DETECTION OF URBAN EXPANSION AND ITS IMPACT ON LAND SURFACE TEMPERATURES IN KIRKUK, IRAQ, USING REMOTE SENSING AND GIS

Shamal Hussein AHMED

MASTER'S THESIS

Department of Soil Science Plant Nutrition

Supervisor: Prof. Dr. Alaaddin YUKSEL

2017

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BİNGÖL UNIVERSITY
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This thesis was unanimously approved by the following jury on 07.06.2017

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Prof. Dr. İbrahim Y. ERDOĞAN
Director of the Institute

PREFACE

Mainly, I thank Allah for providing me the opportunities that I have received. It is through your grace that I have come this far in this incredible journey. A great appreciation and sincere gratitude goes to my supervisor, Prof. Dr. Alaaddin YÜKSEL, Your support and mentorship have been invaluable to me for the continuous support of my Master study, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped me all the time while writing my thesis. and i am thankful for Faculty of Agriculture of Bingol University, and to all the staff of the Soil Science and Plant Nutrition department, Assoc. Prof. Dr Ramazan MERAL, Assist Prof. Dr.Yasin DEMİR. Assist Prof. Dr. Abdulkadir SÜRÜCÜ, Prof. Dr. Ali Riza DEMİRKİRAN, Assist. Prof. Dr.Vedat AVCI and for their willingness to help me during my study. I am grateful to my parents for their unwavering encouragement and support throughout my endeavours; I dedicate it to my generous Mother, brothers, my sisters. I have a special thanks to my friends Mr Gaylan RASUL, Mr Awara MOHAMMED, Mr Safin NAJIB, for their helped me writing my thesis. I also want to thank all those people who helped during my MSc study.

Shamal Hussein AHMED

Bingol 2017

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ÖZET

Bu araştırma, Irak'ın kuzeyinde Kerkük kentinde kentsel genişlemenin arazi kullanım / arazi örtüsünün değişimini ve arazi sıcaklığı üzerindeki etkisini değerlendirmek için Landsat 5 TM ve Landsat 8 OLI'yi kullanılarak yürtülmüştür. Arazi yüzey sıcaklığı dağılımının tahmini ve mevcut arazi kullanım tipleri ile olan ilişkisi, kentsel mikro iklimin araştırılması için çok önemlidir; arazi yüzey sıcaklığını belirlemek için CBS teknikleri ile üç yıl boyunca mekansal dağılım algoritması modeli kullanılmıştır. Ağustos 1992, Temmuz 2006'da iki Landsat 5 TM görüntüsü elde edilmiş ve Temmuz 2016'da bir Landsat 8 OLI görüntüsü elde edilmiştir.

Bu çalışmada, farklı arazi örtü tiplerini sınıflandırmak için farklı sınıflandırma teknikleri uygulanmış ve uydu sensörü aracılığıyla yansıma sıcaklığı hesaplanarak arazi yüzey sıcaklığı elde edilmiştir. Sonuçlar, 1992 ile 2016 yılları arasında, açık ve kapalı alanlar arasında %64,92 den %32,13' e bir düşüşle büyük bir değişimin olduğunu gösterirken, yapılaşma oranında 1992 den 2016 yılına %14,61 den %35,06'a bir artış olduğunu göstermiştir. Diğer yandan vejetasyon altındaki alanlarda %24.18 artış olmuştur. En düşük LST değerleri, su ve vejetasyon bölgelerinden 1992'de 35^{o}C, 37^{o}C , 32^{o}C, 33^{o}C 2006'da 35^{o}C, 36^{o}C 2016'da alınmıştır. Çorak topraklarda 1992, 2006 ve 2016 yıllarına ait üç yıllık sürede en yüksek sıcaklık değerleri sırasıyla 44^{o}C, 38^{o}C ve 46^{o}C olarak gerçekleştiği saptanmıştır. Bu çalışmada önemli bir husus, kentsel yüzey fraksiyonunun kısır ve açık araziler gibi çevreden daha serin olduğu bulunmasıdır. Bu bulgu LST analizi ile tespit edilmiştir. Öte yandan, LST ve NDVI arasında anlamlı bir negatif korelasyon bulunmuş ve bunların sırasıyla 1992, 2006 ve 2016 için -0,78, -0,69 ve -0,55 değerlerinin türetilmiş korelasyon değerlerine sahip oldukları tespit edilmiştir. Sonuç olarak, uzaktan algılama verileri ve CBS, kentsel gelişme ile arazi sıcaklığı arasındaki ilişkiyi incelemek ve gözlemlemede çok etkili olduğu kanıtlamıştır. Bu çalışma ile kentsel alanların kısır ve açık arazilere genişlemesini teşvik etmek için öneriler yapılmıştır.

Anahtar Kelimeler: Arazi kullanım örtüsü / değişiklikleri; Normalize edilmiş farklı bitki örtüsü indeksi (NDVI); Parlaklık sıcaklığı; Bölünmüş Mono-pencere algoritması; Özellik profili Kerkük şehri.

