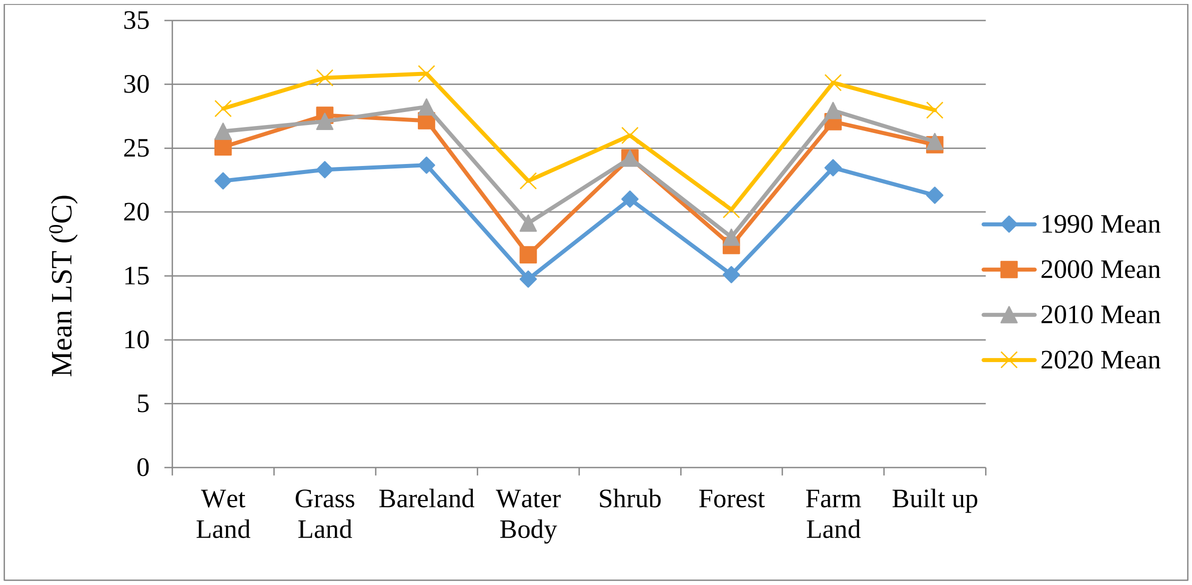


Figure 4. 11 Comparison of mean LST in different LU/LC during the study period in the study area

Table 4. 6 Temperature change during 1990-2020 in the study area

Class Name	Mean change in (^{0}C)			
	2000-1990	**2010-2000**	**2020-2010**	**2020-1990**
Wet Land	2.65	1.23	1.77	5.65
Grass Land	4.25	-0.47	3.39	7.17
Bare Land	3.48	1.08	2.6	7.16
Water Body	1.9	2.49	3.31	7.7
Shrub	3.22	-0.01	1.78	4.99
Forest	2.29	0.66	2.15	5.1
Farm Land	3.61	0.89	2.17	6.67
Built up	3.96	0.24	2.47	6.67

