Assessment of the Effect of Land Use Land Cover Change on Surface Temperature Using GIS, RS and SPSS. A Case of Wolkite Town.

Wabi Sifire Shimura

A Thesis Submitted to

The Department of Geomatics Engineering

School of Civil Engineering and Architecture Presented in a Partial Fulfilment of the Requirement for the Degree of Master's in Geo-Informatics Engineering

Office of Post Graduate Studies

Adama Science and Technology University

July, 2021

Adama, Ethiopia

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Major Advisor**: - Dr. Roba Gemechu**

Co-Advisor**: - Dr. Boja Mekonnen**

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APPROVAL SHEET

I/we, the advisors of the thesis entitled "Assessment of the Effect of Land use Land Cover change on Surface Temperature using GIS, RS and SPSS. A case of Wolkite Town" and developed by Wabi Sifire Shimura, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Dr. Roba Gemechu ______________________ _______________

Major Advisor Signature Date

Dr. Boja Makonnen ______________________ _______________

Co-advisor Signature Date

We, the undersigned, members of the Board of Examiners of the thesis by Wabi Sifire Shimura have read and evaluated the thesis entitled "Assessment of the Effect of Land Use Land Cover change on Surface Temperature using GIS, RS and SPSS. A Case of Wolkite Town" and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Geo-informatics.

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Chairperson Signature Date

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Internal Examiner Signature Date

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External Examiner Signature Date

Finally, approval and acceptance of the thesis is contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

_____________________________ ____________________ __________________

Department Head Signature Date

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School Dean Signature Date

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Office of Postgraduate Studies, Dean Signature Date

DECLARATION

I hereby declare that this Master Thesis entitled “Assessment of the Effect of Land Use Land Cover change on Surface Temperature using GIS, RS and SPSS. A Case of wolkite Town” is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation

Wabi Sifire Shimura ______________________ _______________

Name of the student Signature Date

RECOMMENDATION

I/we, the advisor(s) of this thesis, hereby certify that I/we have read the revised version of the thesis entitled “Assessment of the Effect of Land Use Land Cover change on Surface Temperature using GIS, RS and SPSS. A Case of Wolkite Town” prepared under my/our guidance by Wabi Sifire Shimura submitted in partial fulfillment of the requirements for the degree of masters of Science in geo-informatics engineering. Therefore, I/we recommend the submission of revised version of the thesis to the department following the applicable procedures.

Dr. Roba Gemechu	________________________	________________
Advisor	Signature	Date
Dr. Boja Mekonnen	________________________	________________
Co-advisor	Signature	Date

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ACRONIMES

DEM	Digital Elevation Model
ETM	Enhanced Thematic Mapper
ERDAS	Earth Resource Data Analysis System
GIS	Geographic Information system
FAO	Food Agricultural Organization
SE	Surface Emissivity
RS	Remote Sensing
ST	Surface Temperature
LULC	Land Use Land Cover
NMA	National Metrological Agency
NDVI	Normalized Vegetation Index
OLI-	Operational Land Imagery
PV	proportion of Vegetation
TM	Thematic Mapper
USGS	United State Geological Survey
SPSS	Statistical Package for the Social Science

ABSTRACT

The human being factors and urban expansion has a great role on changing surface temperature and changing environmental conditions. This thesis is focused on a basic objective of assessment of the effect of land use land cover change on surface temperature in the case study of Wolkite Town. The Town is experiencing rapid urbanization, limitation of green area aesthetical values and unproportioned land use design problems that has resulted in remarkable surface temperature. The geospatial tools and special package for social science tool used for analysis purpose. This study tries to investigate and identify land use types which have the most influence to the increase of surface temperature in wolkite Town. For the present thesis Landsat5 thematic mapper images of 1990, Landsat7 enhanced thematic mapper image of 2000 ,2010 and Landsat8 of image 2020 was obtained from united states geological survey for the study area. Using bands 1-5 and 7 of the pre-processed images the land use land cover pattern was mapped by supervised classification with the maximum likelihood classification algorithm of ERDAS imagine 2014 software and the correlation between surface temperature and normalized difference vegetation index Analyzed by spatial package for the social science tools. Three classes considered for the study are Urban Settlement, green area and Agricultural Land, from the three-class agricultural land and urban settlement have a great domination in study area and covers 85.03% from the total area coverage. The significant change of agricultural land was -35.56% and similarly in urban settlement net change is +35.77%. The result showed that maximum air temperature was observed in built up areas of the city with the value of 34.7^{0}c at 2020 and minimum temperatures are observed in areas where green area and agricultural land values are 18.9^{0}c at 1990. Normalized difference vegetation index is found to have negative correlation with ST at a value of -0.98 and the Pearson significance value were 0.002. The thesis that appropriates strategies are necessary for the sustainable management of the urban area and environmental protection management.

Key words: surface temperature, land use land cover and normalized difference vegetation index

CHAPTER I: INTRODUCTION

1.1. Back Ground of The Study

A rapid urban settlement expansion and human factor have severely altered the biophysical environment. The expansion of urban settlement has significant influence on different aspects of the quality of life and research in determining the patterns of urbanization and quantifying their impacts is the need of the hour. Unplanned urbanization sprawl will directly affect the land use and land cover of the area. The changes in land use/cover include loss of Agricultural lands, loss of forest lands, increase of barren area, increase of impermeable surface of the area because of the built-up area, etc (Cosku HG.2008).

Development of land use land cover is very much useful to the city planner and policy makers. For the sustainable urban ecosystems, the amount of land required for growing the vegetation can be estimated from these studies (Ashis Sarkar, 2019). The major factor for increasing of surface temperature and development of Urban Heat Island. Surface temperature is increased by adynamic heat discharges due to energy consumption, increased land surface coverage by artificial materials having high heat capacities and conductivities, and the associated decrease in green area like vegetation cover and water pervious surfaces which reduce the surface temperature through evapotranspiration. Landsat8 images are widely used to observe and model the biophysical characteristics of the land surface. In addition to the identification of Land use/cover maps band 6 for landsat4 and landsat5 as well as band 10 and 11 of the Landsat8 imagery is useful for deriving the surface temperature. Many researchers used the Landsat imagery to develop land use/cover images as well as temperature images. K.C. Seto stated to monitored the land-use change in the Pearl River Delta using Landsat TM (K. C. Seto et al., 2002).

According to United State Environmental institute Agency suggest that 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 (Kikon, et al., 2016). Major causes of environmental changes are due to the various anthropogenic activities that are integrated not only with the present but also with the past. The common problem, especially urban settlement, directly affect the surface temperature due to the conversion of vegetation surfaces into impervious surfaces (Zhang et al., 2013). According to (Ziaul 2017), the changes in land use will affect the degree of absorption of solar radiation, surface temperature, evaporation rate, transmission of heat soil, heat storage and wind turbulence. Also, this will result in an alteration in the near-surface atmosphere, energy, water balance, as well as environmental processes in the cities (Balakeristanan, 2012).

Land feature and its environment have been modified for thousands of years due to human induced activities. These changes are intensified by high population pressure, migration, and socio-economic activities. The changes have been found in various spatial scale from local to global level (Mahmood R, 2010). Different human activities like agriculture and settlement expansion are continuously decreasing the vegetative cover of the earth's surface. Consequently, the concentration of carbon dioxide is increasing in the atmosphere which in turn detecting the surface energy budget there by producing changes in local, regional and global climate (Lilly Rose A, 2009). Uncontrolled population growth and the rapid development of world-wide urbanization have an extreme impact on the environment (Coskun HG, 2008). Urban expansion and industrialization have been increased from time to time with the escalation of population number and rural-urban migration particularly in developing countries.

The progress of urbanization settlement is concerned with the conversion of land use/land cover. the conversion in arable land to paved surface has resulted in decline in natural land cover especially vegetation. Rapid town expansion process brought about many eco-environmental problems, such as the drastic change of land use and development of urban heat island (Jiang J, 2010). The land cover changes modify amount of absorption of solar radiation, evaporation rates, thermal storage of surfaces and wind turbulence. Identification of the natural environment by human being through urban development and expansion has a major impact on the urban microclimate at local and global climate in wider scale. One major phenomenon that arises as a result of this exploitation is the increase in land surface temperature (Igun E, 2018). The major problems that counter for facilitating surface temperature is unbalanced urban design and giving a less attention for natural environmental balanced elements like vegetation coverage, recreational area around urban settlement and giving a great value for aesthetical areas. Wolkite town is one of the administrative areas of Gurage Zone, the town has been characterized by rapid urban expansions, population growth and lack of good urban design problems. Due to that the land class of the town change time to time and those unfortunate change of land covers facilitate for surface temperature increment.

1.2. Statement of the problem

Urbanization and unplanned human activity are continuously decrease the vegetation cover of the earth’s surface to cause environmental changes, especially the terrestrial ecosystem at local, regional, and global scales (Kikon, et, al, 2016). Due to the increase of population, industrialization and other natural and human activities, its land-use/land-cover patterns are changing. One of the main factors that responsible for the increment of ST is land-use land-cover change. Now a day the world global warming and environmental change are a series headache for both developed and under developed countries. In Gurage Zone Wolkite Town land surface temperature has been increasing from season to season and one of the major problems are unproportionally urban land use design. Therefore, what signifies the relevance of this study is a wide array of applications that gives information of ST and LU/LC status of the area as an input for planning and decision making.

In this thesis work, RS, GIS (geospatial tools) and SPSS tools were used to examine and better understand LU/LC, the relationship between LU/LCC and ST of Wolkite Town. The basic argument why this thesis work proposed and done in South Region, Gurage Zone Wolkite Town is that, the area is characterized with rapid climate change, topographic pattern, different land-use land-cover change and unbalanced urban expansion are highly dominated. In addition to that previously Wolkite Town authorized body don’t given a great attention for this rapid surface temperature on this study area and also no one can support by investigation based on evidence.

1.3. Objectives of the study

1.3.1 General Objective

The general objective of this thesis is to assess the effect of LU/LC change on ST in wolkite Town using GIS, RS, SPSS and applying techniques.

1.3.2 Specific objective

To conduct the general objectives the following five specific objectives were formulated. Those are to: -

- Identify the spatial change in the surface temperature in relation to LULC
- Determine the role of NDVI in ST
- Identify their correlation of each LULC with ST and NDVI

1.4. Research Question

- What are the spatial patterns of LU/LC changes of the study area?
- what is the major role of NDVI in ST?
- How LULC are correlated with NDVI and ST in the study area?

1.5. Scope of the study

The present study was conducted in the Wolkite Town South Region; Ethiopia. The study areas have different land-use/land-cover patterns and the LU/LC has been changing from time to time. As a result, ST of the town has been rising from time to time. However, the increase of ST is not supported by research rather than perception of local communities. In order to know and compute the trend of LU/LC change, to know the correlation between ST and NDVI with Land-use land-cover (LU/LC). For each land-use/land-cover classes the ST values assessed and LU/LC classification should be supported by field verification. Increasing ST leads to environmental problem such as climate change and seasonal fluctuation. Unless land for urban settlements and agricultural land properly managed, it can affect and have a negative impact on the environment. Therefore, to overcome this problem, the present thesis study would contribute for decision makers as information and identifying different LU/LC classes and changes.

1.6. Significance of the study

The significance of the study would give information about the trend of LU/LC and ST change of the area and it could be used as an input for government policy makers, urban and rural land management, natural resources managers, environmental experts and other concerned bodies for their decision-making processes. In addition to this, it could be a reference or initial step and used as input for coming researchers based on the analysis of the study and it helped to quantify the relationship between ST and LU/LC, and can be an important input to predict future land warming. The output of the study would provide better information for wolkite town urban design concerned body during wolkite town aesthetical configuration about the changes in urban areas and surrounding. Integrated application of GIS and remote sensing techniques or geospatial tools and its applicability, which is time and cost effective for analysis and impact of LU/LC dynamics on ST. It also provided the opportunity to understand the trends of changes like agricultural to urban, green area to agricultural and its driving factors.

1.7. Thesis Paper Organizations

This thesis organized by five chapters, the first chapter includes background of the study, statement of problems, objectives of the study, research questions, scope of the study and significance of the study. The second chapter contains literature reviews, whereas the third chapter contains data analysis method, location of the study area, climatic condition, image classification method and general work flow chart. When the fourth chapter contained result and discussion of the overall thesis work. the last chapter is contained conclusion and recommendation.

CHAPTER II: LITRATURE REVIEW

Many researches had been conducted in effect of land use land cover change on surface Temperature in Ethiopia and all over the world. Different scholars used different Technology options and approaches to evaluate the various land surface temperature configurations. A number of studied results had been published, some of the thesis paper is reviewed and evaluated in the subsequent sub heading.

2.1. Over view concept of land use land cover

Our earth surface contains so many natural and manmade features. Those features have their own properties and advantages for day today life of human beings and other living things. Those being on, below or above the earth surface depending on the natural strata classification. Most of peoples change the environment through day-to-day activities and human being are one of the main facilitating agents for deforestation, urbanization and over cultivation. However, for identifying their uses and behavioral properties it needs sophisticated technological instruments and guide line sources.

Satellite based navigation earth exploration system take the most area coverage to producing ideal information of different features. Land-cover refers to the observed biophysical cover on the earth’s surface, including water bodies, vegetation, soil and hard surfaces. Land-use is the exploitation/utilization of the land by human activities for the purpose of settlements, agriculture, forestry, and by pasture altering land surface processes including biogeochemistry, hydrology and biodiversity (Di Gregorio and Jansen, 2000). The definition also given by FAO (1999) for land-use is as the arrangements, activities and inputs people undertake in a certain land cover type to produce change or to maintain it. According to Lambin and Meyfroidt (2010), transition in LU/LC can be caused negative socio-ecological feedback that comes from a rigorous degradation in ecosystem services/ as a result of from socio-economic changes and innovations.

2.2. Reasons of land use land cover

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

United States Environmental Protection Agency (USEPA, 2004), identified the general causes of LU/LCCs are: Natural processes, such as climate and atmospheric changes, wildfire and pest infestation. There for direct effect of human activity such as road and illegal house construction and deforestation (clearance of trees) and Indirect effects of human activity are such as, water diversion leading to lowering of the water table.

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

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

2.4. Geographical Information Systems

Geographical Information Systems (GIS) is a computer-based information system used for capturing, retrieving, and analyzing spatial and non-spatial data. It is a collection of hardware, software and procedures that have become an essential part of modern geographical work. GIS are important in any discipline or field of human activity, which involve the position of objects on earth, their attributes and phenomena for which the geographical space is important. GIS have a wide range of applications in both, the rural and urban environments. it is a field of research, development, and applications encompassing computer technology oriented to the acquisition, storage, processing, analysis and presentation of spatial information.

A basic knowledge of GIS is essential for work applications in government agencies, the private sector and research organizations. (ResourceStudyProgram, 2008). The spatial data are the data that have location value and that non-spatial data are a data, which describe more the spatial data in the form of a table. According to Burrough (1990), data in GIS is composed of three dimensions that mean spatial (geographic), time and attribute. Some people believe that geographic information system as the system of hardware and software, which contribute to analyze applications or information processing (Maguire, 1991). According to ESRI GIS defines organized collection of computer hardware, software, geographical data and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information". (ESRI 1995) "GIS is an integrated system of computer hardware, software, and trained personnel linking topographic, demographic, utility, facility, image and other resource data that is geographically referenced." (NASA).