DETECTION OF URBAN EXPANSION AND ITS IMPACT ON LAND SURFACE TEMPERATURES IN KIRKUK, IRAQ, USING REMOTE SENSING AND GIS

ABSTRACT

This research applied Landsat 5 TM and Landsat 8 OLI for evaluating land use/land cover change of urban expansion in the city of Kirkuk north of Iraq and its impact on land surface temperature. Estimation of the land surface temperature distribution and its relation to existing land use types are very significant to the investigation of the urban microclimate, spatial Mono-window algorithm model were used for determining land surface temperature with GIS techniques to study and for three year periods. Two Landsat 5 TM images were obtained in August 1992, July 2006 and one Landsat 8 OLI image was obtained in July 2016. In this study supervised classification techniques was applied to classify different land cover types and the land surface temperature was obtained by computing the brightness temperature from the satellite sensor. The results displayed that between 1992 and 2016, there was a great change occurred in the between land cover types such as open land is decreased from 64.92% in 1992 to 32.13% in 2016 and while the built up increased from 14.61% in 1992 to 35.06% 2016, and vegetation land increased to 24.18% in the period of study, While many people have returned to Kirkuk after 2003 Saddam Hussein regime fell, urban expansion recent in this study area related to the factors of change political and economic. The lowest LST readings were taken from the water and vegetation lands with values of 35^{o}C, 37^{o}C in 1992, 32^{o}C, 33^{o}C in 2006, 35^{o}C, 36^{o}C in 2016. The barren lands recorded the highest temperature of 44^{o}C, 38^{o}C and 46^{o}C, for the three years 1992, 2006 and 2016, respectively. An important note in this study is the fact that urban surface fraction where found to be cooler than the surrounding areas such as barren and open lands. In this study, this is detected by the LST analysis conducted. On the other hand, there is a significant negative correlation between LST and NDVI and them having derived correlation of the values of -0.78, -0.69 and -0.55 for 1992, 2006 and 2016 respectively. Conclusively, remote sensing data and GIS proved to be very effective in studying and observation the relationship between urban development and land surface temperature. Recommendations were made to encourage the expansion of urban surfaces into the barren and open lands.

Keywords: Land use cover/changes; Normalized difference vegetation index (NDVI); brightness temperature; spilt Mono-window algorithm; feature profile Kirkuk city.

1. INTRODUCTION

Urbanization is the material growth and rural land or natural in urban areas as a result of the population migration to the menu of urban areas (Guo et al. 2012). According to the Dictionary" of Cambridge, and the process by which more and more people leave the countryside to live in the cities" in other words, urbanization leading to the development of the neighboring large cities and rural areas gradually increasing population density quietly.

Urbanization is an important phenomenon of global administrator, planers and Environment (Gat et al. 2008). Urban extension really the reason the amendment processes around it (Zhong et al. 2016). A change in the process of urbanization drives to the loss of agricultural land and the subsequent amendment to Apartment areas (Ranjeet Kaur 2013). Urbanization phenomenon engines alteration in land cover components of physical feature such as higher absorption of solar radiance and hot capacity of greater than or thermal energy, and surface albedo and soil moisture. The result of this difference in temperature between the urban areas and the surrounding areas, and accordingly the surface of the medical exam vary between urban and suburban areas, such as roads, construction and pavements asphalt, another way to lessen built-up heat in an urban area is gradually increasing whiteness in the region. This can be done through the preface of high-albedo reflective material including paint colors to light the roofs of buildings, roads, sidewalks, replacing the darker surfaces low albedo (Saleh 2011; Gartland 2008; Voogt 2003 Akbari et al. 2001). According to the reconstruction of the profound has on the environment of the region and its economy (ZHU 2011; Yi et al. 2016; Bhatta et al. 2010). Urban sociology also drafts that the psychology of people and lifestyles are changing in an urban environment.

Urban heat islands (UHIS) are cause by population growth. According to (Jin et al. 2012) actually, urban heat island is one of the leading numbers on the environment in terms of its impact on land use and vegetation. According to (Fraser 2005) Impenetrable surfaces that has not passive relationship with the environment; it also has a huge heat capacity of the Plants. And UHI is the result of an increase in temperature of any industrial area of man-made, in other words, urban metropolitan area, which is much warmer than the surrounding rural areas, the main reason for the urban heat island and surface modification of urban development (Chen et al 2006; Perini et al. 2014; Saleh 2011). Reported that it is the obverse, Cities are generally warmer than the surrounding areas with reason the urban head island effectiveness.

Relative humidity will become lower if the temperature increases provided there is no supply of moisture from outside (Myint and Okin 2009). In urban area the temperature is more and the absolute humidity also is less, urban heat island is similar to desert only. Moreover, less evaporation means, less water vapor enters the air and hence less humidity only (Alazba et al. 2015; Abdullah et al. 2012). Expound, process of the transformation of solar radiation needs through of evapotranspiration into humidity, which supports to decrease temperature, subsequently, to warm down in the air surface of vegetation can be a good supporter to raise cooler in air surface of urban areas.

It determines of definition urban heat island or the causes which share to UHIS appearing that land surface temperature (LST) has the distinctive characteristic of sharing in the process of creating, it entails energy fluctuations and interactions between the ground and the atmosphere (Abdullah et al. 2012; AL sultan et al. 2005). More commonly, the LST in urban heat island studies have focused on air temperature within the Urban Canopy Layer (UCL), below the roof tops in the spaces between buildings(Lowry 1977). Therefore, LST differs from the land surface air temperature (LSAT), because it clears heating and cooling process in the LST slower than earth's surface (Valiente et al. 2010). UHIS are defined and stressed the importance of distinguishing between the various types, and is directed simple classification scheme. For various surface, also the urban atmosphere layers distributed into three layers; canopy layer heat island (CLHI), boundary layer heat island (BHLI), and surface urban heat island (SUHI), more commonly UHI air temperature within the urban canopy layer, below the roof tops in the space between buildings and also air temperature in boundary layer is located above the average height the buildings ,However, the relationship between CLHI and BHLI are relative warming urban island and surface stricture and surrounding rural area(Goward et al. 1981; Hung et al. 2005; Li et al. 2004). However, land surface air temperature near the earth's surface similarly the air temperature usually they have measured by meteorological stations, therefore, many factors have proportional to the land surface heating process's such as the rate of moisture in the soil, typical urban are materials impervious in the land surface and solar radiation .As a result, the replacement of natural cover by urban materials is not a sufficient clarification for the Created from of the urban heat island (Benrazavi et al 2016; Sun et al. 2003).