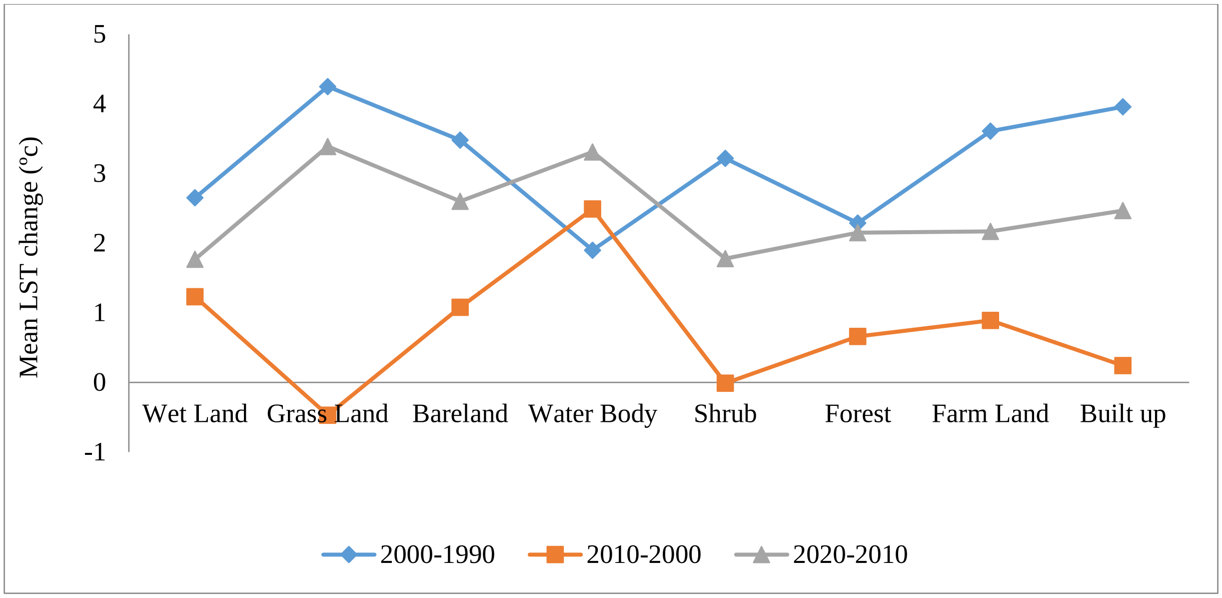


Figure 4. 12 Mean LST changes during 1990, 2000, 2010, and 2020 in the study area

From 1990 to 2000, the mean LST of Addis Abeba and its Surrounding area have higher by 2.7°C. Table 4.4 shows that all major LU/LC classes have been identified in the study period, increment in the LST. In grassland, bare land, farmland, and built-up areas, the highest mean LST has been recorded. Whereas, in water bodies, wetlands, and shrubs, the lowest mean LST was recorded. Comparisons of mean LST with groups of LU/LC for the study period, as shown in Figure 4.11. From 1990 up to 2020 LST increased significantly in the study area. (Table 4.6).

4.2.2. Relationship between normalized difference vegetation index and land surface temperature

The 1990, 2000, 2010, and 2020 Landsat images analyzed showed that NDVI and LST have inverse relationships. A low NDVI value has high LST values and low LST values have high NDVI values. In the case of the water body, however, the relationship between NDVI and LST has direct relationship since the value of both NDVI and LST was lower for the water body. The R2 values for the study period were 0.28, 0.18, 0.29, and 0.11 for the NDVI and LST correlations. In general, when we have high NDVI value the LST is lower & when we have low NDVI the LST increase therefore, a negative correlation was observed between the values of NDVI and LST. Figure 4.12 displays the land surface temperature and NDVI association for the years 1990, 2000, 2010, and 2020.