2.5. Remote Sensing

Remote sensing is a process of detecting objects without physical contact. The detection was takes place with three stages those are reflection, refraction and transmission. It is detecting of information of some property of an object or phenomenon, by a recording device that is not in physical or intimate contact with the phenomenon under observation study and it pertain gathering information pertinent to the surrounding, such as measurements fields, electromagnetic radiation, or acoustic energy. Techniques applied such devices as the camera, lasers, and radio frequency receivers, radar systems, sonar, seismographs, gravimeters, magnetometers, and scintillation counters (Noamlevin, 1999). it is major tools of geospatial technologies that are having a growing impact in a wide variety of areas from commerce to science to public policy.

The area of remote sensing evolved from the interpretation of aerial photographs to the analysis of satellite imagery, and from local area studies to global analyses, with advances in sensor system technologies and digital computing. Now a day remote sensor system can provide data from energy emitted, reflected, and/or transmitted from all parts of the electromagnetic spectrum.

Applications of these data include population and demography studies, study of sites, energy studies using hydrological models, urban planning, environmental treaty enforcement, and agricultural yields. The material that follows provides a brief overview of the historical development of remote sensing, emphasizing the increasing complexity of platforms, systems, and tasks (J.Estes, 2001). Reflectance is acquired with a sensor other than (or in addition to) a conventional camera through which a scene is recorded, such as by electronic scanning, using radiations outside the visible range, radar, thermal, infrared, ultraviolet, as well as multispectral, special techniques are applied to process and interpret remote sensing imagery for the use of producing maps, thematic maps, in the fields of agriculture, archaeology, forestry, geography, geology, and others. (American Society of Photogrammetry). According to Plant pathology it is the practice of deriving information about the Earth's land and water surfaces using images acquired from an overhead perspective, using electromagnetic radiation in one or more regions of the electromagnetic spectrum, reflected or emitted from the Earth's surface (Jams B.Camphell, 1944). RS refers to the use of instruments for measuring electromagnetic radiation reflected or emitted from an object.

The equipment detects reflected or emitted radiation in the ultraviolet, visible, or infrared part of the spectrum. The equipment used for remote sensing may be hand-held, ground-based cameras with films and filters, digital cameras, video systems, and radiometers or they may be carried on balloons, aircraft, and satellites. Many of instruments store data obtained from field situations, and data are then printed out and are analyzed directly or by transferring them to a computer and creating visual images of data. (George, 2005)

2.6. The Advantage of GIS and Remote Sensing in land use land cover change

Now a day geo-spatial tools are highly interesting to analyze spatial and nonspatial data for different institutes. the integration of GIS and remote sensing produce meaning full information spatially earth information-based system data**.** Remote sensing and geographic information system techniques have been widely used over the world for the study of historical changes in LU/LC and LST analysis.

Remote sensing has been used to identify vegetation cover, air pollution, ST and other surface characteristics (Zha, 2012; Weng, 2004). It provides a large variety and amount of data about the earth's surface for detailed analysis, change detection with the help of various airborne, and space born. The availability of historical remote sensing data, the reduction in data cost and increased resolution from satellite platforms, remote sensing technology appears ready to make an even greater impact on monitoring land-cover change. Land-use/land-cover changes can be analyzed over a period using Landsat sensors such as Landsat Multi Scanner (MSS) data and Landsat Thematic Mapper (TM) data by image classification techniques (Gumindoga, 2010). Historical and current sources of remote-sensing information are obviously quite important for measuring and monitoring changes in landscape parameters (terry, 2019).

2.7. Normalized Difference Vegetation Index

It is used to identify vegetation greenness and is useful in understanding vegetation density and assessing changes in plant health. NDVI is an indicator of vegetation health based on how plants reflect certain ranges of the electromagnetic spectrum and also calculated as a ratio between the red (R) and near infrared (NIR) values in traditional fashion (NASA 2000):

NDVI= (NIR - R) / (NIR + R)

For Landsat 4-7, NDVI = (Band 4 – Band 3) / (Band 4 + Band 3).

Although Landsat 8, NDVI = (Band 5 – Band 4) / (Band 5 + Band 4).

NDVI is a reliable indicator of land cover conditions and variations in a wide range of studies spanning regional to global scales (A. Anyamba,2005). Amount of natural vegetation were significantly affected by climate variability at various spatial and temporal scales (Fabricante,2009). The dominant important climatic factors rainfall that directly affecting vegetation dynamics and closely correlates with NDVI due to its irregularity and seasonal variability.

The central to us understanding plant health is electromagnetic spectrum. It is fundamental to how NDVI works and allows us to determine how healthy, or unhealthy; a plant is based on how it reflects energy and light. However, for human eye, a plant is green because the chlorophyll pigment in it reflects green waves and absorbs red waves. In plants cell structures reflect the near-infrared (NIR) waves. Therefor during photosynthesis occurs, the plant develops and grows and contains more cell structures. That means a healthy plant one with a lot of chlorophyll and cell structures actively absorbs red light and reflects NIR. An unhealthy plant will do the exact opposite**.** The relationship between light and chlorophyll is how we can use NDVI to tell apart a healthy plant from a diseased one.

Plants have healthy condition actively absorb red light and reflect near-infrared light. The instrument of satellite sensors measures wavelengths of light absorbed and reflected by green plants. The index detects and quantifies the presence of live green vegetation using this reflected light in the visible and near-infrared bands**.** Put simply, NDVI is an indicator of the vegetation greenness the density and health of each pixel in a satellite image (Nikita, 2020).

Previously, different researchers outside Ethiopia did researches in relation to the impact of LU/LC changes on land surface temperature. In Ethiopia there are some papers related to the proposed title. Recently Gebrekidan,2016 studied modeling land surface temperature from satellite data, the case of Addis Ababa, which presented in Africa hall, United Nations conference center Addis Ababa; Ethiopia (ESRI Eastern Africa Education GIS conference which held from 23−24 September, 2016). The study mainly focuses on modeling ST of Addis Ababa city, which acquired Landsat 5 and 8, from 1985 and 2015.

Finally, the results show that negative correlation was found between Normalized difference vegetation index and Surface Temperature and the study indicates the need for urban greening and plans to increase vegetations covers to sustain the ecosystem of the city and to minimize urban heat island effect. The value of range for a given pixel always result in a number that ranges from minus one (-1) to plus one (+1); however, no green leaves give a value close to zero. The result of no vegetation is zero and close to +1 (0.8 - 0.9) indicates the highest possible density of green leaves. (NASA, 2000). Vegetation amount have been visibly influenced by climate variability. The NDVI has been the most commonly used index in vegetation dynamics.

The research was conducted to examine the effects of climatic variability (rainfall) on NDVI for the periods 1982–2015 in the Gojeb River Catchment (GRC), Omo-Gibe Basin, Ethiopia. The trend in NDVI and rainfall time series was assessed using a Theil–Sen (Sen) slope and Mann–Kendall (MK) statistical significance test at a 95% confidence interval. The result residual trend analysis (RESTREND) method was used to investigate the effect of rainfall and human induction on vegetation degradation. (Dagnachew, 2020).

2.8. Surface Temperature

Surface Temperature (ST) plays a fundamental role in various geophysical processes at varying spatial and temporal scales. Satellite-based observations of LST provide a viable option for monitoring the spatial-temporal evolution of these processes (Sammy, 2020). According to mada district study on the impact of land use land cover (LULC) on surface temperature (ST) in English Bazar Municipality of Malda District using multi spectral and multi temporal satellite data. Seasonal and temporal ST is extracted in three phases e.g., in

1991, 2010 and 2014. Results show that ST increases 0.070 °C/year and 0.114 °C/year during winter and summer periods respectively and significant ST difference exist over different LULC units. urban settlement retains maximum ST in all selected phases. Correlation coefficient among different deriving factors of ST with ST reveals that impervious land maximally control ST (r = 0.62) followed by water bodies and vegetation cover. A single land use unit like impervious land water body and vegetation also create differences in ST (R^2 of NDVI vs. ST ranges from 0.47 to 0.607; NDVI vs. ST ranges from 0.441 to 0.62). ST is almost co linear with aerial temperature as indicated by significant correlation value (0.44604 for January and 0.658 for April 2014) at 0.01 level of significance and the temperature gap between them ranges from 3.5 °C to 6.5 °C. Such co linearity validates the ST models.

The analyzed temperature gap is also strongly controlled by LULC. The LULC pattern is getting changed, its imprint is reflected on ST and air temperature. So, immediate thinking about new urbanism should be adopted, started and implement to arrest the rising temperature and effect of urban heat island. (Swades, 2017)

This research investigates the relationship between Surface Temperature and Land Use/Land Cover in Langkawi Island by using Normalized Difference Vegetation Index (NDVI) and Modified Normalized Difference Water Index (MNDWI) qualitatively by using Landsat 7 ETM+ and Landsat 8 (OLI/TIRS) over the period 2002 and 2015. Pixel-based classifiers Maximum Likelihood (MLC) and Support Vector Machine (SVM), has been performed to prepare the Land Use/ Land Cover map (LU/LC) and the result shows that Support Vector Machine (SVM) achieved maximum accuracy with 90% and 90.46% compared to Maximum Likelihood (MLC) classifier with 86.62% and 86.98% respectively. The result revealed that as the impervious surface (built-up /roads) increases, the surface temperature of the area increased. However, surface temperature decreased in the vegetated areas. From linear regression between ST and NDVI these indices can be used as an indicator to monitor the impact of Land Use/Land Cover on Surface Temperature. (Suzana, 2016)

surface temperature (ST) is affected by surface-atmosphere interaction. However, the degree to which surface and atmospheric factors impact the magnitude of ST trend is not well established. Here, we purposely used surface energy balance, boosted regression tree model, and satellite observation and reanalysis data to unravel the effects of surface factors (albedo, sensible heat, latent heat, and ground heat) as well as incoming radiation (shortwave and longwave) on ST trends in East Africa (EA). (Temesgen, 2020)

Surface Temperature (ST) is a fundamental aspect of climate and biology, affecting organisms and ecosystems from local to global scales. Identified as one of the most important Earth System Data Records by NASA and other international organizations (King, 1999), ST measures the emission of thermal radiance from the land surface where the incoming solar energy interacts with and heats the ground, or the surface of the canopy in vegetated areas. This quality makes Surface Temperature (ST) is a fundamental aspect of climate and biology, affecting organisms and ecosystems from local to global scales. It identified as one of the most important Earth System Data Records by NASA and other international organizations (King, 1999). According to Solomon Abirdew analyze rain fall and temperature trained analysis from1986-2015 at Endibir station Gurage Zone he used Mann Kendall test for analysis and final result is the minimum and maximum value of temperature in 2013 is 18.8^0~~c~~ and 32.5^0c. even if he tries to analyze temperature, he loses more graphical and statistically evidence part.

The above literatures are done by different researcher that over viewed on land surface temperature analysis. The researcher uses more or less similar methods and materials especially landsat4, landsat5, landsat7 and landsat8 of RS data. Even if those researchers are used remote sensing data and produce ST map, they missed the statically analyzed part means, which land use land cover are more factor for increment of ST, correlate, lack of confidence interval to realize the output result, some researchers use old data and old analysis method, old software's used for surface temperature variation. There for this research highly focused on those gaps and analyze the surface temperature based on integrating different geospatial software's, statically analyzed software SPSS and identify the correlation between each land use category with NDVI and ST.

CHAPTER III: METHODOLOGY

In order to attain the above general and specific objectives of the study, the following methods and techniques were followed.

3.1. Description of the study area

3.1.1. Location

Wolkite (also transliterated Wolkite) is a town and separate woreda in south-western Ethiopia. The Town is one of administrative center of the Gurage_Zone of the Southern_Nations, Nationalities_and Peoples' Region (SNNPR), this town has a latitude and longitude of 8°17′N 37°47′E and an elevation between 1910 and 1757 meters above sea level and crossing the main asphalt road from Addis Ababa to Jimma. It is neighborhood by Kebena woreda and it was part of former Goro woreda.

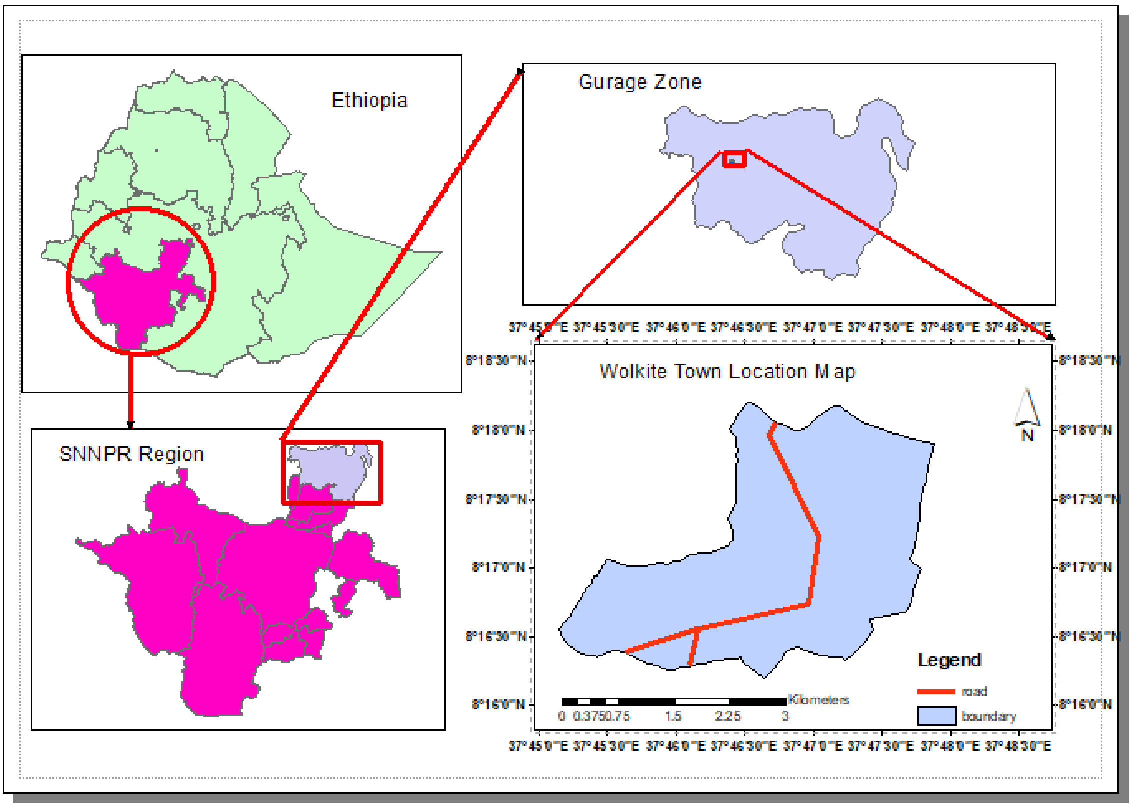

Figure 3.1: Location Map of Study Area

3.1.2. Topography

Topography is identifying the natural and manmade features below, on and above the ground surface. It includes such as landforms, elevation, latitude, longitude and topographic maps. The wolkite town has a more of flat area. It also bordered on the north east Kebena woreda, west abeshge werda and south by the Oromia region. The slope of the study area is maximum value 22.66 and the lowest values is zero. Also, the maximum and minimum value of elevation for this study area are 1910m and 1752m respectively as shown on the map below in Table 3.2.