The negative influence of the urban heat island on the microclimate and environment, will, it shares in the process of increasing land radiation and rising heat in the atmosphere of microclimate (Stredova et al. 2015). Subsequently, fixing key parameter in the model LST can be a well stride to estimate the land surface energy exchange and the temperature, to study changing local, territorial and global environment (Battista et al. 2016; Sun et al. 2003). LST is will an exporter for getting to information and data point of about deferent classes of land skin, analysis of the Earth's surface temperature is necessary to field a variety of studies such as Climate, environment, hydrology, vegetation monitoring and assessment of soil moisture and geology (Wan et al. 1996; Kerr et al. 2005). Thermal remote sensing the degree of urban surface temperature is a special case of monitoring the surface temperature, which varies in response to the surface energy balance (Voogt et al. 2003).Also, thermal infrared is emitted energy that is sensed digitally, it is excellent technique in modeling of environmental elements, processing and interpretation of data acquired primarily in the thermal infrared (TIR) region of the electromagnetic (EM) spectrum, thermal remote sensing, radiations emitted by ground objects are measured for temperature estimation. As a result, it seems that remote sensing high-value and accepted widely as a tool to monitor meteorological stations (Albright et al. 2011; Aires et al. 2001).

As is well known, LST is required for a wide variety of scientific studies - from climatology to hydrology to ecology and bio geology, the evaluation of measuring LST has been provided. The model LST used to many deference studies such as modeling global warming, greenhouse effect, and drought modeling (Dousset and Gourmelon 2003; Zhang et al. 2006).As well, as the climate in relation to urban areas, LST is the advanced model parameter to determine plan stripy, its suitable to guess of land surface temperatures relate to planned urban area effective to mitigate in air surface temperature, while dependable to succeed master-plan for urban areas with dilation green area to mitigate in air surface temperature, LST information is useful to decision makers and planers of urban planning also a good way to decrease storage heat and control the climate in the urban areas (Kumar et al. 2012; Kerr et al. 2005; Perini et al. 2014).

Satellite image is essential to explain the thermal ground surface of understanding to the relationship between the different categories of vegetation and surface temperature, the Normalized Difference Vegetation Index (NDVI) one of the most important method, the land surface temperature method is a good way to show off the rate of vegetation in the area, it has impact on the evapotranspiration processes and soil moisture of the land (Ahmed et al. 2005; Takemata et al. 2004).

In this study, LST has been conducting relevant information on the urban expansion in the city of Kikruk, it has been implemented due to the rapid and massive expansion of the city of Kikruk the sprawl phenomenon has been well documented in the literature and informal sources is. In addition, there has been no research done on the spatial effects of urban development in the LST through the use of remote sensing and geographic information systems. Moreover, in the past two decades, many environmental problems have appeared in the area, such as dust – storm in the summer season and Droughts during the winter season.

Consequently, it has become essential to accurate analyze and monitor environmental changes in urban areas so that they can make appropriate decisions to improve the deteriorating environmental conditions in those areas. Conduct such research is necessary to understand the causes and consequences of changes in the urban areas, especially using remote sensing and geographic information systems. Understanding the distribution of surface temperature characteristics can help planners to discover new ways to solve urban problems and develop informed the regional plans of the city Kikruk.

Aim and Objectives Of The Study

The primary purpose of this study was to analyse the impacts of urban expansion in the Kirkuk city on land surface temperature using both remote sensing and geographic information system.

Research Objectives

- To study the spatial model of urban expansion LULC change in the study area.
- Determine changes in land surface temperatures on each land use / land cover class during the study period.
- To make recommendations for further studies.

Research Question

- During the period under study, what are the changes that have occurred in the ranks of the land cover?
- Is there a spatial variation LST in the Kirkuk city?
- Is there a relationship between surface temperature and land cover and vegetation built up area?
- To what extent urbanization surface temperature affected during the period studying?

Statement Of The Problem

The Kirkuk city, it has testified prominent expansion, growth and developmental human activities like building, road and pavement construction, elimination of Forests and many other human activities, consequently, this has led to increased land consumption, land Cover modification into man-made structure has created many of the negative effects on the environment and thus causing pollution, global warming and greenhouse gas effects, using and alteration in the statues of land use / cover over time without any detailed and comprehensive attempt to assess the situation, because it changes over time In order to detect the land consumption rate, so planners and decision-makers need reliable date and accurate information on the land surface temperature, also make attempt to a suitable decision of predict the same and possible changes that may occur in this situation, so propose that planners can be an essential tool for planning, Therefore it is necessary to study such as this to be carried out, especially using remote sensing (RS) and GIS techniques, as a result, if Kirkuk city will avoid the associate problems of urban heating , it is therefore necessary LST information and using remote sensing and GIS techniques.

2. LITERATURE REVIEW

There are several studies about cold islands in urban areas around the world, especially those region that share similar climatic conditions with that of the area being studied. This phenomenon is unique to desert climate, arid and semi-arid environments. Temperature in the degree of brightness, as noted, it is the most popular way to retrieve land surface temperature, Especially in studies on urban development with the land surface temperature, Used on a large scale data TM infiltrated OLI + in these studies, they are distinct yet closely linked characteristics of the Earth’s surface and their requirements land use/cover change analysis, while land cover categories could be crop land, forest, wetland, pasture, roads, urban areas among others, there is general consensus that the existence of an inverse relationship between surface temperature and NDVI. This can be deduced by the rotor that the amount of biomass in the region plays in controlling the Earth's surface temperature.

Ibrahim (2017) analysed the distribution of surface temperature in the city of Duhok, Landsat 5 TM and Landsat 8 OLI images for the years 1990, 2000 and 2016 were acquired, The analysis done in this study showed that there is a great difference between the temperature in the urban areas and surrounding areas, due to the lack of substantial vegetation in the surrounding areas of Duhok city. Brightness temperature was also used for LST derivation. NDVI, NDBI, NDBAI and NDWI values were obtained for the purpose of investigating the relationship between surface radiance temperature and land cover types, the results showed a negative correlation, supervised classification methods were utilized to make 4 land use classes. Were found to have high LST of the barren land and built-up areas, ranging from 47^{o}C, 50^{o}C, 56^{o}C , while lower temperatures are related to water bodies and vegetation areas , ranging from 25^{o}C, 26^{o}C, 29^{o}C , in 1990, 2000 and 2016 respectively.