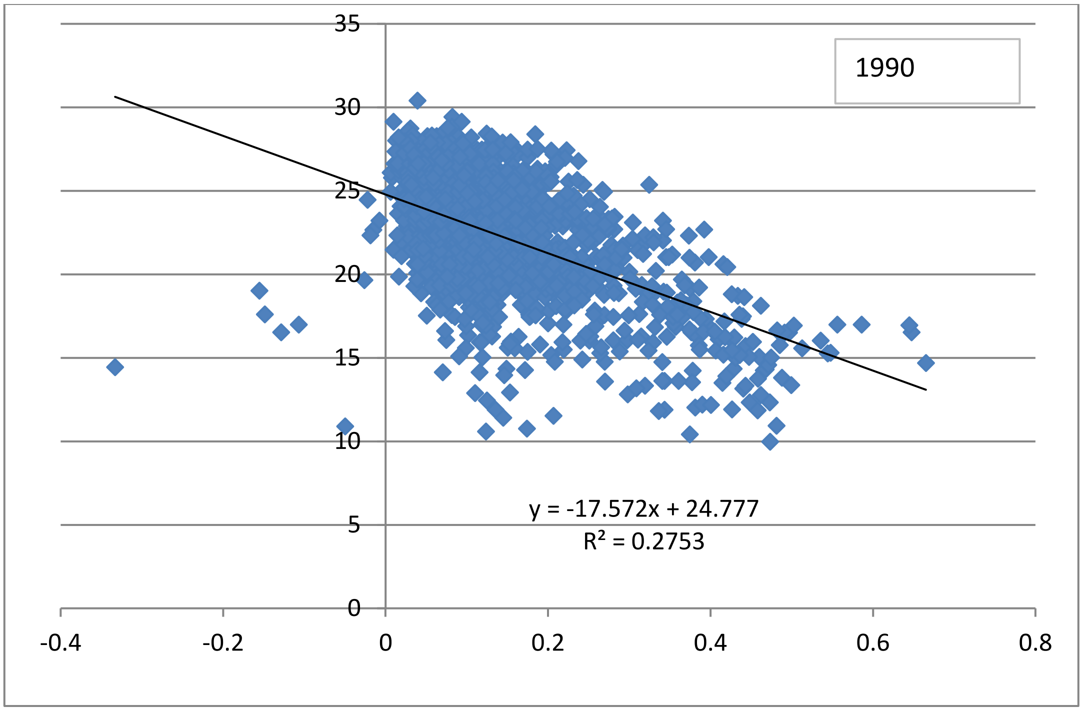


Figure 4. 13 LST and NDVI index correlation for the year 1990

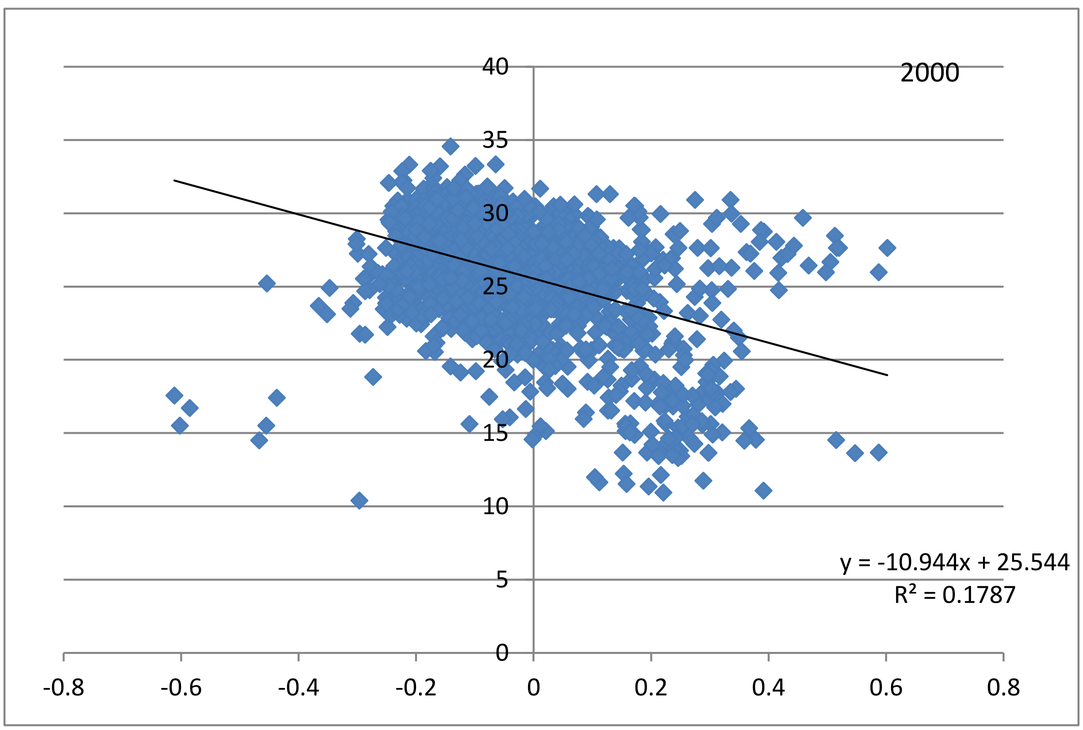


Figure 4. 14 LST and NDVI index correlation for the year 2000

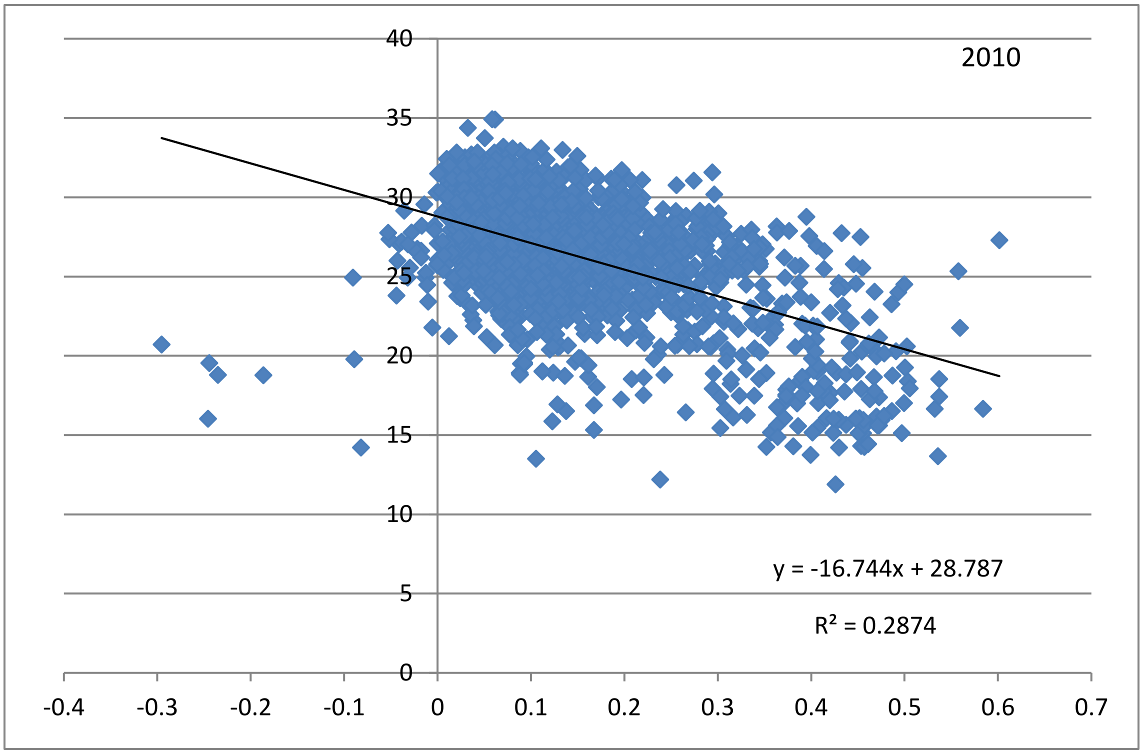


Figure 4. 15 LST and NDVI index correlation for the year 2010

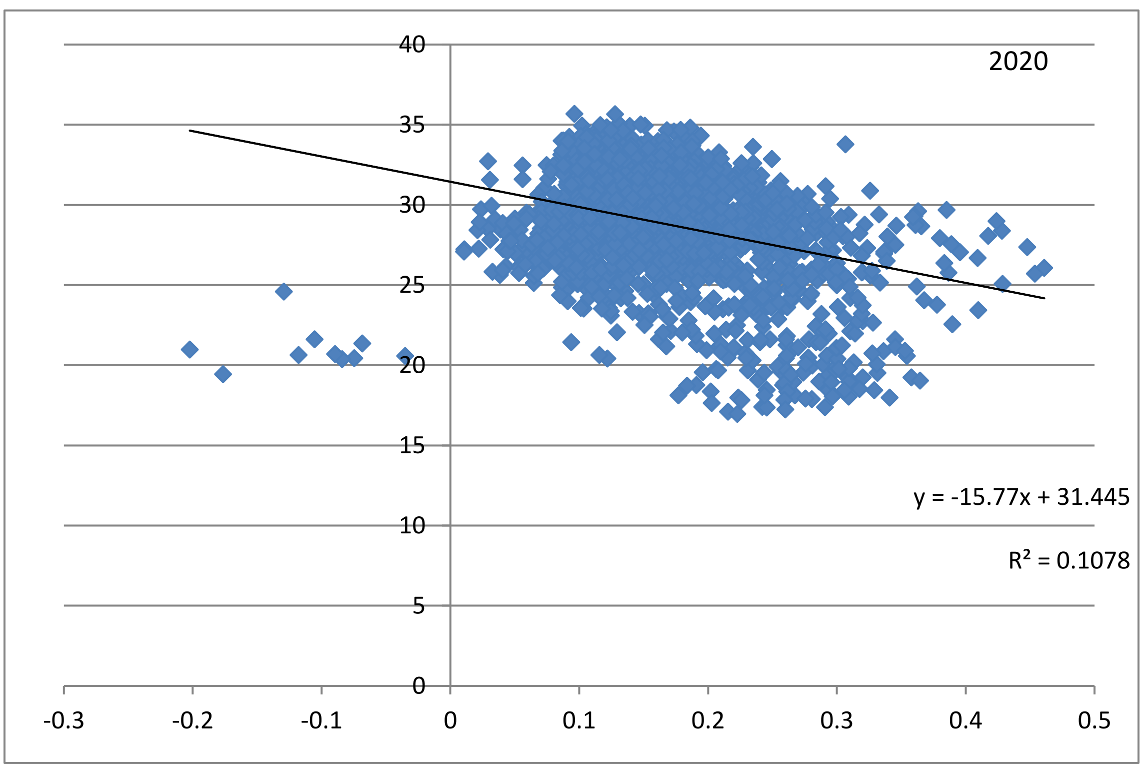


Figure 4. 16 LST and NDVI index correlation for the year 2020

CHAPTER FIVE

5. DISCUSSION

5.1. Land-use/land-cover status of Addis Abeba and the surrounding area during 1990 - 2020

LU/LC changes indicate that there is relatively higher population growth and the increase in needs of land for settlement and agriculture in the study area. These changes cause adverse impacts on the environment. The study by Houghton (1994), shows that the growth in human population, economy, technology, and environmental changes are the major factor liable for LU/LC inconsistency. Change of LU/LC has become most important troubles and a significant driving force of environmental changes (FAO 1999).