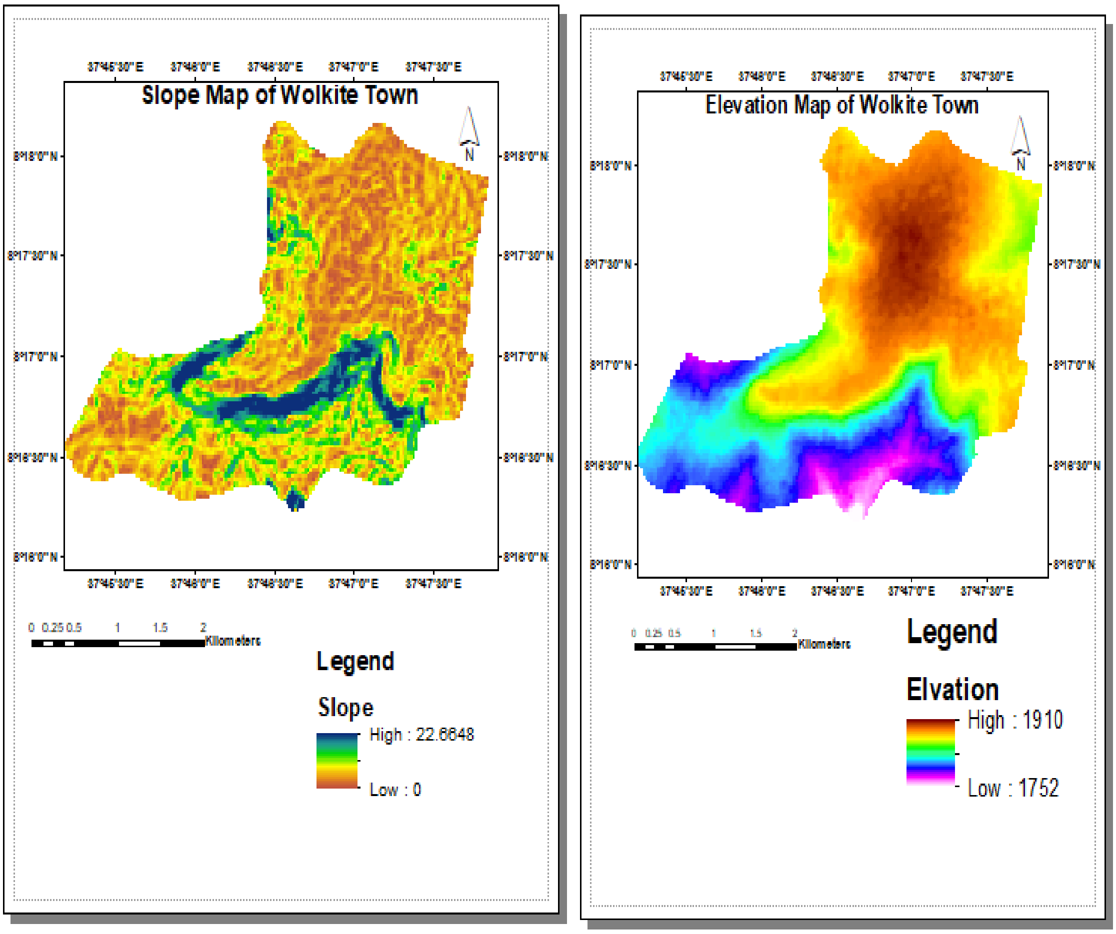

Figure 3.2: A) Slope map of study area B) Elevation map of study area

3.1.3. Climate

A. Rainfall

The amount of rain fall recording had given a basic information for different concerned body. Long-term rainfall record from1992 to 2017 at the wolkite metrological station shows an average annual rainfall of 1104.28mm and the maximum monthly average rainfall was 192.2mm in the month of July 1990 (Fig.3.3). according to National Mereological agency data statics shows that on the average, most rainfall or rainy season is June, July, August and September. Whereas, the dry month is in January, February and March. On average, the warmest month is January and February the graph shows monthly reported rainfall recording data from a year 1992-2017. This thesis focused a year from 1990-2020 but, National Metrology Agency have only those year data for the study area.

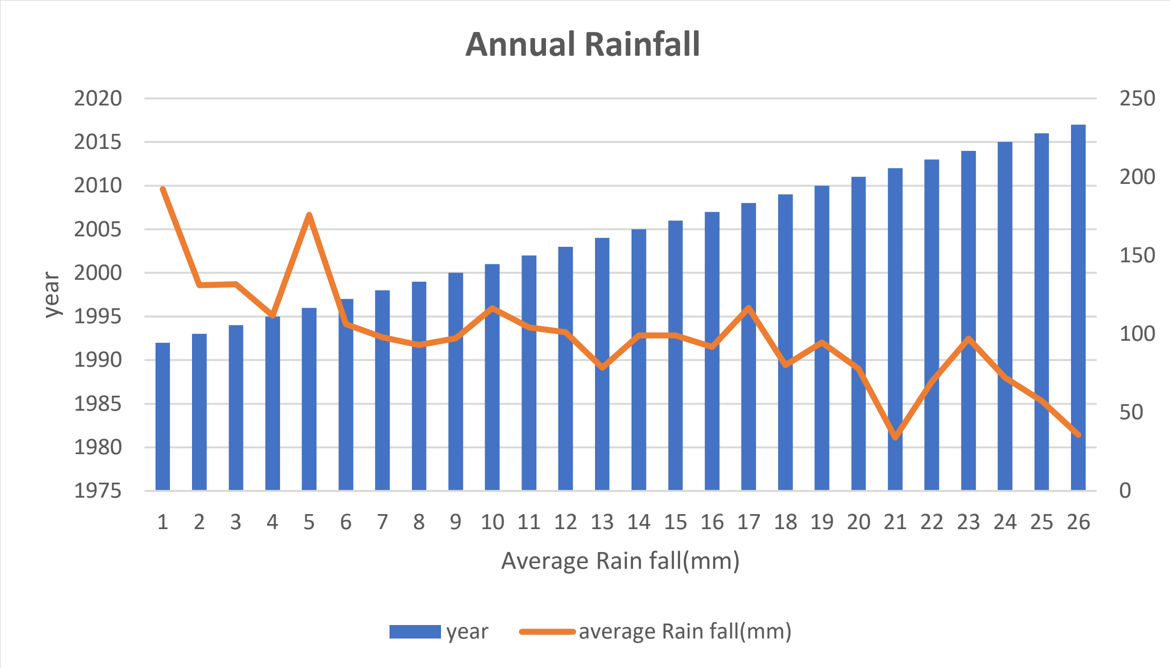

Figure 3.3: Distribution of annual rainfall in the study area (1990–2017).

The average rainfall recorded between 1992 and 2000 was 1489.5 mm, while 2000 and 2010; it was 1164.41mm and 7664.9mm for the years between 2010 and 2017. The distribution of annual rainfall from (1992–2017) is presented in (Fig.3.4)

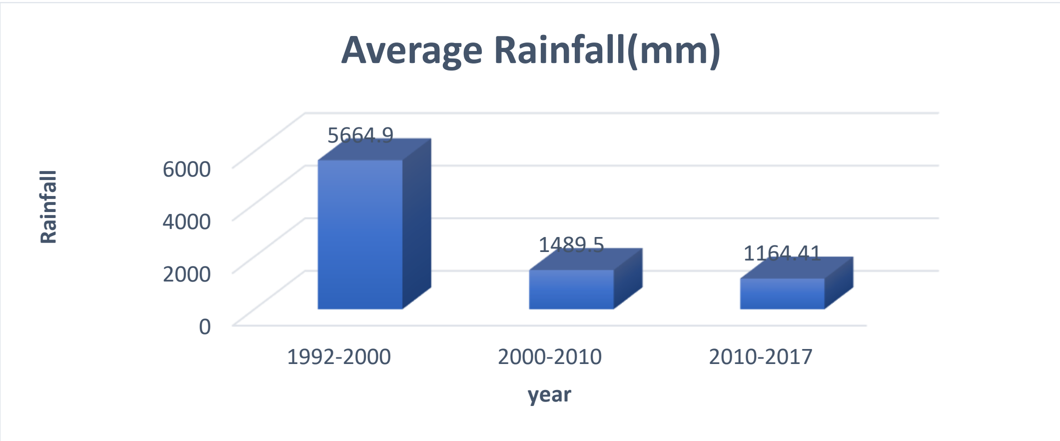

Figure 3.4: Total average rainfall of study area

B. Temperature

The National Meteorological Agency recording data shows the mean annual temperature of the wolkite town is 29.6 in 1990 and 34.4^{0}c in 2017. It could be classified as semi humid to semi-arid climate, which characterizes the altitude range between 1752–1910 m above mean sea level. In the study area, the hottest month with maximum mean temperature of 34.7ºC was May. The detailed information presented in (Fig. 3.5).

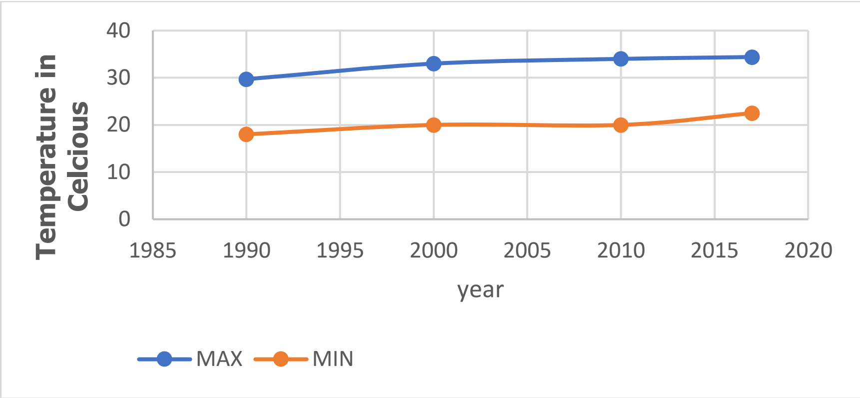

Figure 3.5: Maximum and minimum Temperature during a year 1990–2017.

3.1.4. Population

According to CSA (2007), the total human population of Wolkite Town is about 28,866. Out of this, 15074 are men and 13,792 are women. While in 2019 CSA projected data (estimated population) the total population is about 67,463. From this, about 33,806 are men and 33,657 are women. The detail information is presented in (Fig.3.6)

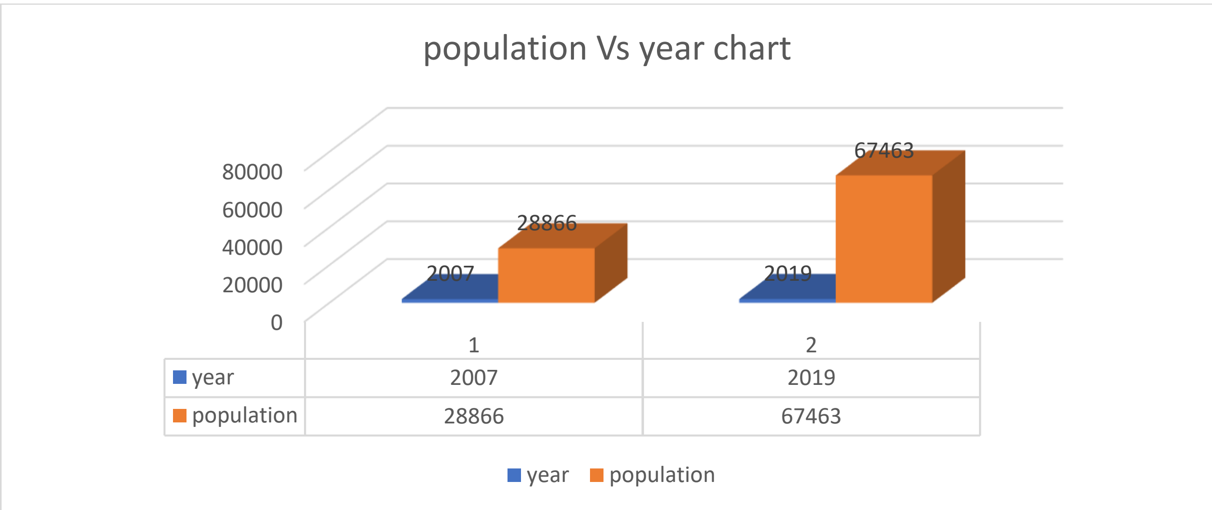

Figure3.6: Population of Wolkite Town in (2007-2019)

3.2. Data Used Type

3.2.1. Primary Data

The primary data that includes in this research are Landsat satellite image (Landsat data): Thematic Mapper (TM) 1990, Enhanced Thematic Mapper Plus (ETM+) 2000 and 2010 and

Operational Land Imager/Thermal Infrared (OLI/TIRS) 2020 obtained from USGS. Digital Elevation Model (DEM) data for mapping the elevation field data, point of LULC were used.

3.2.2. Remote Sensing Data Acquisition

One scene of Landsat 5 TM (1990), Landsat7 ETM+ (2000 ,2010) and Landsat 8 OLI/TIRS (2020) cloud free image of the study area with the path of 168 and row 054 were acquired (downloaded) from the website of earth explorer. usgs.gov, United States Geological survey (USGS). The-acquired data is world datum (WGS84) projection system. Remote sensing images used to calculate ST, NDVI and LULC in Wolkite Town are shown in the following (Table 3.1) and multispectral band in (Table.3.2).

Table 3.1: Data sources for conducting research

1. Primary Data source	Launched year	Source
Landsat-5 TM	Dec 1990	USGS
Landsat-7 ETM	Jan 2000 & Dec 2010	USGS
Landsat-8	Jan2020	USGS
Point data		Google Earth
DEM data		USGS
2. Secondary Data source		
Metrological data		NMA
Population data		CSA
3. Type of Software used	Version	
GIS	10.8	
ERDAS	2014	
SPSS	IBM Statistics 22	
Micro Soft	2013	

A. Landsat Thematic Mapper (TM)

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

Table 3.2 Landsat5 sensor information

Satellite Sensor	Band	Description	Wave length (micrometer)	Resolution	source
Landsat5	Band1	Blue	0.452-0.518		
	Band2	Green	0.528-0.609		
	Band3	Red	0.626-0.693		
	Band4	Near Infrared	0.776-0.904		
	Band5 1	Short wave Infrared	1.567-1.784	30	USGS
	Band6	Thermal	10.45-12.45	120	
	Band7	Middle Infrared	2.097-2.349	30	

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

The Landsat Enhanced Thematic Mapper Plus sensor onboard the Landsat 7 satellite has acquired images of the Earth nearly continuously since July 1999, with a 16 day repeat cycle. Landsat 7 ETM+ images consist of eight spectral bands with a spatial resolution of 30m for bands 1-5 and 7 whereas the thermal band 6 and panchromatic band 8 has a resolution of 60 and 15 m, respectively. Detail information is shown in Table 2.3.

Table 2.3: Landsat7 detail sensor information

Satellite Sensor	Band	Description	Wave length (micrometer)	Resolution	source
	Band1	Blue	0.452- 0.514		
	Band2	Green	0.519- 0.601		
Landsat7	Band3	Red	0.631- 0.692		
	Band4	Near Infrared 1	0.772- 0.898		
	Band5	Near Infrared 2	1.547 -1.748	30	
	Band6	Thermal	10.31-12.36	60	USGS
	Band7	Middle Infrared	2.065-2.346	30	
	Band8	Panchromatic	0.515-0.896	15	

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

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

Table 3.4: Landsat8 sensor information

Satellite Sensor	Band	Description	Wave length (micrometer)	Resolution	source
	Band1	costal aerosol	0.43-0.45		
	Band2	Blue	0.45-0.51		
	Band3	Green	0.53-0.59		
	Band4	Red	0.64-0.67		
	Band5	Near Infrared	0.85-0.88	30	
Landsat8	Band6	Short wave Infrared 1	1.57-1.65		
OLI/TIRS	Band7	Short wave Infrared 2	2.11-2.29		
	Band8	Panchromatic	0.50-0.68	15	USGS
	Band9	Cirrus	1.36-1.38	30	
	Band10	Thermal Infrared 1	10.60-11.19	100	
	Band 11	Thermal Infrared 2	11.50-12.51		

Source: data, for illustration purposes only

3.2.3. Secondary Data

Secondary data used in this study comprises meteorological data such as average monthly temperature (1992–2010) and average monthly rainfall (1992–2017). These meteorological data was used for evaluation and validation. In addition to this, the other data used in this study were population data from CSA to understand the status of the population of the study area (CSA, 2007 and 2019).