Li and Jackson (2004) examined Deriving land surface temperature from Landsat 5 and 7 during have taken two places in SMEX02/SMACEXf from 2002, And used Landsat TM / ETM scenes of the 2002 study used the temperature of temperature brighten, to get the surface temperature values. Results showed that among the various data in a single month in 2002. The works are estimated temperature and brightness compared with concurrent measurements tower on the grounds. The surface temperature is not similar between the brightness temperature estimates based on satellite and tower brightness temperature was 0.98 JC Landsat 7 and 1.47 JC Landsat 5, In addition, Raise the surface temperature characteristics are important because they have significant implications for the changes in the land surface estimating flow between the high-resolution Landsat regional and global sensors such as MODIS.

Weng and Lu (2003) assessed the impact of land surface temperature–vegetation abundance relationship for urban heat island studies, The area studied is the city of Indianapolis, the studied located in the middle of the Marion County, Landsat ETM+ images for the year 2002 were acquired and supervised classification using texture color and radiometric channels were employed, it traditionally used the Normalized Difference Vegetation Index (NDVI). The analysis done in this study showed that there is great difference stronger negative correlation between the temperature in the urban areas and unmixed vegetation fraction than with NDVI for all land cover types across the spatial resolution, These variations are also present in the other imagery, and are responsible for the spatial patterns of urban heat islands, Note that urbanization, when accompanied with an increase of the vegetated areas, It may help to reduce heat and carbon congestion and create a healthy environment.

Mohan and Kandya (2015) evaluated the impact of urbanization land-use/land-cover change on diurnal temperature range(DTR), the case studied of tropical urban Airshed of India, in this studied focused on the effect of urbanization on the land surface temperature (LST) based DTR. Spector radiometer (MODIS) with 1 km spatial resolution for the period of 11 years (2001–2011) was acquired. A traditional classification method was used and DTR was calculated by subtracting the night-time LST from the daytime LST, Analysis done in this study showed that there is a steady increase in areas that suffer from the data transfer speed of less than 11 degrees Celsius, which usually resemble urban class, in other words, from 26.4% in the year 2001 to 65.3% in the year 2011 and subsequently The data transfer speed up the whole of Delhi, which was 12.48 degrees Celsius in 2001 progressively reduced to 10.34 degrees Celsius in 2011, and show the existence of a significant decreasing trend.

Similar properties in the Las Vegas Valley Southern Nevada, Using the information systems of the Landsat 5 and 7, the Thermal properties of the Tampa Bay, Florida and Las Vegas, Nevada were evaluated and the results showed that the urban surfaces Las Vegas has had a cooling effect during the day, also known as the island of urban cool or heat sink Xian and Crane (2006).

Saleh (2011) analysis and verification of the spatial distribution surface temperature characteristics with respect to land use in urban areas. The case study area is Baghdad. Landsat 7 ETM + thermal images were obtained in 2002. It has been using the traditional method of classification based on the data of high-resolution IKONOS and brightness temperatures have been used also to derive the LST. Has been getting NDVI values for the purpose of investigating the relationship between NDVI and the degree of surface radiation temperature for each type of vegetation and the results of showed a negative relationship. The Commercial and residential areas, Which form greater part of the city, were found to have high LST, When considering the high level in the city's distribution coupled with a very low vegetation, It can be concluded that the reduction of vegetation significantly contributed to the increase in the LST in the city of Baghdad. Land surface temperature appears to rise as a result of developments of land in urban areas. The results showed that there is a corresponding increase in surface temperature with urbanization.

Chen et al. (2016) applied remote sensing and GIS techniques to investigate of Urbanization and Urban Heat Island in the Beijing the capital of China, Multi temporal images from Landsat TM/ETM for the years 1992 and 2012 were used, while brightness temperature method was used to derive LST and the investigation was carried out by the correlation analysis with the official statistics from DMSP-OLS, The results showed a significant increase in urban land area during the periods studied and that these urban areas had the highest surface temperature, The study also reported there is a strong negative relationship between the degree of the land surface temperature and NDVI, it means that the biomass and increase the vegetation cover and reduced surface temperature to be.

Adeyemi and Botai (2015) investigated effect land use or land cover changes are also thought to affect the climate of the Tshwane metropolis, in this studied to easement of experience rapid urbanization as a result of the conversion of natural lands into large man-made landscapes ,increase in impervious surfaces and a decrease in vegetative cover, his paper described how vegetation and impervious surface area (ISA) it's have taken place in Tshwane metropolis, Gauteng Province of South Africa, it were used thematic spectral indices and mean surface temperatures derived from the thermal bands with classified method to extraction of urban area from Landsat 8 LCDM, 2013, and Landsat 7 ETM+, 2003 images, Well a target in the present paper identified linear correlation between the two types of land cover and surface temperature (LST) derived from thermal bands also examined. The result shows that in this assay for the detection of ISA that the increase was caused by urban sprawl and this contributed to the increase in the surface temperature.

Kwarteng and Small (2005) in the cities of New York and Kuwait in this study focused on the analysis of the degree of surface temperature distribution, New York has a temperate climate while Kuwait is sited in the desert environment. Landsat TM and ETM+ images of Kuwait City and New York City were both acquired in 2001. They used the satellite brightness temperature equation. Due to the lack of significant vegetation in the surrounding areas of Kuwait City, Urban regions recorded the lowest latter to the desert and surrounding areas. This way, generally all the vegetation in areas that includes the transfer of the highest temperature of the earth's surface due to the absence of evaporation, which calls for change from the heat with humidity. It is interesting to The surface temperature is higher in urban areas of New York City Of the areas included as an after effect of the vegetation that surrounds the city's thickness and participated in air cooling through the evaporation process from solar radiation. Concisely, the analysis revealed that there is a difference in surface properties and the flow of energy in Kuwait City and New York City, which lies in the desert and temperate environments, respectively.