Alemayehu, (2008) shows the occurrence of drought, high temperature, flood, minimum rainfall, and increasing sea levels are the indicators of climate change. This study revealed that LU/LC changes severely in study area during the past 40 years. The area coverage of built-up was 10823.49 ha and grassland area was 27645.3 ha in 1990. In 2020 built up reached 89600.16 ha and grassland 59840.46. It indicates that there is growing needs of land for settlement, the agricultural expansion and shelter.

According to Ang Kean Hua& Owi Wei Ping, (2018) including a free zone of a less concrete structure can support to reduction raising the temperature effect. Well Planed urbanization, implementing a green building, and well managed LU/LC change decrease LST impact on the ecosystem.

5.2. Normalized difference vegetation index

The normalized difference vegetation index is a vegetation situation measurement and it is useful to find out about LST. The NDVI study was discovered as an appropriate measure of LST and dryness, according to Mihai (2012) and Weng (2004). The results of this research also showed that NDVI varies from the central parts of the study area to the southern, northern, and certain southeastern parts of the study area and dominated by bare ground, farmland, and shrub land categories. In this analysis, the correlation coefficient between NDVI and LST was evaluated and R2 values accounted for 28 percent for the year 1990, 0.18% for 2000, 0.29 % in 2010 and 0.11 for 2020 which demonstrates how the vegetation condition influences the area's LST and NDVI in the LST distribution. In line with this, the present study revealed that, except for the water body class, NDVI has inverse relationship with LST

5.3 Land surface temperature

In quantifying the LST of the field, a thermal band of the Landsat image was used. Settlement, farmland and bare land have the highest LST. The primary reason behind lower NDVI and high LST values in the farmland LU/LC class is that the imagery was acquired during the dry season and January during harvesting period. Because of the primary harvesting season in Ethiopia (November, December, and January), Farmland, bare land, and settlement types show high surface reflectance. The land was very dry after harvesting crops and, at the same time, the land reflectance was high. For water body (zero) bare ground, and settlement and farmland classes, the Normalized Difference Vegetation Index value is lower. The values were, however, relatively high in the case of forest and shrub land. It is necessary to find the relationship between the LU/LC type and LST type to assess the thermal status of the surface of the ground by satellite.

The normalized differences vegetation index plays an important role in LST evaluation and investigation. Except in the case of the water body, land surface temperature and NDVI have indirect relations in various LU/LC groups. There are low NDVI and LST values in the Water body LU/LC class. Vegetation status (NDVI value) and LU/LC categories have an effect on the value of LST. This does not mean, however, that the LU/LC type is the only factor in the increase in LST. In moderating the surface temperature of a particular area, there are many other contributing variables to increase or decrease the LST value, such as trees and massive building shades. Trees have great importance over grasslands, also, that they cool surface while absorbing most of the strongest built surface; the planting pit is much smaller than their canopy, and the shade the canopy brings is cast over a larger surface area than the canopy area. Surface temperatures have much wider differences, with surface temperatures on hotter than grass areas (Armson *et al.,* 2012)

Besides, plants can improve thermal relief and human health, increase psychological balance, and make cities more impressive, leaf color and shape also significant, decrease co_2 release.

In and out of tree shade can offer a good indication of how it affects human thermal comfort. In a previous study, the authors have shown that constant tree shade can reduce mean radiant temperatures (Armson *et al*., 2012).

Different researchers used thermal bands to study LST. Hiwot Abreha, (2012) used Landsat and spot images to study the impact of LU/LC on the LST of Addis Abeba. The study investigates the interaction between LU/LC, LST, and NDVI. A negative relationship between NDVI and LST values is suggested by Hiwot, (2012). But, in this case, the water body should be considered an exception, as the water body has low NDVI and LST values. During the study period, the result of the current study shows that different LU/LC values have different NDVI and LST values.

Small-scale farmers moved to settle in open area shrub land and unplanned use of land resources was the key aspect of an increase in LST settlement area expansion (Belete, 2017). The relationship between land cover changes, biodiversity, and land degradation is very high in less developed areas; because of that land cover is transformed at the cost of forest and vegetation into a human settlement area, farmlands, and grazing lands (Maitima *et al.*, 2009). Regarding LU/LC changes in the study area, with the expansion of settlements, water body and Vegetation (forest, shrub land, grassland, wetland, and open space) and farmland have highly declined. This is particularly observed in the study area. In this area, small-scale farmers moved and began to occupy open space and shrub land, grassland, and forest as a result of the expansion of the settlement area. According to Lemi, (2018), rapid settlement, mismanagement, and poor agricultural practices which were responsible for the change in the study area affect land use management and environmental sustainability.