3.2.4. Software Packages Used

Software packages used for this study were ArcGIS 10.8 for image analysis; calculate ST, NDVI and map preparation, ERDAS (Earth Resources Data Analysis System) Imagine 2014 for RS application in order to process satellite images including image enhancement, preprocessing and for LU/LC classification.

Google earth also used to check and compare results with ground truth, especially for the year 1990, 2000, 2010 and 2020 LU/LC verification: open-source software was used for raster manipulation include neighborhood analysis and map algebra. In addition to ERDAS Imagine software, Arc GIS software used for classification to compare and contrast the results and SPSS tools used for analyzing the correlation ship between LU/LC, NDVI and ST. Microsoft office, Microsoft Excel and Microsoft power point were used to create word documents, analyze spreadsheets, to do graphs, manage databases and for presentation

3.3. Work flow chart

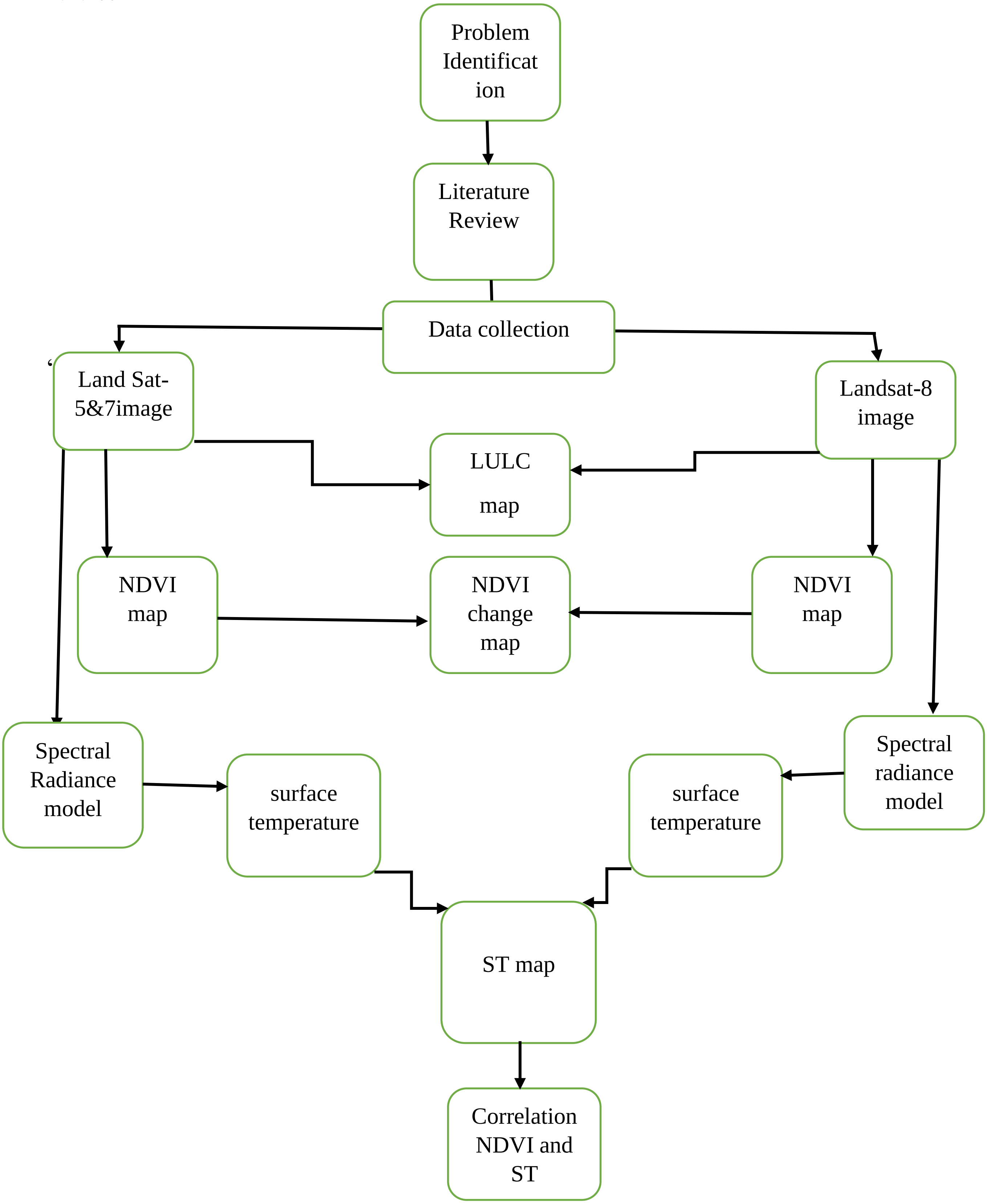

Figure 3.7: General work flow chart

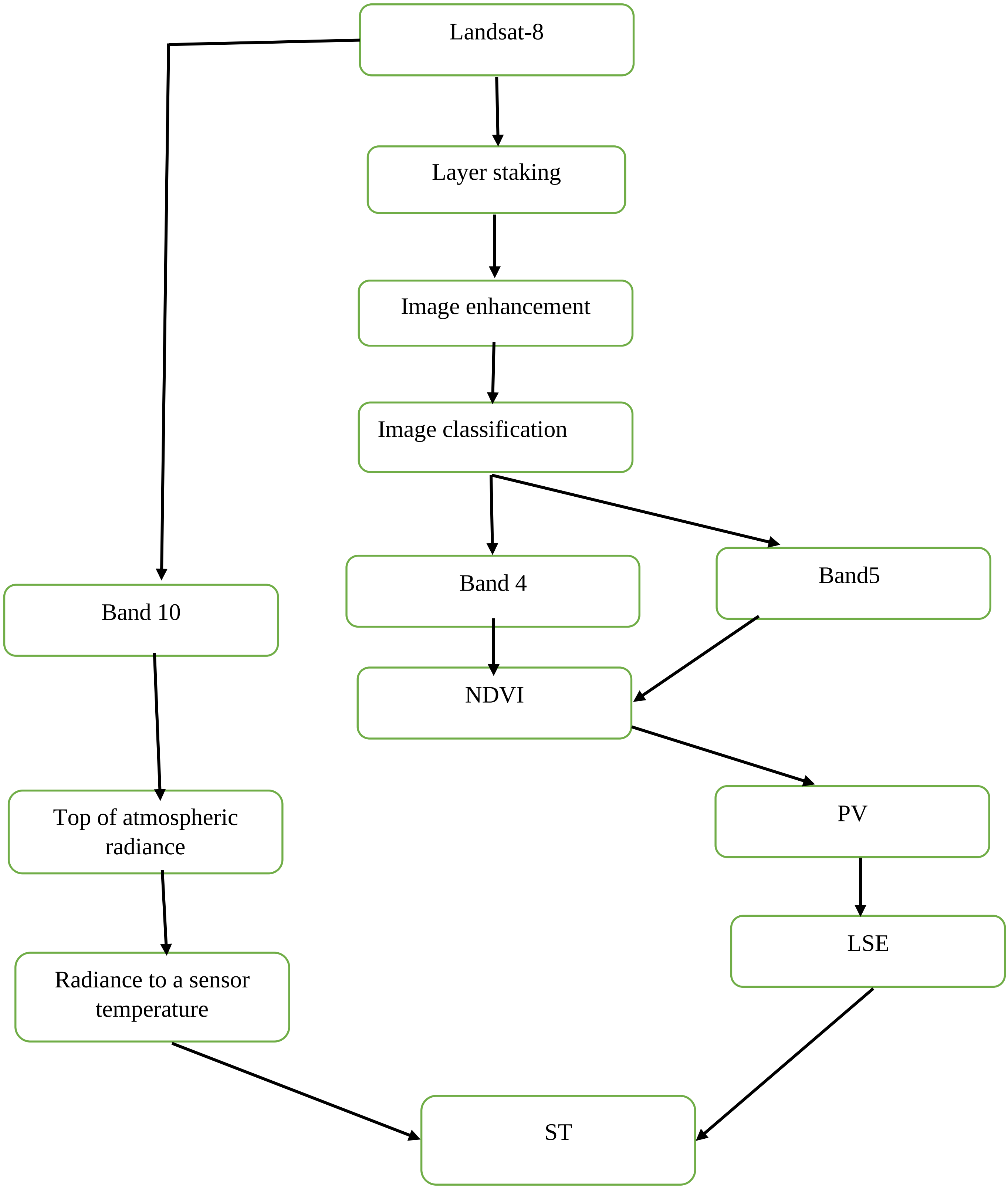

Figure 3.8: Work flow chart of spectral radiance model in Landsat8 OLI/TRIS

3.4. Description of Methodological Approach

All the above methods and materials had been used on this thesis and all the primary data were downloaded from USGS except point data, then process those data means image enhancement, haze correction, georeferencing and supervised the classification of each land use type by using ERDAS imagine software and the other part of determining the NDVI, LSE, ST values was analyzed to produce LULC, NDVI, LSE, ST maps on ArcGIS and confidentiality of correlation were determined using SPSS tools.

3.4.1. Data Preparation and Analyzing

Satellite image by its nature have some distortion, noise, haze and stripes. Therefore, before processing the data, image pre-processing activities were done. Preprocessing includes importing, layer stacking, and sub-setting of the image based on the boundary of Wolkite Town, geometric correction, radiometric correction, and removal of stripes, pan sharpening and other image enhancement techniques. Radiometric correction is a removal of atmospheric noise to make more representatives of the ground truth conditions based on the sensors. These all previously mentioned activities were done to improve visible interpretability of an image by increasing apparent distinction between the features in the scene. In addition, the image was also georeferenced-using boundary of the Woreda. During georeferencing and reprojecting process, Adindan UTM Zone 37N coordinate system was followed for raster and vector data in the study to maintain uniformity. Adindan UTM Zone 37N is local datum that Ethiopia used.

3.4.2. Digital Image Processing (DIP)

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

3.4.3. Image enhancement

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

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

3.4.4. Image classification

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

A. Supervised classification

Supervised classification is the techniques most often used for the quantitative analysis of RS image data depending on their reflectance properties. It uses the spectral signature obtained from training samples to classify an image. Image classification toolbar, can easily create training samples to represent classes. With supervised classification, it can be identified sample of information classes (any land-cover type) of interest in the image. The supervised classification image of each year involves pixel categorizations by taking training area for each class of LU/LC. After the training area assigned for each class classification activity was performed. For farmland, forest land and settlement LU/LC types taken10 site. Areas in digital images were marked as signature of individual identity and the field truth verification was adapted to represent LU/LC class (Coppin and Bauer, 1996).

Using Multispectral Band from band 1 to 5 and 7 for TM 1990 and ETM+ 2000 and 2010 also for OLI 2020 1 to 7 Bands of the preprocessed images the land-use/ land-cover pattern mapped was by supervised classification with the likelihood classification algorithm of ERDAS Imagine 2014 software. In supervised classification, with the help of image processing techniques, the user specified type of the land-use land-cover classes. The 4 major classes studied in Wolkite Town were Farm Land, plantation and settlement. The advantage of the supervised classification was development of information classes, self-assessment using training sites and training sites reusable. However, information classes may not match spectral classes, the signature homogeneity, uniformity of information classes may be varying.

B. Maximum Likelihood classification

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

C. Ground Truthing

A ground truthing activity was carried out in the study area, in which different LU/LC classes were validated. The observed LU/LC includes: farmland (small scale agriculture), plantation and settlement (urban and rural settlement). These LU/LC classes were used in producing the map legends and with the assist of GPS, training set data used for image classification were acquired. During this ground truthing activities, photos of scenes of interest and coordinates from sampled LU/LC classes were captured.

3.4.5. Land-use/Land-cover change detection

Land-use/land-cover change detection was done by involving images of 1990, 2000, 2010 and 2020. Using GIS techniques thematic image was compared. The cross-operation process of mapping LU/LCC over time began with mapping the recent 2020-satellite imagery, then looking back in time to map the 1990 imagery. Post classification is among the most widely used approach for change detection purpose (Chen, 2000). The analysis of LU/LCC maps involved technical procedures of integration using the ArcGIS software techniques. The first task was to develop a table indicating the area coverage in square kilometers and the percentage change for each year 1990, 2000, 2010 and 2020 measured against each LU/LC classes. Therefore, to calculate LU/LC change in percentage equation (eq.3.1) were used (Lambin et al, 2001)

$$\text{Percent change of each LU/LC class} = \frac{observed\ change}{sum\ of\ area} * 100 \qquad \text{Eq. (3.1)}$$

3.5. Derivation of Normalized Difference Vegetation Index and Surface temperature

3.5.1. Derivation of Normalized Difference Vegetation Index

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

The index was defined by the following equation

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

where, NDVI= Normalized Difference Vegetation Index

NIR= the near infrared band 4, R= is the red band 3. Equation 3.2 is used to calculate NDVI for the sensor TM 1990, 2000, ETM+ 2010and OLI 2020.But in case of Landsat 8 NIR is band 5 and the red band is a band 4 (Weng et al., 2004).

To calculate fractional vegetation cover (FVC) the following Eq. 3.3 was used.

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

where, FVC = Fractional Vegetation cover

NDVI= Normalized Difference Vegetation Index

NDVIs is NDVI for soil and NDVIv=NDVI for vegetation

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

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

where, Pv =Proportion of Vegetation

NDVI=Normalized Difference Vegetation Index

NDVI min= Normalized Difference Vegetation Index minimum value

NDVImax= Normalized Difference Vegetation Index maximum value

3.5.2. Derivation of Surface Temperature

Calculating surface temperature passes different steps: -To calculate the SE, it is important know the inherent characteristics of the earth's surface and change the thermal radiance energy during calculating ST (Sobrino et al., 2012). The emissivity constant values for vegetation and soil are stated in Table 3.5.

Table 3.3: Emissivity constant value of Landsat 8.

Emissivity	Band 10	Band11
	0.971	0.977
	0.987	0.989

The following equation 3.5, 3.6 and 3.7 used to compute Land surface Emissivity, of Band 10 and 11.