Weng (2001) remote sensing and geographic information systems applied for the detection of urban expansion in the Pearl River Delta region in southern China, assessment and its impact on the land surface temperature. Used multiple times images from Landsat for the years 1989 and 1997, while the method was used temperature and brightness to draw LST, the results showed a significant increase in urban land area during the period studied and that these urban areas was higher surface temperature, followed by arid land surrounding it. The study also reported a strong negative correlation between the degrees of the land surface temperature and NDVI, implying that the greater the land cover's biomasses are the lower the surface temperature will be.

In semi-arid regions of the urban area of Algeria's Oran city Bounoua et al. (2009) used Landsat ETM + data to identify the effect of LST on the dynamics of water cycling, and the balance of carbon and surface energy. The results showed that it was possible for urban area to play a positive role in reducing the LST in the arid and semi-arid regions. As is clear from this study, Urbanization in the city of Oran, It has had little effect on the production of heat island in this region. In addition to the results showed that the dynamics of these indicators are greatly affected by land cover types and determine the vegetation. The most important indicator of the extent of the LST and carbon absorption, as a result of this, the study recommended the continuation of the construction of buildings in this region process, Along with the cultivation and planting trees, which were very important in reducing the LST and provide a better environment for the people living in this city.

From the previous literary works, it has been observed and the presence of a certain direction in the analysis of the degree of the Earth's surface temperature in urban areas. Either classified as either citiess urban heat island effect, the effect of the cool island in the urban areas. The used of thermal Landsat data to calculate the overall surface temperatures in the areas of case study. NDVI images are derived from the values to test the relationship with LST. Classification of the supervision is the preferred method to draw the lessons of land use in these studies. And it found that the brightness temperature also popular among the study of literature, and in contrast to other algorithms such as single-window, split-window, etc.

It is important to link the results of these literary works on the research questions asked in this study. All of these studies monitoring the spatial variation of the surface temperature in the study areas. In conducting their analysis, they are classified as areas of their studies in different land use / land cover and then took readings LST from every area of the ground cover to test the relationship between vegetation and temperature. Mainly sought to understand the impact of urban expansion has made in the cooling or heating the land surface temperature, thus creating urban heat islands, Cole urban phenomenon. The urbanization through these writers as a decisive factor in studies LST, monitors joint relationship between urbanization and LST increase decrease. Habib (2007) has gravitated has drawn attention to the LST that affect environmental factors that are similar to those found in the study area, It remains to be seen from the analysis of whether the results would be similar.

3. MATERIAL AND METHOD

3.1. Study Area

The study area, Kirkuk governorate, it is located in the north of Iraq. It is situated between latitude 35.28N, Longitude 44.24E. Kirkuk is located between the Zagros Mountains in the northeast, the Lower Zab and Tigris rivers in the west, the Hamreen Mountains in the south, and the Sirwan. It is bordered to the north by Erbil, in the east by Sulaymaniyah and the south governorate by Salaha Din. Governorate has a total land mass of about 9,679 km^2 (see Figure 3.1).

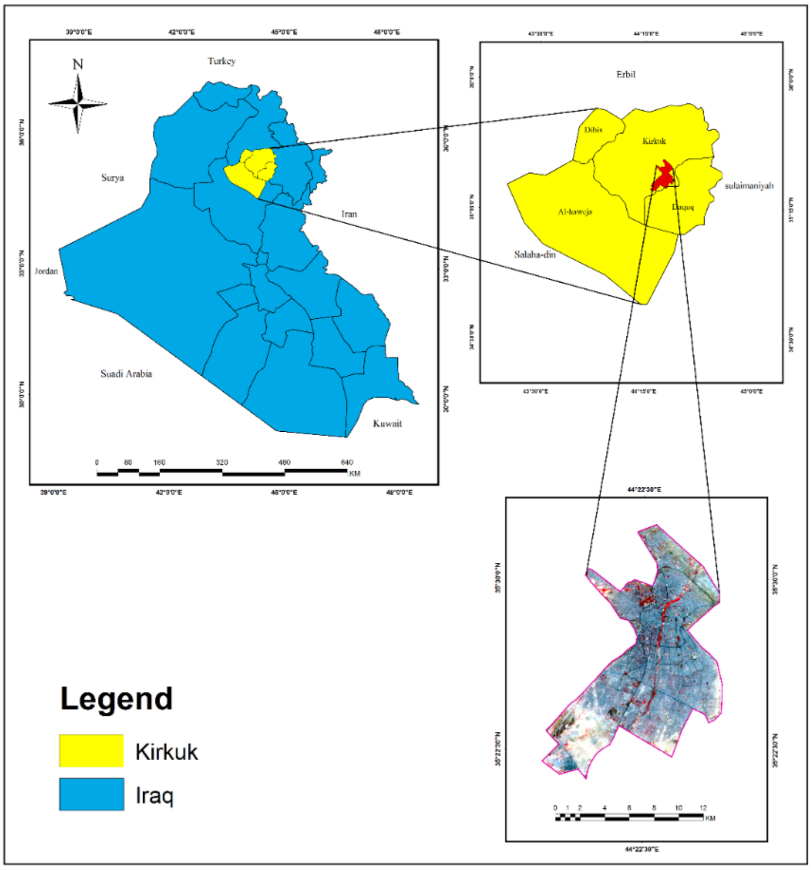


Figure 3.1. Illustration of the location of the study area, satellite image for Kirkuk city