In this study area, at around Mt Entoto Mt, Yeka mt, and Mt Yerer area, there was dense forest. This area was, however, deforested over time and converted into farmland and settlement. The study area is thus severely deteriorated and vulnerable to natural hazards such as soil erosion. However, as evident from the classified satellite images, LU/LC has a positive effect on the atmosphere often. For instance, the conversion of exposed area (bare land) to plantation LU/LC type helps to control the increment of LST.

The normalized vegetation difference index and the LST have an indirect relationship. That may, however, be a direct relationship, especially in the body of water. Burgan and Hartford (1993), states that Water, clouds, non-reflective surfaces and other non-vegetated areas are indicated by negative values, while positive values reflect reflective surfaces such as vegetated areas. It does not, however, imply that all negative NDVI values have high LST values. The surface temperature of the land relies on the reflective conditions of the earth's surface. In general, there is a high LST in the area of non-vegetated and non-reflective surfaces compared to vegetated and water bodies.

There are eight major LU/LC classes, according to the outcome of this research, and the LST value varies for each class. Waterbody and vegetation classes (forest, shrub land, grassland, and wetland) have the lowest LST value whereas settlement; bare land and farmland class have the maximum LST. The spatial and temporal distribution of LST during the years 1990 and 2020 showed that extreme changes occurred in the region during the study period. The distribution of the LST value in 1990 was between 6.98 ^{0}C and 36.78 ^{0}C, minimum and maximum respectively, while the minimum and maximum LST values ranged from 7.49 ^{0}C to 37.60 ^{0}C respectively in 2000, the minimum and maximum LST values in 2010 were 9.93 ^{0}C & 37.95 ^{0}C and minimum and maximum 2020 ranges from 12.6 & 38.3 respectively.

5.4.Impact of Land surface temperature Increase on the Environment

The land surface temperature increase has major impact on the environment. LST rise contributes to air temperature increase which causes respiratory disease, heart disease, and allergies. The increment of LST affects air quality because while the temperature increases it will be easy for bacteria to spread. In addition to health problems, the high surface temperature increases evapotranspiration. Household energy consumption, construction material & process, emission of greenhouse gases contributes to the LST increment.

According to WHO, (2013) Environmental change could cause heat related mortality and morbidity. Cold related health problem and death is decreasing. Infectious disease, heart disease allergies flooding and drought are frequently happening due to result of climate change. Delayed costs of weather disaster on human health are hard to measure.

Rapid population growth has caused in the increase of new cities, industries, vehicles, and infrastructures. Urbanization and industrialization have been influenced in the drastic change of land cover types around the world. This has resulted in the extensive environmental changes around the world. Global warming, changes in ecosystems, climate change, greenhouse emissions, increase of sea level and many other problems are increasing day by day due to the massive transformation of land cover types. Currently urbanization have adverse effects on the ecosystem. (Solomon, 2007)

According to E. Igun & M. Williams, (2018), his study indicates that need for city planners to incorporate green spaces and tree covers with urban development actions. Besides, to help regulate urban temperatures, the right trees should be planted in the right place which could be areas where high temperatures are expected or recorded. Other urban sustainability practices like green walls and green roofs which are presently being used to moderate urban temperatures in cities around the world could also be adopted by city planners. This would support in improving the livability index as well as realize environmental sustainability.

CHAPTER SIX

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

For various applications, such as LU/LC change detection and environmental protection programs, satellite data is functional. Landsat imagery has the ability to investigate the dynamics of the LU/LC and to analyze the LST spatio-temporal distribution. To assess and examine the effect of LU/LC changes on LST, the current study used Landsat TM 5 and Landsat 8 OLI/TIRS images. The land surface temperature and LU/LC derived from Landsat data provide valuable information to track human activities and changes in the environment. In Addis Ababa and the surrounding area, it was revealed that Landsat images are very useful in quantifying and mapping LU/LC transition, NDVI, and LST. Economic and natural resources and their utilization in time and space have been linked to the LU/LC pattern of the study area. The wetland, water body and vegetation groups (forest, shrub land & grassland) have the lowest LST value, while built-up area has the highest LST value; the highest LST is the bare land and farmland class relatively in the study area (See page 46-48). In the current study area, land-use/land-cover has changed from time to time. Changing land-use/land-cover has an impact on LST. The minimum and maximum LST have been increased each year. In monitoring LU/LC changes and tracking temperature variations and conditions in the area, the calculated LST therefore plays an important role. The conclusion of this study showed that during 1990, 2000, 2010, and 2020, LSTs in Addis Ababa and the surrounding area increase (see page 47 & 48). This was because of changes in LU/LC, human activities, and the area's climate variability. A high variation in LST between different types of LU/LC was indicated by the land surface temperature of the zone. It has been found that the derived LST values from satellite data are in perfect harmony with the interpolated temperature values from the weather stations used. Somehow, the derived NDVI values from satellite data are also a good indicator of the study area's LST status. Therefore, the use of GIS and remote sensing data to explore the differences in the study area in LST and various LU/LC class patterns demonstrates that it suggests a faster and more cost-effective technique with the benefit of covering a large area.