SE is = 0.004Pv+0.986 Eq. (3.5)

3.5.3. Radiometric Correction

Radiometric correction requires converting a remote sensing digital number to spectral radiance values and data for comparison. Image processing procedures that are used to correct errors, converting digital number (DN) values to radiance and then reflectance was categorized as a Radiometric correction (Parente, 2013). To perform the conversion of digital number to spectral radiance equation (3.6) was used.

$$L\lambda = Lmin + (Lmax - Lmin) * DN/255 \qquad \text{Eq. (3.6)}$$

where, L λ=spectral radiance

Lmin=spectral radiance of DN value 1

Lmax=spectral radiance of DN value of 255

DN=Digital Number

3.5.4. Conversion at sensor spectral radiance

In radiometric calibration, pixel values, which were represented by Lλ in remote sensing raw data and unprocessed image data, were changed into absolute radiance values. Equation 3.7 was used to perform the conversion at sensor spectral radiance or satellite data scaled into 8 bits

$$L\lambda = \left(\frac{\mathrm{Lmax}\lambda - \mathrm{Lmin}\,\lambda}{Qcalmax - Qcalmin}\right)(Qcal - Qcalmin) + LMIN\lambda \qquad \text{Eq. (3.7)}$$

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

$L_{max\lambda}$= Spectral at Sensor Radiance that is scaled to Qcalmax

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

Qcalmax= Maximum Quantized Calibrated Pixel values corresponding to $L_{max\lambda}$

Qcalmin= Minimum Quantized Calibrated Pixel values corresponding to $L_{min\lambda}$

Qcal= Quantized Calibration Pixel value (DN)

3.4.5. Conversion to Top of Atmosphere (TOA) reflectance Landsat

Thematic Mapper top of atmosphere reflectance data must be corrected and processed. because of variation in solar zenith angle due to time difference between data acquisition. The gained output also calibrated to reflectance value. Equation 3.8 was used to compute TOA.

$$P\lambda = \frac{\pi . L\lambda . d}{ESUN\lambda . COS\Phi s} \qquad \text{Eq. (3.8)}$$

where, Pλ=planetary top of atmosphere (TOA) reflectance, it is unit less

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

Lλ=spectral radiance at the sensor's aperture

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

ESUNλ=mean exoatmospheric solar irradiation (from meta data)

Φ= Solar zenith angle

3.4.6. Conversion of radiance into brightness temperature

Thermal infrared data can be converted from atmosphere reflectance (Lλ) to effective sensor brightness temperature (TB) using thermal constants provided in the Meta data file. Remote sensing data (Landsat imagery) thermal band that is band 6 on thematic mapper and enhanced thematic mapper plus needs to be converted from at sensor spectral radiance to effective at sensor brightness temperature. Brightness temperature is the radiance travelling upward from the top of earth atmosphere. To covert Lλ (spectral radiance) to TB (brightness temperature) equation 3.9 was used (Rajeshwari and Mani, 2014).

$$TB = \frac{K2}{\left(\ln \frac{K1}{L\lambda}\right) + 1} \qquad \text{Eq. (3.9)}$$

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

K2=calibration constant 2

Ln=natural logarithm

K1=calibration constant 1

λ=spectral radiance at sensors aperture

3.4.7. Accuracy Assessment Determination formulas

Over all accuracy= $\frac{\text{Total number of corrected pixel}}{\text{Total number of referenced pixels}} * 100$ Eq. (3.10)

Producer accuracy= $\frac{\text{number of corrected pixel in each category}}{\text{number of referenced pixel in each pcatagory}}$ *100 Eq. (3.11)

CHAPTER IV: RESULTS AND DISCUSSIONS

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

Land-use/land-cover classification result of 1990 showed that the dominant LU/LC classes were agricultural land and urban settlement. These classes accounted for 85.03% of the overall area coverage. From the total area of 10.29 km square, agricultural land accounted for 5.85 kmsq (56.85%) and urban settlement accounted for 2.9 kmsq (28.18%). The other LU/LC green area accounted for 1.55 kmsq. (15.06%) of the total area. The green area covered the smallest area than all than other classes. Analysis of 2000 image also showed that agricultural land constitutes the largest proportion of land in the study area with the value of 5.55 kmsq (54.02%), followed by urban settlement, which accounted 3.44 kmsq (33.48%). Other LU/LC green area accounted for 1.28% of the total area. In 2000, also green area covered the smallest than other classifications. Land-use/land-cover classification results of 2010 image revealed that the dominant LU/LC categories were agricultural land and urban settlement together accounted for 87.45% of the total area coverage.

Agricultural land accounted for 4.30 kmsq (41.81%) in 2010 and urban settlement accounted for 4.69 kmsq (45.64%) in 2010. Other LU/LC classes were green area accounted 12.5% of the total area. Land-use/land-cover classification results of 2020 were highly dominated by urban settlement accounted for 6.66 kmsq (64.03%) and the other area accounted for agricultural land 2.15 kmsq (20.89%) and green area 1.55kmsq (15.07%). However, the extent of agricultural land decreased by 36% from 1990. Generally, agricultural land is the major LU/LC of the area in relation to area coverage, followed by urban settlement. Detailed statistical data for each of these classes and LU/LC map of the study period are shown in Table 4.1and Figure 4.1

Table 4.1: LU/LC class and area coverage of study area from (1990-2020)

NO	LU/LC Class	1990		2000		2010		2020	
		Area, (kmsq)	Area (%)	Area, (kmsq)	Area (%)	Area, (kmsq)	Area (%)	Area, (kmsq)	Area (%)
1	Agricultural land	5.85	56.85	5.56	54.02	4.30	41.81	2.16	20.89
2	Green area	1.55	15.06	1.28	12.51	12.39	12.57	1.55	15.07
3	Urban settlement	2.90	28.18	34.45	33.48	4.69	45.64	6.59	64.03

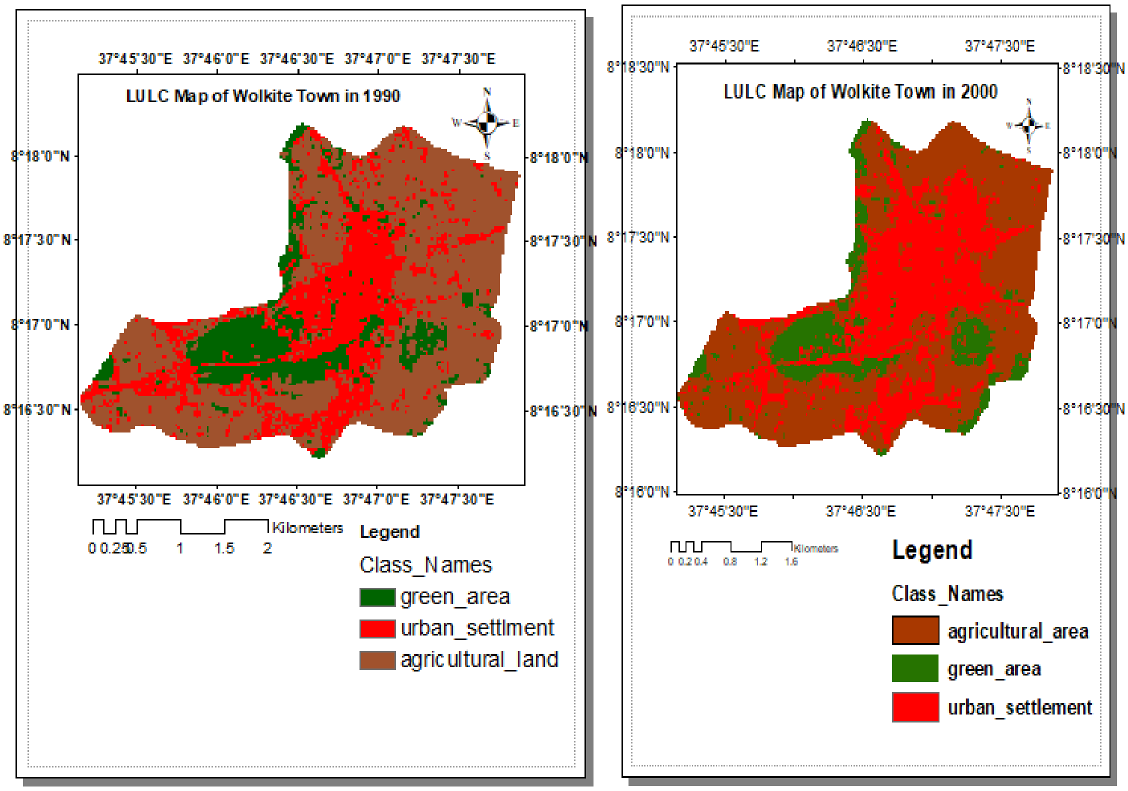

Figure 4.1: LU/LC map of study area in 1990 and 2000

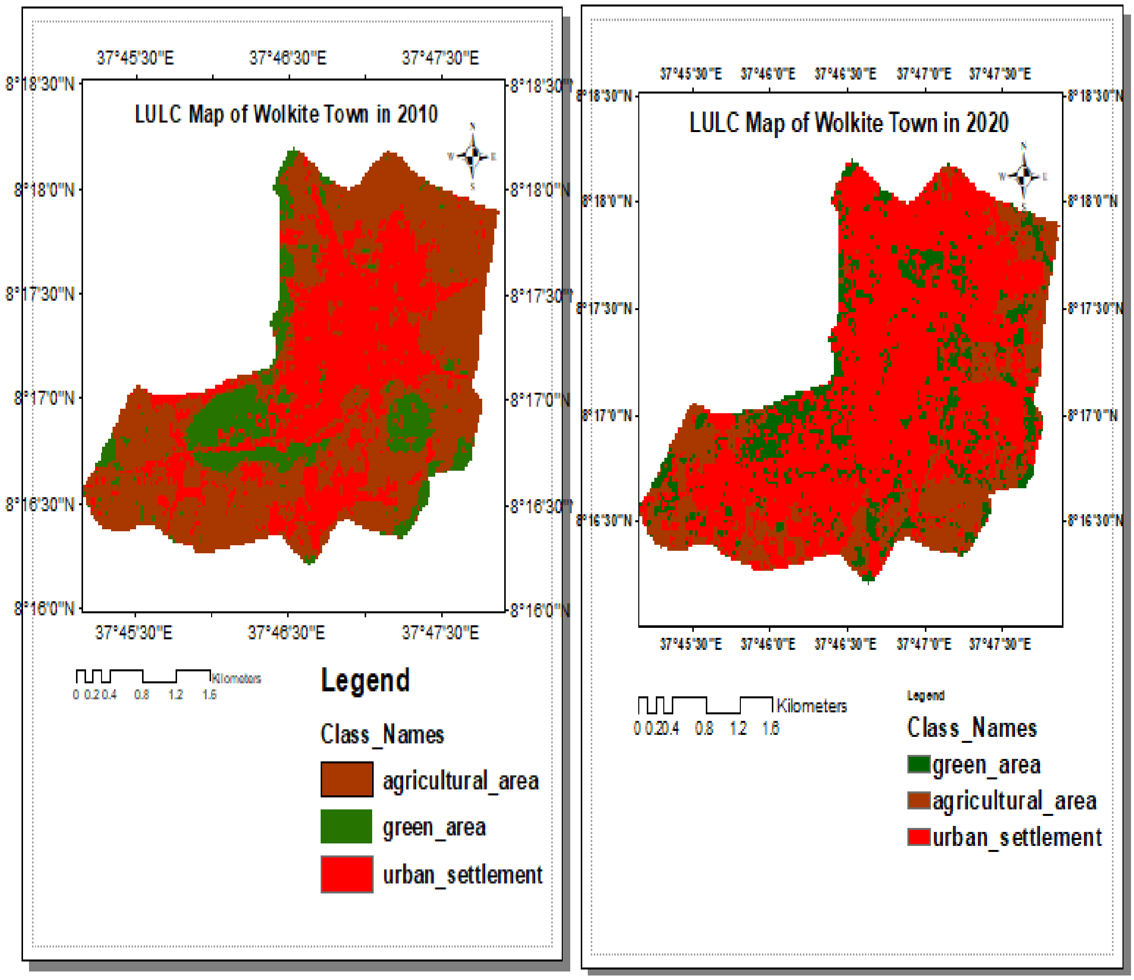

Figure 4.2: LU/LC map of study area in 2010 and 2020

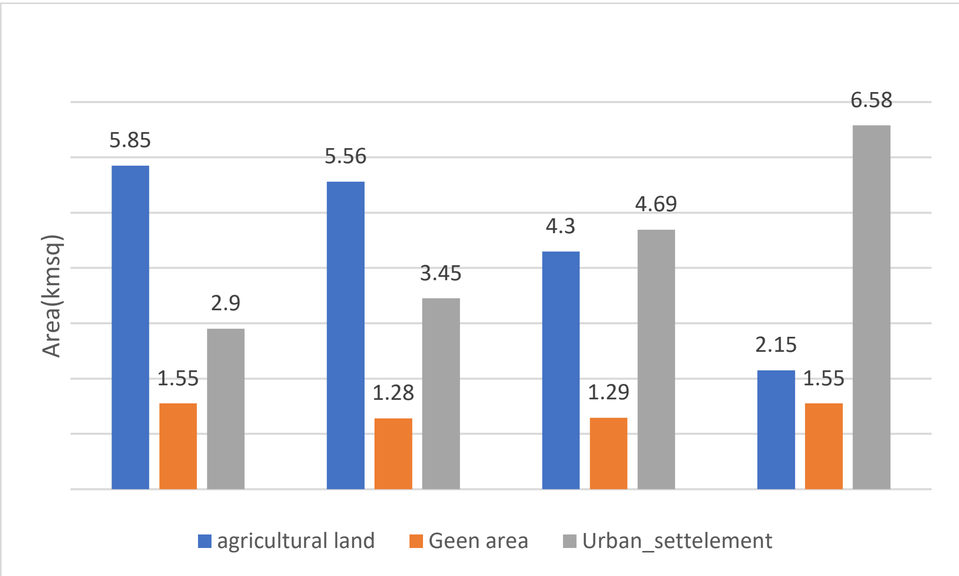

Figure 4.3: Land-use/land-cover distribution and changes in the study area

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

Land-use/land-cover patterns in the study area have indicated a significant change in between 1990 and 2020 years. Among the three major LU/LC classes, agricultural land and urban settlement covered more than 80% of the area in all the study years. Urban settlement has been increasing from 1990 to 2020. It has increased from 28.18% in 1990 to 33.48% by 2000 and 45.65% in 2010 to 63.95% by 2020. Green area showed fluctuations from 1990 to 2020. Green area was 15.06% in 1990, which was decreased to 12.51% by 2000 and then increased to 12.57% in 2010 also again increased to 15.07% by 2020. Agricultural land showed continuous decrement from 1990-2020. It was 56.85% in 1990, which decreased to 54.02% by 2000 and decreased 41.85 by 2010 to 20.89% in 2020 (Table 4.2).

Table 4.2: Land-use/land-cover distribution and net changes during 1990–2020.