The governorate including four districts such as Dibis, Daquq and Al-haweja, the study area of recognize the characterized by a Mediterranean climate. Referring to Koppen classification it is type CSA, which is characterized by a wet and cold winter and a warm and dry summer. There are two short seasons (spring and fall) between winter and summer with moderate climate conditions and a maximum temperature 25^{o}C. Summer lasts from the beginning of May to the beginning of October and winter expands from November until the start of March. In winter, the lowest recorded temperature in Kirkuk is 28.0°F (-2.2°C), which was recorded in January. The highest recorded temperature in Kirkuk is 120.0°F 49°C, which was recorded in July. A lot of precipitation happens from November until April. Generally, the annual precipitation of Kirkuk city 350 ml per year, the average temperature for the year in Kirkuk is 73.0°F (22.8°C). The warmest month, on average, is July with an average temperature of 96.0°F (35.6°C). The coolest month on average is January, with an average temperature of 48.0°F (8.9°C) the (Köppen Climate Classification subtype for this climate is "Bsh"(Mid-Latitude Steppe and Desert Climate). However, this has recently declined due to climatic and environmental changes. In 2007, the Iraqi government estimated the population of Kirkuk at 902,019 .According to the latest census conducted by the Kirkuk governorate in 2011, the other three districts of Kirkuk are Daquq, Al-Hawiga and Dibis, an the total population in governorates was 1,395,614, according to World Food Programme estimates. About 3% of Iraq's total population, Kirkuk is also highly urbanized with estimates that only 31% of its residents live in rural areas.

3.2. Method

3.2.1. Landsat Satellite Data

The study analyses secondary data to identify the effects of urbanization on LST of the study area. Landsat TM images were obtained from Glovis (USGS) (http://glovis.usgs.gov)for the 8 August 1992, 30 July 2006 and 25 July 2016 with a spatial resolution 30 m. Two Landsat TM images and one Landsat OLI image (path 169, row 035) were obtained from the Glovis Web site and used as a primary data. All of its bands were used for this study, in particular Band 6 Landsat 5 TM (thermal infrared) with

Band 10, 11 in Landsat OLI 8 Thermal Infrared Sensor (TIRS) which is the most suitable for the detection of LST (Table 3.1).

Table 3.1. Landsat-5-TM and Landsat-8-OLI data

Image satellite	**Landsat TM**	**Landsat TM 5**	**Landsat OLI 8**
Data	8-8-1992	30-7-2006	25-7-2016
Time	07:01:42	07:32:14	07:39:00
Path	169	169	169
Row	035	035	035
Projection	UTM zone 38	UTM zone 38	UTM zone 38
Ellipsoid	WGS 84	WGS 84	WGS 84

3.2.2. Data Processing

The software used for the study was Arc map 10,3 analysis of satellite imagery, and evaluate the results and the establishment of maps, and used several software packages including ENVI 5.2 and ArcGIS 10,3. In addition, for the purpose of statistical analysis and regression and create graphs and charts, Microsoft Excel and Grapher7 were used.

In this study, an analysis of satellite images using two approaches: the first approach shares the use of supervised image classification techniques and the extraction of NDVI values with the purpose of obtaining LST from the images. The second way to convert input raster files in geographic information systems for ease of calculation and the environment are being manipulated in the numerical results through the functions of the Table feature of the ArcGIS system software. And it shows the progress of the overall work for the analysis of satellite images (Figure .3.2).