6.2 Recommendations

The aim of this study was to evaluate and investigate the impact of LU/LC changes based on Landsat images from 1990, 2000, 2010, and 2020 on LST in Addis Ababa and the surrounding area. The study showed that for each LU/LC class, the conversion of LU/LC types to another type of LU/LC types, such as from vegetation area to farmland, farmland to settlement, and the LST value was different. There is a case, however, in which the change could have a beneficial effect on LST. The planting of eucalyptus trees and some perennial crops, for instance, contributed positively to the low LST value. Therefore, recommendations were drawn on the basis of the outcome of this study as follows: -

- In existing strategies for managing resources and controlling environmental changes, land-use/land-cover change is a critical element. Therefore, high attention should be paid to the proper management of land use and the ecological impact of each LU/LC by governmental and non-governmental bodies.
- Urban greening helps to moderate both surface and air temperature of an area.
- Use environment friendly construction material to reduce the impact of LST due to construction material and process.
- Promoting cooperation between organizations and institutions is crucial to implement the land management plan. EFCCC, EEFRI
- Raise awareness of local people about land-use practices and establish mitigation measures
- Conservation measures in both the rural and urban green areas of the study area should be conducted and planting trees and delineating green areas should be recommended, in particular in high-density communities and bare land areas.
- Government Should Organize and support new management and Land use plan.
- LU/LC improvements should be monitored by land management authorities and environmental experts by various steps to minimize the effects on the environment.
- As an input for future scholars who want to study the effect of LST spatio-temporal change, the results of this research will help.

References

A. J. Prata, V. Caselles, C. Coll, J. A. Sobrino & C. Ottlé (1995) Thermal remote sensing of land surface temperature from satellites: Current status and future prospects, Remote Sensing Reviews.

Alemayehu Mengistu (2008). Climate Variability and change. Ethiopian journal of Animal production.

Aires, F., C. Prigent, W. B. Rossow, and M. Rothstein, (2001), A new neural network approach including first-guess for retrieval of atmospheric water vapor, cloud liquid water path, surface temperature and emissivity over land from satellite microwave observations, J. Geophys.

Anantharaj, V. G., Fitzpatrick, P. J., Li, Y., King, R. L. & Mostovoy, G. V. Impact of land use and land cover changes in the surface fluxes of an atmospheric model. In International Geoscience and Remote Sensing Symposium (IGARSS)

Andrew Farina, (2012) Exploring the relationship between land surface temperature and vegetation abundance for urban heat island mitigation in Seville, Spain, Lund University

Ang Kean Hua & Owi Wei Ping (2018) The influence of land-use/land-cover changes on land surface temperature: a case study of Kuala Lumpur metropolitan city, European Journal of Remote Sensing.

Armson, D. & Stringer, Pete & Ennos, Roland. (2012). The effect of tree shade and grass on surface and globe temperatures in an urban area. Urban Forestry & Urban Greening.

Belete Tafese, (2017), Impact of Land use /Land cover changes on Land Surface Temperature in Adama Zuria wereda, Ethiopia, using Geospatial tools

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

Berg, P.; Moseley, C.; Haerter, J. Strong increase in convective precipitation in response to higher temperatures. Nat. Geosci. (2013)

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

Dash, P., Gottsche, F. -M., Olesen, F. -S., & Fischer, H. (2002). Land surface temperature and emissivity estimation from passive sensor data: Theory and practice-current trends. International Journal of Remote Sensing.

Dubayah, J.Dozier & F.W.Davis .(1990)Topographic distribution of clear-sky radiation over the Konza Prairie, Kansas

Dwyer, John & Mcpherson, E. & Schroeder, Herbert & Rowntree, Rowan. (1992). Assessing the benefits and costs of the urban forest. J. Arbor. 18.

Emilio, C. (2008). The role of satellite remote sensing in monitoring the global environment.

Dr. F. Escobar, Assoc Prof G. Hunter, Assoc Prof I. Bishop, Dr A. Zerger. Introduction to GIS, Department of Geomatics, The University of Melbourne).

FAO/ UNEP. (1996). Our land our future, FAO/AGLS. Rome. P48.