N0	LU/LC Category	1990		2000		2010		2020		Net change during 1990-2020
		Area Km2	Area %	Area Km2	Area %	Area Km2	Area %	Area Km2	Area %	
1	*Agricultural Land*	5.85	56.85	5.56	54.02	4.30	41.81	2.15	20.89	-35.96%
2	*Green Area*	1.55	15.06	1.07	12.51	1.29	12.57	1.55	15.07	+0.01%
3	*Urban Settlement*	2.90	28.18	3.45	33.48	4.69	45.64	6.58	63.95	35.77%

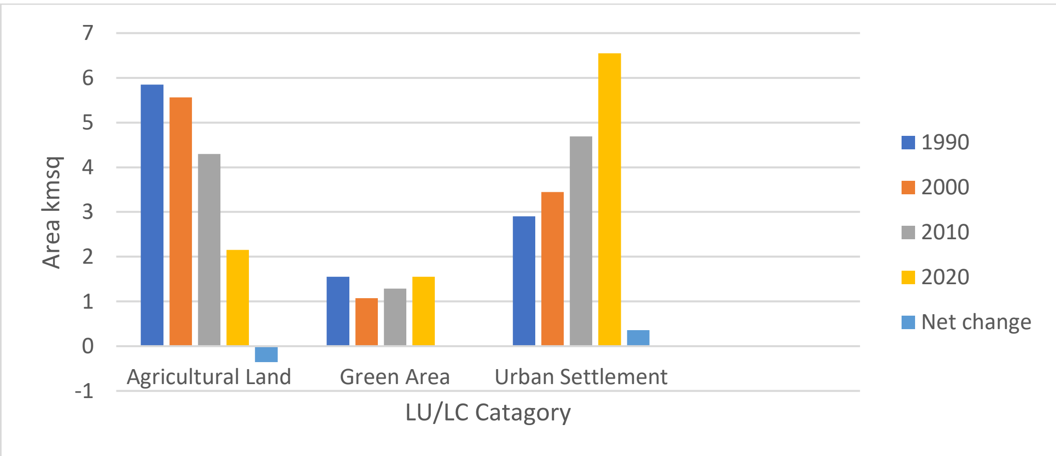

Figure 4.4: Land-use/land-cover changes during 1990—2020 in Wolkite Town

where, Agricultural area includes farming land crop production areas

Green area includes vegetations, small shrubs, and greenery recreational area

Urban Settlement includes built up areas like road, building,

4.3. Accuracy assessment

The accuracy assessment of LU/LC for the years 1990, 2000, 2010 and 2020 analyzed from a total sample of 43,37,34 and 31 respectively and the overall classification accuracy of 91.33%, 84.6%, 85.3% and 86.5%, respectively. For the years, 1990 and 2020 values are 0.87 and 0.84, respectively. The detailed information of producers and user's accuracy is indicated in Table 4.3.

Table 4.3: User and Producer accuracy for LU/LC category in 2020

	Green area	Agricultural land	Urban Settlement	Total (user)
Green area	11	2	0	11
Agricultural land	0	12	3	15
Urban Settlement	1	1	9	11
Total (producer)	12	15	12	37

Over all accuracy= 32/37*100= 86.5%

User Accuracy: -

Green area= 11/11*100= 100%

Agriculture= 12/15*100= 80%

Urban settlement= 9/11*100= 82%

Producer Accuracy: -

Green area=11/12*100 =92%

Agriculture=12/15*100=80%

Urban settlement=9/12*100=75%

Table 4.4: User, Producer and Overall accuracy of study area (1990-2020)

LU/LC category	1990		2000		2010		2020	
	User (%)	Producer (%)	User (%)	Producer (%)	User (%)	Producer (%)	User (%)	Producer (%)
Agricultural land	87	93	83	79	86	90	80	80
Green area	86	92	84	89	76	82	100	92
Urban Settlement	100	90	78	92	91	87	82	75
Over all accuracy (%)	91.33		84.6		85.3		86.5	

4.4. Normalized difference vegetation index

In this study, it has been observed that the vegetation cover was moderately more in 1990 and 2000 with maximum NDVI values of 0.57 and 0.47, respectively. The highest value shows healthy vegetation. Vegetation cover has decreased for the year 2020 with the NDVI value of 0.38. Normalized difference vegetation index result for the years 1990, 2000, 2010 and 2020 are presented in Figure 4.5. The normalized difference vegetation index result of 1990, 2000,2010 and 2020 showed that the northwest and southwest part of the study area resulted higher NDVI value. As indicated in Figure 4.5, vegetation cover has decreased and non-vegetated area has been increasing gradually over the study period. Table 4.5 showed statistical information of NDVI value for the year 1990, 2000, 2010and 2020.

Table 4.5: Statistical information of NDVI value of study area

Year	Max	Min
1990	0.57	-0.02
2000	0.47	-0.02
2010	0.40	-0.01
2020	0.38	0.01

Where, Min = Minimum, Max = Maximum

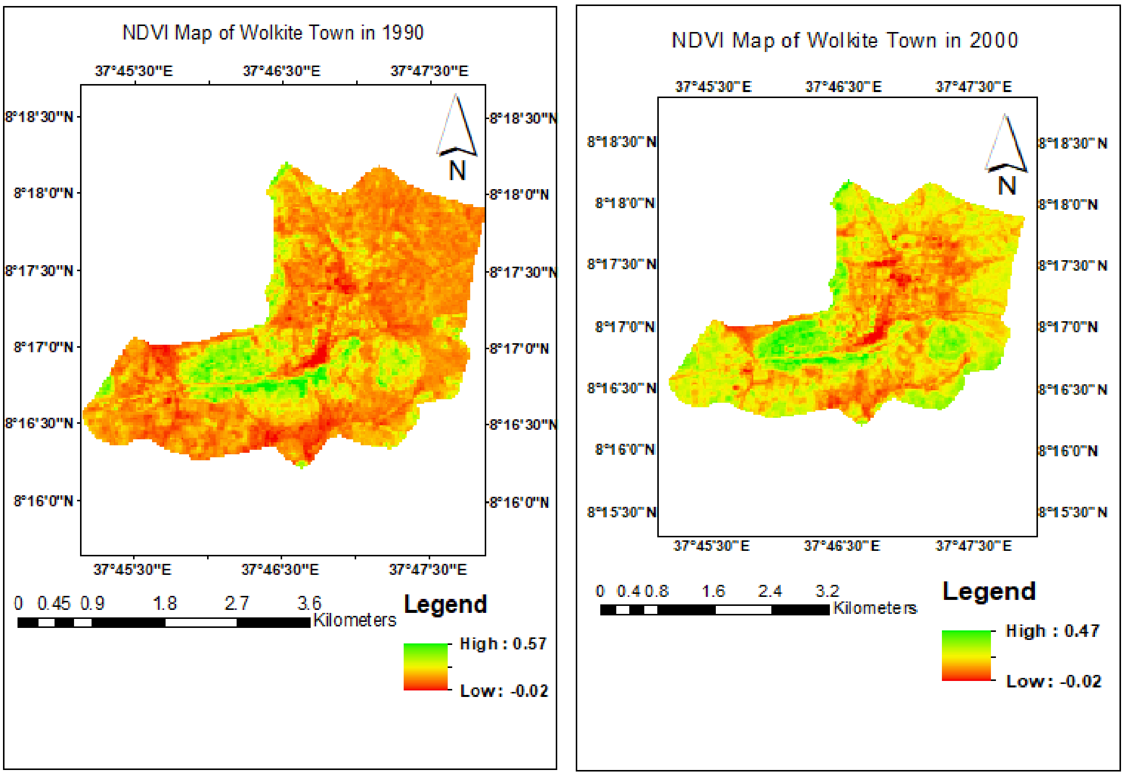

Figure 4.5: NDVI maps of the study area in 1990 and 2000

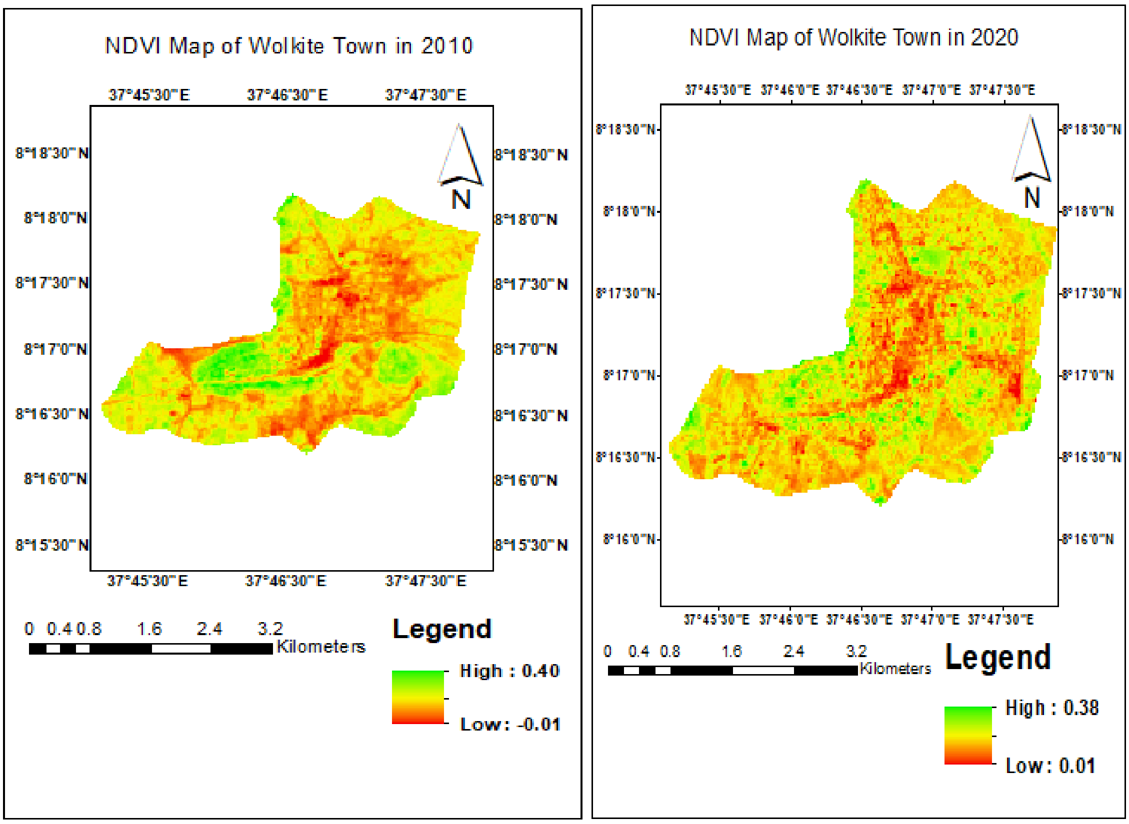

Figure 4.6: NDVI the study area in 2010 and 2020

4.5. Relationship between land-use/land-cover, NDVI and ST

Maps extracted from near infrared and red-bands of the study periods indicated that different LU/LC has different NDVI values. As NDVI is related with the vegetation condition, the value varies from area to area based on vegetation intensity of the sites. green area has the highest NDVI value than other classes. Based on the SPSS analyzing result the study area land use land cover has both negative and positive correlation with NDVI. For instance, to see from output tabular data agriculture and NDVI relation is 0.83 this indicates appositive correlation and green area has a correlation value 0.11 this indicates there a less vegetation coverage on study area and correlation between green area and NDVI. Whereas there is a negative correlation between NDVI and urban settlement because of the output value is -0.87 more detail information are illustrated below in (Table. 4.6). The other parameters are identifying the correlation between LU/LC with ST based on person value test. Agricultural land has a value of -0.75 this indicates negative correlation with surface temperature and green area has a negative correlation with ST at a value of -0.28 as well as there is appositive correlation between urban settlement and ST. However, based on SPSS output result there is strongly negative relationship between ST and NDVI see on (Table 4.6) below.

Table 4.6: Correlation of LU/LC with NDVI and ST

LULC category		NDVI	ST
Agriculture	Pearson Correlation	.827	-.749
	Sig. (2-tailed)	.173	.251
	N	4	4
Green area	Pearson Correlation	.119	-.283
	Sig. (2-tailed)	.881	.717
	N	4	4
Urban settlement	Pearson Correlation	-.872	.802
	Sig. (2-tailed)	.128	.198
	N	4	4

4.6. Resulted Surface Temperature of Wolkite Town from a year (1990-2020)

The spatial distribution of LST of the study area was extracted and quantified using Landsat TM of 1990, ETM+ of 2000, 2010 and OLI/TIRS thermal bands. The analysis from such images indicated that the LST value of the study period ranged from 18°C to 34.7°C. As it was observed from the processed thermal images. In 1990 the minimum and maximum value of temperature record is 18.51°C and 29.25^{0}C respectively when we see in 2000 from satellite result the minimum and maximum value is increased by 4^{0}c which means 20^{0}c and

33.46^{0}c respectively, also 2010 the minimum and maximum values are 20.18^{0}c and 34.06^{0}c. From 2020 satellite image shows that the temperature is increased by almost 1^{0}c therefor the increment of surface temperature in Wolkite town is increased by 5^{0}c in the previous 30 years the main problem is decreasing the agricultural and green area coverage reversely increased expansion of urbanization see the detail information from figure 4.7 and 4.8 below.