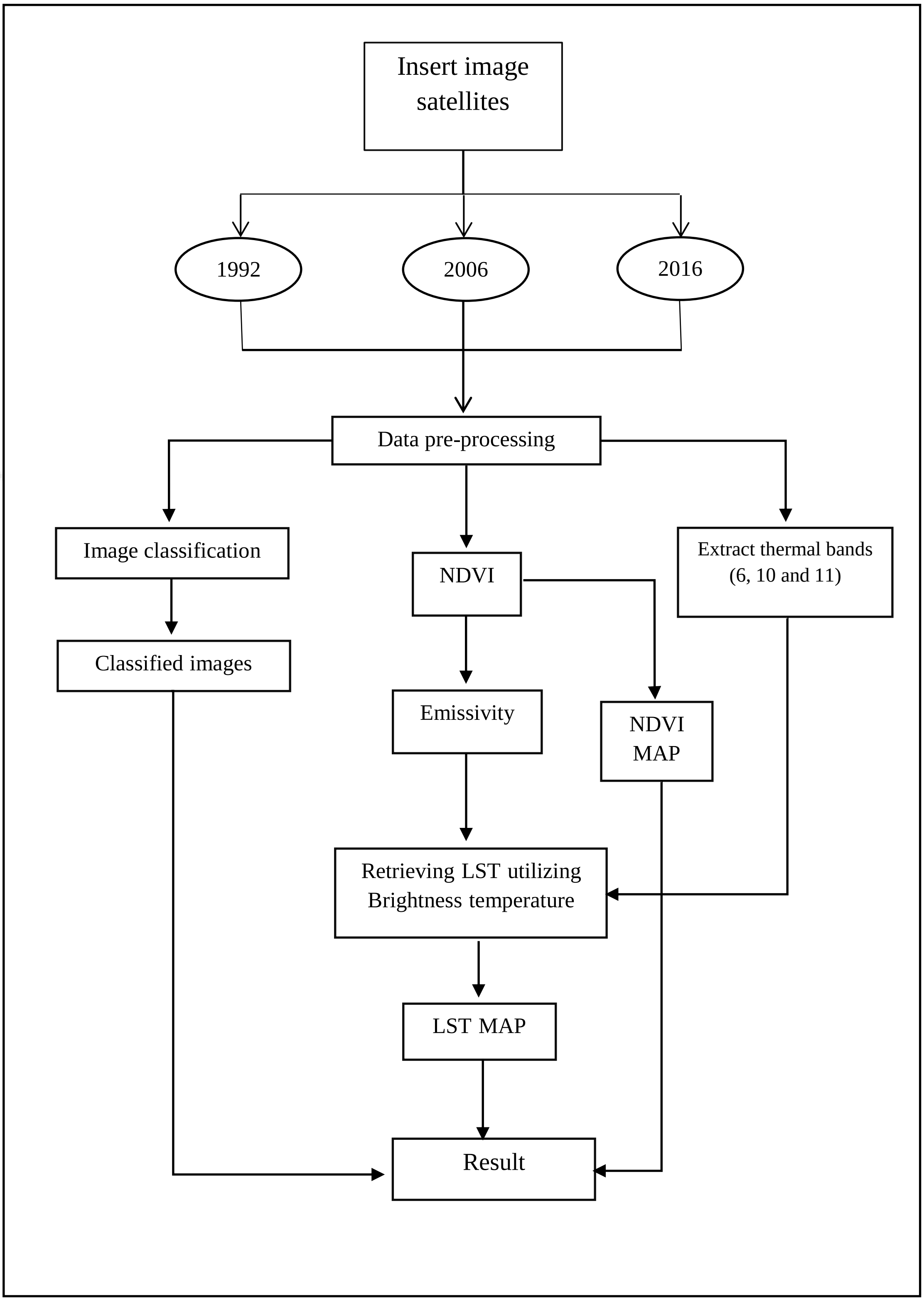


Figure 3.2. Methodological framework adopted for analyzing satellite images

As can be infered from the chart above workflow or image per-processing, it has taken two steps before the rating on the images, in other words, layer stacking and Image sub setting. Layer stacking step includes the creation of color images. Referring Horning, (2009) each band has wavelengths that are specific to both the black and white digital image in a separate image. To produce a color image, the bands of different wavelengths must be combined together (Figure 3.3) the use of false color composite (FCC) using the standard combination of three ranges, namely, Band 4-red, Band3-green, and Band 2 - Near Infrared. In supervised classification steps using Landsat TM images, an integration of the bands is very suiTableand helpful (Lillesand et al. 2008). The next step is a sub-region of interest (Kirkuk city), Landsat image of the ordinary that is downloaded from the website are usually larger in size (see Figure 3.4).

Figure 3.3. Outcome of Layer stacking for Landsat Satellite

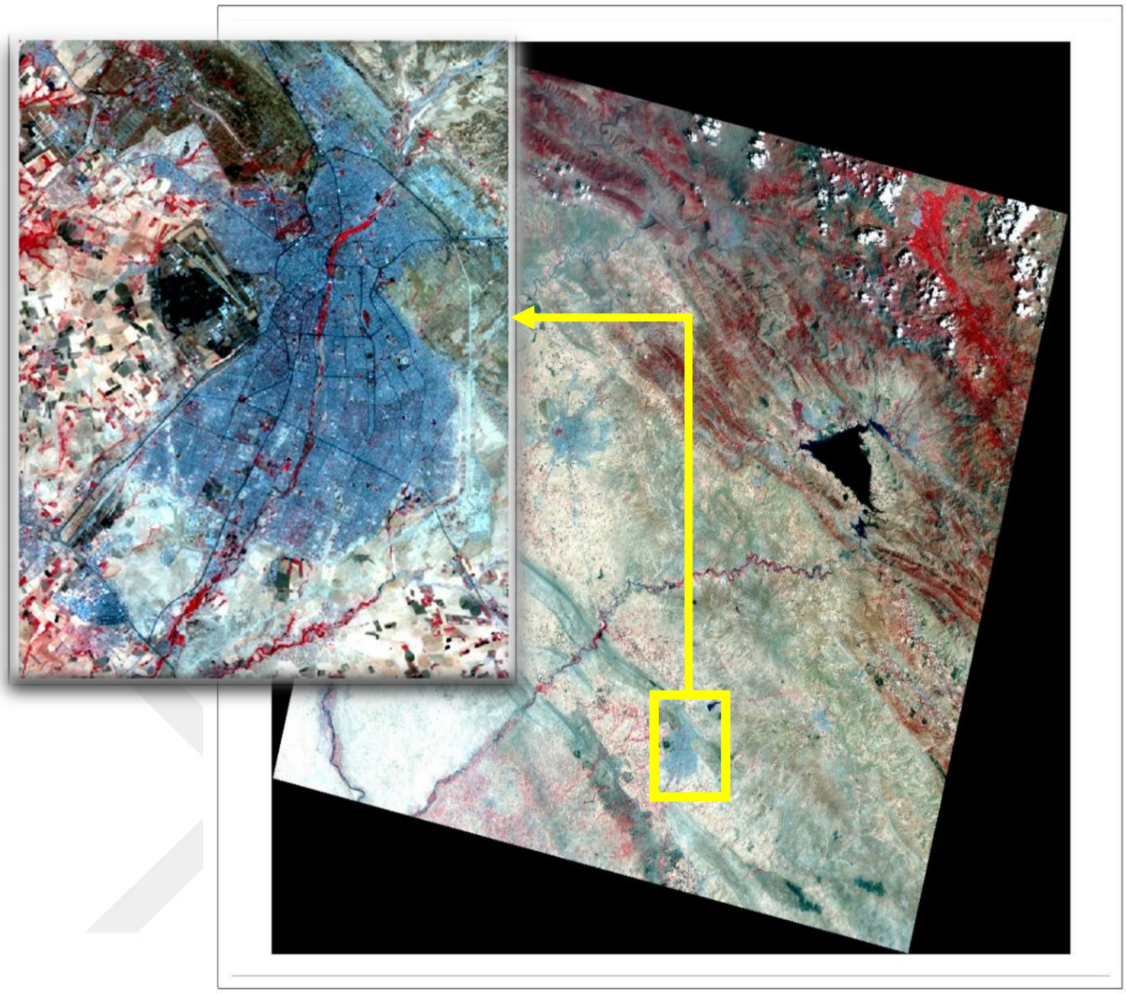


Figure 3.4. Subset Images for selecting Study area on Satellite

assessing the impact of urban growth on the LST. Consequently, the study area was divided into five prime classes of land cover namely, built up, water body, barren land, open land, vegetation area. Table(3.2) it contains a description of each category. And let the objectives of this study, three images 1995, 2006 and 2016 were used.