FAO/UNEP. (1999). Terminology for integrated Resources Planning and Management. Food and Agriculture Organization/United Nations Environmental Program, Rome, Italy and Nairobi, Kenya.

Fu, P. & Weng, Q. A time series analysis of urbanization induced land use and land cover change and its impact on land surface temperature with Landsat imagery. *Remote Sens. Environ.* **175**, 205–214 (2016).

E. Igun1 & M. Williams, (2018). Impact of urban land cover change on land surface temperature

James MM, Mundia CN (2014) Dynamism of land use changes on surface temperature in Kenya: a case study of Nairobi City. Int J Sci Res

Jie Tan 1, De Yu 2, Qiang Li3, Xuelan Tan4 &Weijun Zhou4, (2020). The spatial relationship between land-use/land-cover changes and land surface temperature in the Dongting Lake area, China.

Jing, J., and Guangjin, T. (2010). Analysis of the impact of land use/land cover change on land surface temperature with remote sensing," International Society for Environmental Information Sciences 2010 Annual Conference (ISEIS)

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

Hiwot Abreha, (2012). Impact of Land Use and Land Cover Change on Urban Climate: the case of Addis Ababa city, Ethiopia

Houghton, R. A. (1994). The worldwide extent of land-use change. Bio-Science

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

Kemp, Karen. (1997). The NCGIA core curricula in GIS and remote sensing.

Keramitsoglou, Iphigenia & Kiranoudis, Chris & Ceriola, Giulio & Rajasekar, Umamaheshwaran. (2011). Identification and analysis of urban surface temperature patterns in Greater Athens, Greece, using MODIS imagery. Remote Sensing of Environment.

Kikon, Noyingbeni & Singh, Prafull & Singh, Sudhir & Vyas, Anjana. (2016). Assessment of Urban Heat Islands (UHI) of Noida City, India using multi-temporal satellite data. Sustainable Cities and Society.

Lemi Elala, (2018), the impact of Land use /Land cover Dynamics on land management the case study of Adama Zuria District, Oromia Region Ethiopia

http://www.ltrs.uri.edu/research/LST.htmaccessed on: Oct .18, 2019.

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

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

Mohan, M. & Kandya, A. Impact of urbanization and land-use/land-cover change on diurnal temperature range: A case study of tropical urban airshed of India using remote sensing data. Sci. Total Environ. 506–507, 453–465 (2015).

Paul, S. et al. Weakening of Indian Summer Monsoon Rainfall due to Changes in Land Use Land Cover. Sci. Rep. 6, 1–10 (2016).

Punyatoya Patra, (2016) Remote sensing and Geographical Information System, University of Delhi

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

Nowak, David & Dwyer, John. (2010). Understanding the Benefits and Costs of Urban Forest Ecosystems.

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

Sara Afrasiabi Gorgani, Mahdi Panahi and Fatemeh Rezaie (2013). The Relationship between NDVI and LST in the urban area of Mashhad, Iran

Schmugge, T., Hook, S.J. and Coll, C. (1998). Recovering Surface Temperature and Emissivity from Thermal Infrared Multispectral Data Remote Sensing of Environment.

S. Youneszadeh, N. Amiri, and P. Pilesjo (2015) The Effect of Land use change on Land Surface Temperature in the Netherlands

Solomon, S., D. Qin, M. Manning, M. Marquis, K. Averyt, M. M. B. Tignor, H. L. Miller Jr., and Z. Chen, Eds., (2007: Climate Change 2007) The Physical Sciences Basis. Cambridge University Press.

Sun D.and Rachel T. Pinker. (2003). Estimation of land surface temperature from a Geostationary Operational Environmental Satellite (GOES-8), J. Geophys.

Twan Rovers, (2016) The Impacts of Urban Heat Islands on Northwestern European Cities, Luleå University of Technology

Tzortzi - Georgi, Nerantzia - Julia & Dimitriou, Dimos. (2010). The contribution of urban green spaces to the improvement of the environment in cities: A case study of Chania, Greece. Building and Environment.

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

World Health Organization (WHO), (2013). Climate Change and Human Health - Risks and Responses.

Yue, W., J.Xu.W.Tan and L.Xu. (2007). the relation between land surface temperature and NDVI with remote sensing: application to Shanghai landsat7ETM+data” international journal of remote sensing.

Zhengming, Wan & Dozier, Jeff. (1989). Land-surface temperature measurement from space: physical principles and inverse modeling. Geoscience and Remote Sensing, IEEE Transactions on. 27. 268 - 278

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W	URL: https://www.researchgate.net/publication/334596164_Estimation_of_Land_Use_Change_t ... Fetched: 7/23/2020 9:32:29 AM		1
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