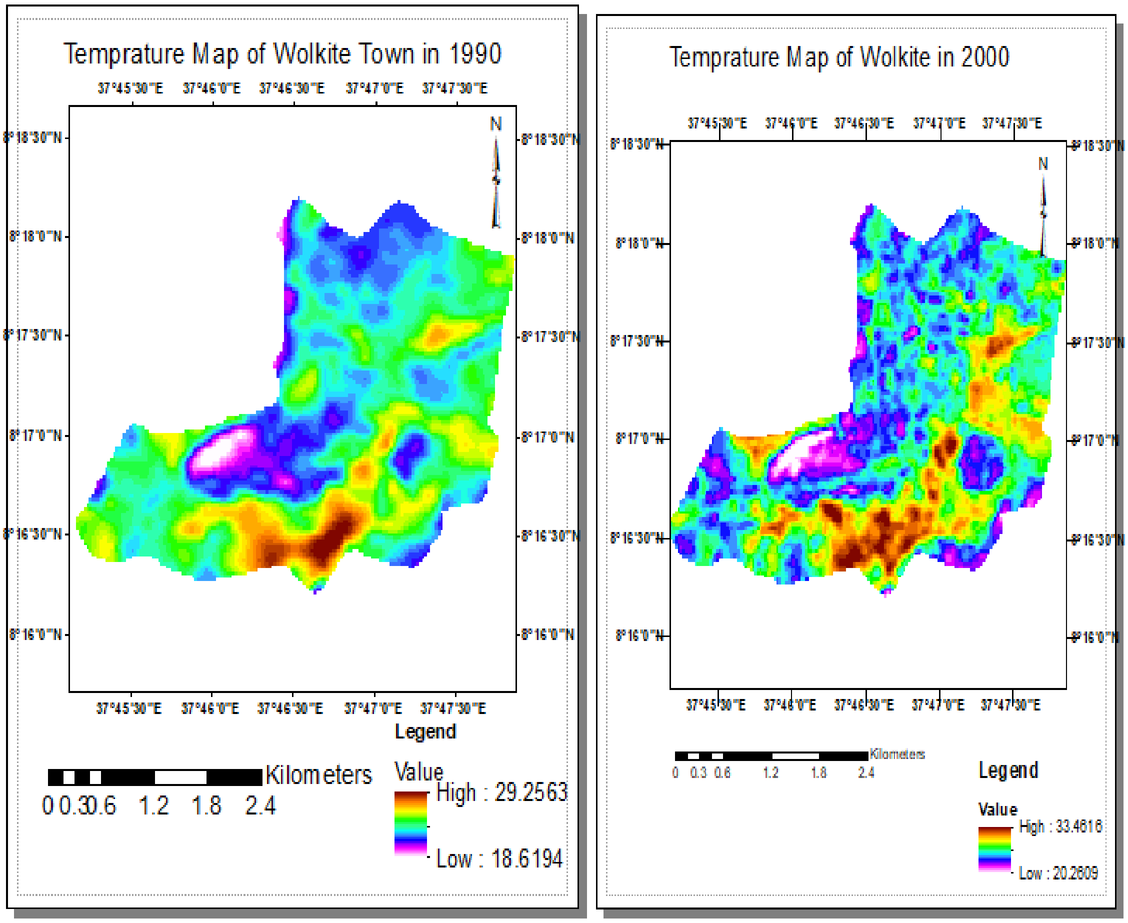

Figure 4.7: ST map of study area in 1990 and 2000

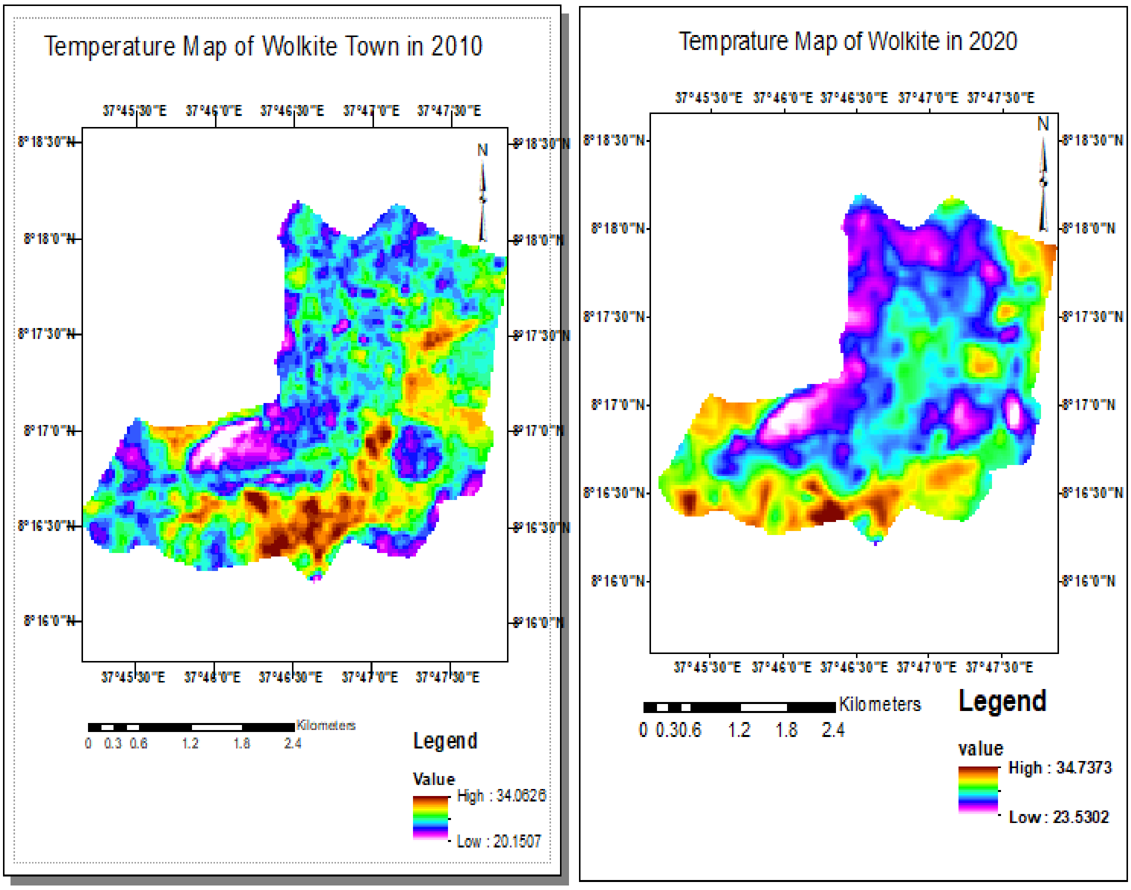

Figure 4.8: ST map of study area in 2010 and 2020

4.7. Land-use/land-cover status of Wolkite Town.

The LU/LC changes experienced across Wolkite Town shows as a sign of population growth and the increase of needs of land for settlement and agriculture. These changes have brought about a series of adverse impacts on the environment. Houghton (1994) revealed that human population growth, economic development, technology and environmental changes are major factor responsible for LU/LC variability. According to FAO (1999), LU/LC changes have become major problems and it is a significant driving agent of environmental changes. Alemayehu (2008) also showed some of the evidence for climate change including occurrence of drought, rising temperature, flood, reduced annual rainfall and rising sea levels. The present study revealed that during the study period there were drastic changes in LU/LC. In 1990, the settlement area was 2.9 kmsq and then it reached 6.55 kmsq in 2020. It is one of the evidences for the increasing needs of settlement. The extent of agricultural land decreased from 5.55 kmsq in 1990 to 2.15 kmsq in 2020. Green area showed fluctuation. In general, the classified satellite image indicates that there is a change due to LU/LC.

4.8. Normalized difference vegetation index

Normalized difference vegetation index is a measure of vegetation condition and used to determine ST. According to Mihai (2012) and Weng (2004), NDVI is found as an acceptable indicator of ST and dryness. The findings of the present study also revealed that NDVI varied from northwest to the southwest. As Agricultural land and urban settlement classes dominate the present study area, the vegetation covers also have a little variation. The NDVI and ST correlation coefficient was evaluated in this study for 2020 was $R^2 = 0.98$, which indicate how the vegetation condition determine the ST of the area and NDVI accounts 98% in distribution of ST. In line with this, the present study revealed that NDVI have strong relation with ST.

According to Pearson decision rule for assessing significant (for $\alpha=0.1$)
When the $p \leq 0.05$ the test significant (there is significant relationship between ST and NDVI)
When $p \geq 0.05$ the test is not significant (there is not significant relationship between ST and NDVI)
Therefore, based on the above rule this study area result relationship is -0.98 this mean there is a negative correlation between the ST and NDVI and also the p-value is 0.02 which means that test is significant (significant relation between ST and NDVI) as it is depicted in (Table 4.7)

Table 4 4.7: Correlation and Pearson rule for ST and NDVI of study area

		Temperature	NDVI
Temperature	Pearson Correlation	1	-.980*
	Sig. (2-tailed)		.020
	N	4	4
NDVI	Pearson Correlation	-.980*	1
	Sig. (2-tailed)	.020	
	N	4	4

*. Correlation is significant at the 0.05 level (2-tailed).

From SPSS output result the relationship between NDVI and ST had a negative relation that mean when, the value of NDVI is increase the amount of surface temperature is decrease in this thesis result shows the value of NDVI were decreased and the surface temperature increased see in (Fig 4.9) below.

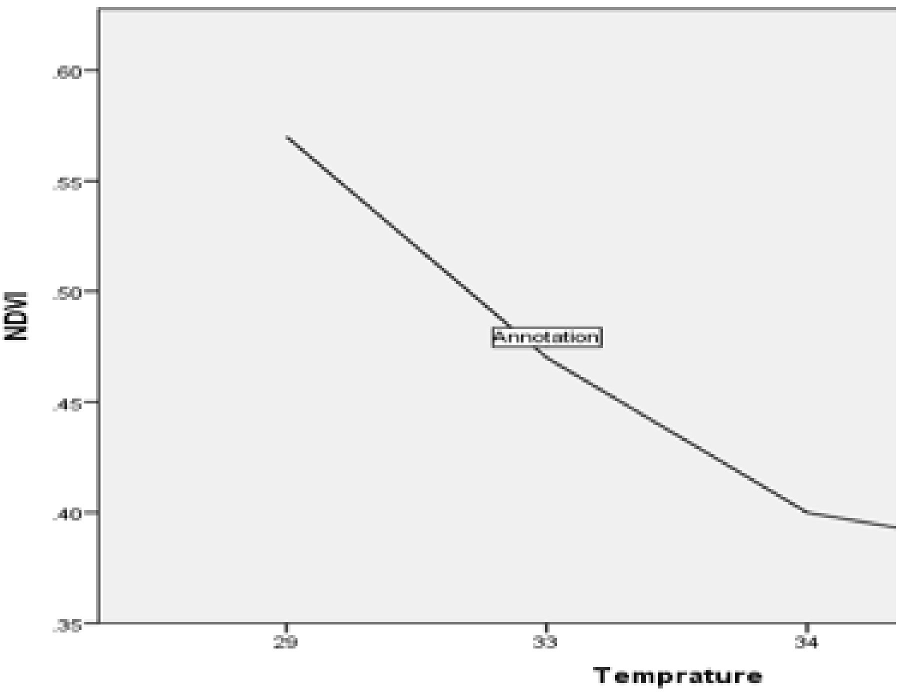

Figure 4.9: NDVI and ST relation graph

4.9. Surface temperature

A thermal band of Landsat image was important in quantifying the ST of the area. In the present study Agricultural Land, and Urban settlement have high ST. The main reason behind less NDVI and high ST values in the area of Agricultural LU/LC class is that the image was taken during the dry season and during harvesting time November and December. In Ethiopia, the main harvesting season is November, December and January. Due to this, agricultural land and urban settlement classes had high surface reflectance. After harvest of crops, the land was very dry and at the same time, land reflectance high. Normalized Difference Vegetation Index value is less for bare urban settlement and agricultural classes. To evaluate the thermal status of land surface by satellite, it is important to find the relation between LU/LC type and ST. Normalized difference vegetation index play a great role in assessing and investigating of ST. Surface temperature and NDVI have indirect relationships in different LU/LC categories. Vegetation condition (NDVI value) and types of LU/LC have impacts on ST value. However, it does not mean that the type of LU/LC is the only factor for the increase of ST. Different researchers used thermal bands to study ST. Gebrekidan Worku (2016) used Landsat satellite imagery to study ST situation of Addis Ababa city. The study investigated the relationship between LU/LC, ST and NDVI. He found negative linkage in NDVI and ST values. Maitima et al. (2009), Khin et al. (2012) and Kerr et al.

(2004) agree with that the main factor for increase of ST in rural as well as urban areas land-cover changes and unplanned use of land resources. In less developed areas the relation between Land-cover change, biodiversity and land deterioration is very high, because of that land-cover are transformed to human settlements, farmlands and grazing lands at the expense of forest and vegetation (Maitima et al., 2009). With regard to LU/LC changes in the study area, with the expansion of settlements, green area, agricultural land and open space have highly declined. This is clearly observed, especially at Wolkite Town. In this area, due to the expansion of settlement, small-scale farmers moved and start to settled in open space.

CHAPTER V: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Major causes of environmental changes are due to the various anthropogenic activities that are integrated not only with the present but also with the past. The common problem, especially urban settlement, directly affect the surface temperature due to the conversion of vegetation surfaces into impervious surfaces (Zhang et al., 2013). Wolkite is one of the intermediate towns for trade transaction especially western part of Ethiopian towns like Jimma and Mizan Aman. It is experiencing a rapid urbanization and most of the land surface is covered with urban settlement. Landsat images for a year 1990, 2000,2010 and 2020 was used from USGS. In addition, integrated geospatial tools like GIS and RS are used for this thesis to analyzed land cover change. In this study an attempted is made to identify relationship between land use land cover and surface temperature by using SPSS tools. Three land use classes have been identified as Urban settlement Agricultural land, green area. Among them agricultural land is decreased by 35.96% from 1990 up to 2020 similarly, urban settlement increased by 35.7% from a year 1990-2020.

Over all classification accuracy determined for each year by using standard formulas and checked with google earth ground truth. Based on this, over all accuracies are 91.3, 84.6, 85.3, 86.5 respectively for a year 1990,2000,2010 and 2020. The maximum and minimum value of temperature were (18.16^{0}c-29.25^{0}c) in 1990 and (23.5^{0}c-34.7^{0}c) in 2020. From the ST images it is clearly understood that surface temperature is continuously increase with the previous thirty years. Also, the correlation value is -0.98 a negative sign indicates there is negative correlation with NDVI and ST. Finally, I concluded that there is LU/LC change and surface temperature change in wolkite Town with inverse relation of ST and NDVI.

5.2. Recommendation

This thesis study focused on the effect of LU/LC change on the surface temperature for a year 1990, 200, 2010 and 2020 in wolkite town. The study result show there is land use land cover change from agricultural to urban settlement and green area. The relationship NDVI and ST is highly negative. This shows that there is unbalance urban planning problem. Due to that environmental management, urban plan designer and land management organization must their own contribution to mitigate ST problems. In this thesis work GIS and RS tools used for satellite image analysis process and surface temperature determination purpose. In addition to that I apply SPSS tools for correlation identification purpose. Nation Metrology Agency should be collaborating to given accurate and time-based data for the future.

Finally, I strongly recommended for the next researcher better to include how much the soil humidity is loosed due to the increment of surface temperature and applying another scientific proof for surface temperature analysis.

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APPENDIXES

Appendix A: Monthly temperature of study area

NATIONAL METEOROLOGICAL AGENCY																
NAME	WOLKITE															
Elevation	**Geogr1**	**Geogr2**	**Element**	**Year**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2000	37.45	8.13	TMPMAX	1990	27.2	26.1	27	26.9	26.9	26.6	24.3	23.2	23.4	x	x	29.1
2000	37.45	8.13	TMPMAX	1991	29.3	27.8	28.3	29.7	28.4	25.1	23.6	22.9	25.2	27.3	28.2	27
2000	37.45	8.13	TMPMAX	1992	27	27.2	29.1	27.5	26.5	25.5	24.7	24.5	24.9	25.8	26.7	26.8
2000	37.45	8.13	TMPMAX	1993	28	27.2	27.8	26.1	26.2	x	23.6	23.6	24.8	26.5	27.8	28.7
2000	37.45	8.13	TMPMAX	1994	29	29.3	27.4	29.6	27.3	25.4	24.4	25.4	25.7	27.5	28.9	29.6
2000	37.45	8.13	TMPMAX	1995	29.8	30.9	30.6	28.5	29.4	27.6	27.4	25.7	26.8	28.7	30.1	29.5
2000	37.45	8.13	TMPMAX	1996	28.7	30.4	28	27.8	27.4	27.2	26.2	26.4	27.1	27.9	27.6	28.4
2000	37.45	8.13	TMPMAX	1997	28.5	29.3	29.8	28.5	28.7	x	27.4	27.6	27.6	27.6	28.1	28.3
2000	37.45	8.13	TMPMAX	1998	27.6	27.5	28.4	28.3	28	28.1	26.8	27.2	27.9	27.8	28.1	28.1
2000	37.45	8.13	TMPMAX	1999	27.9	28.3	29.4	27.7	27.8	27.6	27.3	27.5	26.9	27.3	29.3	30.4
2000	37.45	8.13	TMPMAX	2000	30.5	30.5	33.6	31.5	28.6	26.8	25.1	25	26.1	27.9	28.8	30.1
2000	37.45	8.13	TMPMAX	2001	29.5	32.1	29.5	31	29	x	x	x	x	x	x	x
2000	37.45	8.13	TMPMAX	2004	x	x	x	x	x	x	27.9	26.6	27.4	28.1	28	28.7
2000	37.45	8.13	TMPMAX	2005	28.7	31.3	30.9	29	30.4	26.7	25.9	25.1	25.5	27.4	27.6	28.3
2000	37.45	8.13	TMPMAX	2006	30.2	31.5	31.1	29.7	30.7	30.7	27.6	24.4	26.3	28.3	28.1	28.5
2000	37.45	8.13	TMPMAX	2007	29	29.5	30.9	29.7	33.4	29.3	28.5	28.4	27.2	28	29.2	29.2
2000	37.45	8.13	TMPMAX	2008	29.7	30.1	32	30.3	27.5	26.4	24	24.7	25.9	27.5	29	29.1
2000	37.45	8.13	TMPMAX	2009	30.2	30.3	32.5	31.8	32.6	33.3	26.2	25.3	28.4	31.1	30.5	29.2
2000	37.45	8.13	TMPMAX	2010	30.3	29.7	30.6	29.6	29	27.3	24.7	24.4	27.2	30.9	31.3	29.2
2000	37.45	8.13	TMPMAX	2011	29.6	30.7	30.5	31.6	29.3	26.9	25.1	24.5	27	34.3	30.9	30.2

NATIONAL METEOROLOGICAL AGENCY																
NAME	WOLKITE															
Elevation	**Geogr1**	**Geogr2**	**Element**	**Year**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2000	37.45	8.13	TMPMIN	1999	13.2	12.9	12.4	13.1	13	12.8	13	12.9	12.7	12.6	11.6	11.9
2000	37.45	8.13	TMPMIN	2000	12.2	11.9	13.9	12.9	15.1	14.2	14.3	13.9	14.2	14.5	13.5	13.4
2000	37.45	8.13	TMPMIN	2001	13.7	14.5	12.8	13.6	12.9	11.7	12.9	13.9	13.8	13.4	13	12.8
2000	37.45	8.13	TMPMIN	2002	12.9	13.5	14.3	13.4	14.2	13.5	12.4	15.7	17.6	14.8	14.8	14.6
2000	37.45	8.13	TMPMIN	2003	13.9	14.4	14.2	14.1	x	13.3	13.5	14.5	14	15.2	14.5	12.8
2000	37.45	8.13	TMPMIN	2004	14.9	14.1	14.1	13.9	14.4	14.6	14.1	17.8	16	14.9	13.1	13.1
2000	37.45	8.13	TMPMIN	2005	13	14.9	14.6	13.9	15.2	14	14.3	13.8	14.3	13.8	14.4	14.3
2000	37.45	8.13	TMPMIN	2006	14.3	15	15.4	15	15	14.5	14.6	14.6	14.4	14.2	13.4	13.7
2000	37.45	8.13	TMPMIN	2007	13.8	14.8	15.2	15.2	14.7	14.3	13.9	13.6	13.5	13.5	13.3	12.9
2000	37.45	8.13	TMPMIN	2008	13.9	14.2	15.6	15	14.4	13.7	13.6	13.6	13.4	13.3	14.5	12.8
2000	37.45	8.13	TMPMIN	2009	13.5	13.8	14.1	15.3	14.8	14.5	14	14.1	13.8	13.8	12.2	14.5
2000	37.45	8.13	TMPMIN	2010	14.4	16	15.7	16.2	16.2	15.9	14.8	14.4	13.8	13.6	14	14.4
2000	37.45	8.13	TMPMIN	2011	13.9	14.2	14.3	14.6	14.3	14.3	14.5	14.5	14.4	13.3	14.2	13.8
2000	37.45	8.13	TMPMIN	2012	13	13.2	13.3	13.6	x	13.4	x	x	x	x	x	x
2000	37.45	8.13	TMPMIN	2013	x	x	x	x	x	14.6	x	14.9	x	x	11	x
2000	37.45	8.13	TMPMIN	2014	10.8	10.3	13.4	13.2	13.3	14.8	x	15.7	15.6	13.3	10.9	11.2
2000	37.45	8.13	TMPMIN	2015	x	13	13	13.3	13.4	12.7	13.8	14.9	11.1	13.1	14	x
2000	37.45	8.13	TMPMIN	2016	13.6	13.7	13.6	13.2	14.8	14.6	15.2	15	14.9	12.8	x	x
2000	37.45	8.13	TMPMIN	2017	12.4	13.3	x	x	13.4	13.9	x	x	x	x	x	x
2000	37.45	8.13	TMPMIN	2019	x	x	x	14.9	15.6	x	x	x	x	x	x	x

Appendix B: Daily Rainfall distribution of study area

NAME	Element	YEAR	GEOGR2	GEOGR1	ELEVATION	MO	1	2	3	4	5	6	7	8	9	10	11	12
Wolkite	PRECIP	1992	8.13	37.45	2000	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wolkite	PRECIP	1992	8.13	37.45	2000	2	0.0	2.3	0.0	2.3	0.0	0.0	0.0	1.5	3.8	6.1	0.0	0.0
Wolkite	PRECIP	1992	8.13	37.45	2000	3	2.3	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wolkite	PRECIP	1992	8.13	37.45	2000	4	3.8	9.4	41.3	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	2.3
Wolkite	PRECIP	1992	8.13	37.45	2000	5	0.0	11.7	0.0	0.0	2.4	0.0	0.0	0.0	0.0	6.3	0.0	0.0
Wolkite	PRECIP	1992	8.13	37.45	2000	6	0.0	0.0	3.7	0.0	0.0	0.0	9.8	0.0	38.4	0.0	0.0	6.8
Wolkite	PRECIP	1992	8.13	37.45	2000	7	0.0	9.3	13.6	9.8	4.8	13.7	29.6	33.7	46.1	8.1	0.0	0.0
Wolkite	PRECIP	1992	8.13	37.45	2000	8	27.5	58.3	79.4	56.3	0.0	19.3	7.8	12.6	17.4	10.2	28.6	23.8
Wolkite	PRECIP	1992	8.13	37.45	2000	9	9.4	6.3	0.0	0.0	0.0	0.0	6.5	12.8	13.3	8.4	0.0	0.0
Wolkite	PRECIP	1992	8.13	37.45	2000	10	0.0	18.6	0.0	9.4	0.0	0.0	0.0	0.0	0.0	5.8	0.0	0.0
Wolkite	PRECIP	1992	8.13	37.45	2000	11	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	8.9	28.4	13.6	0.0
Wolkite	PRECIP	1992	8.13	37.45	2000	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0	0.0	0.0
Wolkite	PRECIP	1993	8.13	37.45	2000	1	0.0	0.0	0.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wolkite	PRECIP	1993	8.13	37.45	2000	2	0.0	0.0	0.0	0.0	0.0	56.3	0.0	0.0	0.0	0.0	0.0	0.0
Wolkite	PRECIP	1993	8.13	37.45	2000	3	4.9	2.6	0.0	0.0	6.3	0.0	10.3	4.4	0.0	0.0	0.0	0.0
Wolkite	PRECIP	1993	8.13	37.45	2000	4	0.0	21.7	9.6	40.8	0.0	0.0	28.3	7.9	10.8	0.0	0.0	0.0
Wolkite	PRECIP	1993	8.13	37.45	2000	5	0.0	3.6	9.2	3.4	0.0	0.0	38.9	13.7	8.3	0.0	0.0	0.0
Wolkite	PRECIP	1993	8.13	37.45	2000	7	7.9	13.8	22.0	16.4	14.5	20.2	8.4	38.6	9.3	0.0	3.5	7.4
Wolkite	PRECIP	1993	8.13	37.45	2000	8	32.3	12.6	7.9	2.8	4.3	8.1	20.4	30.2	16.4	5.0	0.0	0.0
Wolkite	PRECIP	1993	8.13	37.45	2000	9	6.7	29.3	10.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.7	18.5
Wolkite	PRECIP	1993	8.13	37.45	2000	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wolkite	PRECIP	1993	8.13	37.45	2000	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	monthly sum
0.0	0.0	8.9	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	16.8
9.8	7.3	2.7	0.0	0.0	24.2	8.3	0.0	0.0	18.6	7.1	0.0	0.0	3.1	15.3			129.8
0.0	2.1	10.6	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	1.7	2.3	0.0	0.0	0.0	29.9
8.9	14.3	0.0	44.6	0.0	0.0	2.4	0.0	0.0	2.5	0.0	58.2	18.3	0.0	3.6	0.0		247.3
0.0	21.4	0.0	6.9	19.7	0.0	0.0	56.4	18.7	0.0	2.7	28.6	3.4	0.0	0.0	2.8	0.0	195.3
0.0	0.0	0.0	56.7	26.9	14.6	0.0	32.8	46.3	38.5	0.0	0.0	33.2	7.9	19.8	0.0		358.2
52.4	32.3	0.0	0.0	0.0	18.8	19.2	13.7	0.0	0.0	0.0	2.3	0.0	0.0	13.8	2.6	0.0	326.9
0.0	3.4	6.8	0.0	0.0	0.0	72.9	59.4	76.8	41.3	18.6	26.4	0.0	3.7	0.0	0.0	16.2	717.1
0.0	0.0	0.0	3.6	0.0	0.0	0.0	6.5	0.0	13.0	0.0	0.0	0.0	17.9	0.0	0.0		109.2
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	18.3	0.0	0.0	0.0	0.0	0.0	55.9
0.0	0.0	0.0	8.9	2.1	38.4	0.0	0.0	0.0	0.0	0.0	7.8	0.0	0.0	0.0	5.2		115.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.3	2.5	0.0	0.0	0.0	7.8	0.0	0.0	31.9
0.0	12.8	7.9	3.2	0.0	0.0	6.4	0.0	0.0	0.0	8.6	0.0	23.7	7.4				136.3
0.0	0.0	0.0	7.5	2.8	0.0	0.0	0.0	0.0	0.0	0.0	28.6	0.0	17.6	0.0	0.0	0.0	85.0
52.9	33.4	27.1	2.5	6.5	0.0	0.0	3.5	1.4	2.3	0.0	0.0	0.0	0.0	0.0	0.0		248.7
7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.8	23.9	0.0	13.3	8.6	203.4
0.0	45.0	16.8	6.7	8.2	0.0	0.0	23.1	27.9	11.4	0.0	0.0	0.0	0.0	0.0	3.7	4.9	309.7
0.0	0.0	0.0	13.5	1.1	4.3	0.0	0.0	0.0	0.0	18.7	45.4	24.3	0.0	0.0	3.4	15.2	265.9
0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8	11.2	0.0	0.0	0.0	0.0	0.0	9.6	24.5		155.5
0.0	1.4	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0

Appendix C: Variable processing summary for ST and NDVI

Variable Processing Summary

		Variables		
		Dependent		Independent
		ST	NDVI	Urban_settelement
Number of Positive Values		4	4	4
Number of Zeros		0	0	0
Number of Negative Values		0	0	0
Number of Missing Values	User-Missing	0	0	0
	System-Missing	0	0	0

Appendix D: adjusted R squared summary tables

Model		R	R Square	Adjusted R Square	Std. Error of the Estimate
1		.980[a]	.959	.939	.62789

a. Predictors: (Constant), NDVI

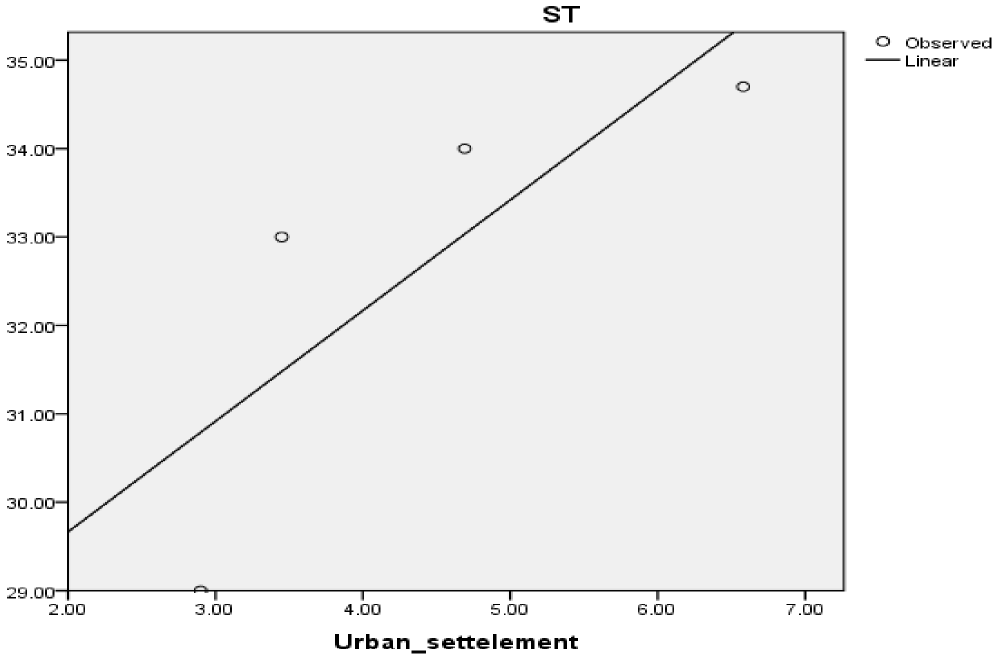
Appendix E: Modal summary for Urban Settlement and NDVI

Dependent Variable: ST

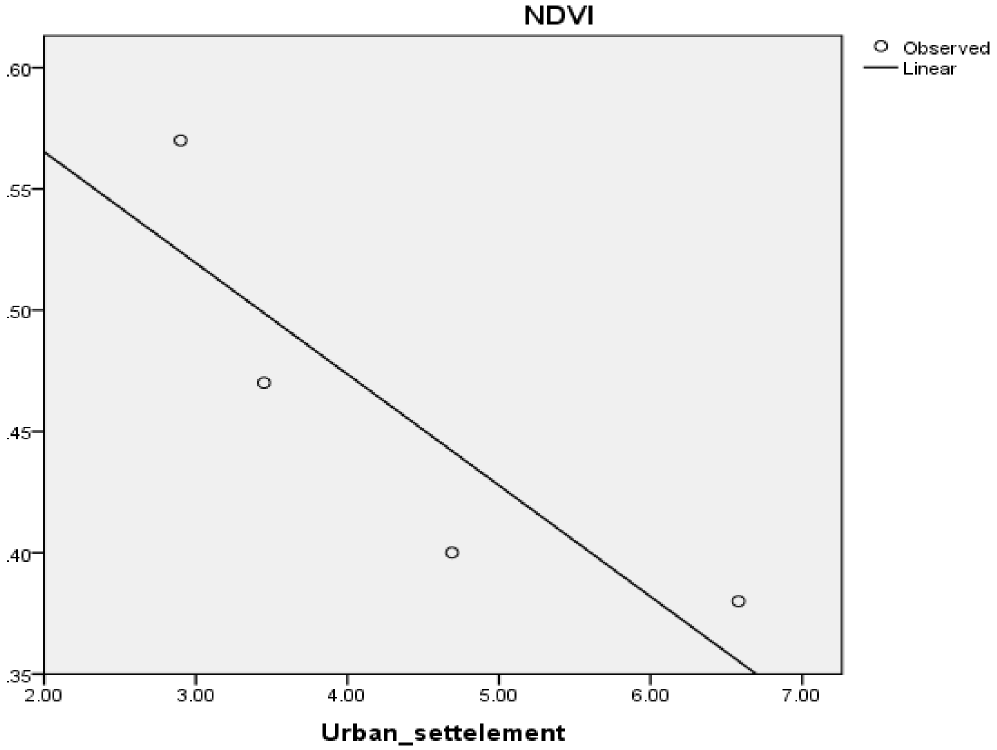
Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	.643	3.607	1	2	.198	27.160	1.252

The independent variable is Urban settlement.

Appendix F: Correlation graph for ST and Urban Settlement



Appendix G: Regression graph for NDVI and Urban Settlement



Appendix H: User and Producer accuracy

Table

point

FID	Shape *	Id	User	Producer
0	Point	1	2	2
1	Point	2	1	1
2	Point	3	3	3
3	Point	4	2	2
4	Point	5	2	2
5	Point	6	1	2
6	Point	7	1	2
7	Point	8	1	1
8	Point	9	2	3
9	Point	10	1	1
10	Point	11	2	3
11	Point	12	2	2
12	Point	13	3	3
13	Point	14	1	1
14	Point	15	1	1
15	Point	16	3	3
16	Point	17	2	3
17	Point	18	2	2
18	Point	19	2	2
19	Point	20	1	1
20	Point	21	2	2
21	Point	22	1	1
22	Point	23	3	3
23	Point	24	2	2
24	Point	25	2	2
25	Point	26	1	1
26	Point	27	1	1
27	Point	28	3	2
28	Point	29	3	3
29	Point	30	3	3
30	Point	31	3	3
31	Point	32	3	1

Appendix I: Google earth ground truth checking