Option types of vegetation affected over the objectives of this study: it is to clarify the relationship between the classes of land cover and LST, revealing the impact of urbanization on LST (Bobrinskaya 2012).

Table 3.2. Description of Land Cover Types

Classes	Description
Built up area	This included all types of man-made features such as buildings, roads, Industrial areas and residential areas.
Water	It has included all of type's water body.
Open land	This areas is not included built -up or any class of vegetation cover.
Barren land	It has thin soil, sand and rock with limited cultivation of life or ability. Generally, where it was found on the vegetation's that occur in this area, and will be spaced more widely apart as shrubs or grasses to pastures (Anderson et al, 1976).
Vegetation area	It includes parks, forest, agriculture and grassland.

3.2.3. Image Classification Technique

The study depends on outcome from carry out image classification methods. The researchers focused on the remote sensing image classification techniques in the subject majority as it is an accurate, effective and reliable way to obtain information on the land surface features when applied to a diversity of areas (Lu and Weng 2006). Images can also be classified to perform the investigation of land value and data extraction. In other word classification is performed in remote sensing to appear earth surface features in digital forms (Rashed and Jugens 2010). Label images appoint pixel images to pre-defined categories of land cover. Utilizing image classification in the processing to extracting information is a complex procedure; subsequently Factors that should be taken into account when making this process include the level of image resolution, Classification technique selection, and suiTablenumber of training samples, and learning skills possessed by the analyst. Digital image classification is common for the analysis of remote sensing images the way (Matinfar 2007). Division the pixels in the images is carried out for gaining significant information of actuality and employing this information to create thematic maps to represent the different land cover classes. Remote sensing includes different image classification techniques and their suitability relies on the sort and purpose of the map of the land applied in the study cover (Lu and Weng 2006) pointed out that efficiently using multi-source remote sensing data and selecting proper classification techniques is useful in minimizing the mistakes in classification and improving the accuracy of classification.Image classification at pixel scale might be unsupervised or supervised (Levin 1999; Adam 2010). Supervised classification was applied for classifying images to get the objectives of this study. Commonly, supervised classification method is preferred by researchers because it provides a more accurate definition of classes and preferable classification accuracy than unsupervised classification. The most vastly used approach of classification is pixel-based image classification which classifies according to the spatial composition of the characteristics of the limit of the local quarter (IM et al. 2008).

The supervised classification founded on pixel requires the selection of training data for every predefined land cover type. In addition, land information of the field can help in gaining enhanced classification, Three stages must be passed before stratifying supervised classification including training data, choosing the suiTableclassifier type and accuracy appreciation (Barandela and Juarez 2002).

In this study training data is the first step to each image, 100 patterns are selected and 50 patterns were given to each land cover class. The data have to include all categories and it should collect from uniform areas, because it shares field survey and reference data from various origins. Hence, in selecting a training strategy many parameters should be considered including number of pixels utilized for training, Training data magnitude, and the effect of spatial autocorrelation, and the variation in the image, time and cost (Foody and Mathur 2002).

Maximum likelihood is a method of estimating the parameters of a statistical model, and it is a set of parameter values given observed outcomes, likelihood is not probability. Maximum likelihood estimation (MLE) is a popular statistical method utilized for proper a mathematical model to some data. The modeling of real world data using estimation by maximum likelihood displays a path of setting the free parameters of the model to provide a good fit. However, a reasonably accurate calculation of the mean vector and the covariance matrix for each spectral class is required to produce the maximum likelihood Classification efficient (Huang et al. 2008).

3.2.4. Accuracy Assessment

The target of accuracy assessment is to complete the classification process. It can determine the value of the data and results, it is essential for treating and analysing remote sensing data (Hashemian and Fatemi 2004). A set of methods have been advanced for appreciating the accuracy of the land cover maps that is extracted from satellite data, for it becomes an substantial subject in the remote sensing area (Congalton 1991; Latifovic and Olthof 2004). States that positional and objective guesses are the two major approaches for accessing the accuracy of remote sensing data. Positional accuracy estimation is a measure of the spatial distribution of features on the land and on the map to find out the levels of division of features in actuality. In contrast, objectives assessment assigns attributes to the features on the map, and deals with the fact the level of features in the classified image or the maps. The study employs error matrix because it is the most vastly used approach which procedures comparisons between classified images and referenced data and it can be performed by selecting random points in order to test the accuracy assessment (Congalton and Green 2009; Congalton RG 2001).

3.2.5. Normalized Deference Vegetation Index (NDVI)

In LST cases, NDVI is a proper parameter and it's one of the most proper used approach for observing vegetation situation, as it is less critical than other indices to the changes in atmospheric condition (Tso and Mather 2009; Roderick 1996). In this study the objectives of using NDVI was to evaluate relationship between NDVI and LST. The basis of the NDVI is a band math between two of the most important Landsat-5 TM bands. These bands are near-infrared (NIR) band 4 and Red (R) band 3, and in the Landsat-8 OLI , near – infrared(NIR) band 5 and Red (R)band 4 (Liu and Zhang 2011; Gao 2009). These bands are using to a parameter green or health vegetation with band 4 (NIR). The equation for extracting accurate NDVI values is show below.

$$\mathrm{NDVI} = \frac{\mathrm{NIR}\mu m - \mathrm{Red}\mu m}{\mathrm{NIR}\mu m + \mathrm{Red}\mu m}$$

3.2.6. Calculating And Retrieving Land Surface Temperature

Several techniques have been suggested for calculating land surface temperature from Landsat 5 imagery and Landsat 8 imagery. The retrieval of land surface temperature has been achieved out of several various methods and approaches, based on various satellite data. The split window approach was suggested in (Sobrino et al. 1991).

This algorithm is suggested for getting LIST from advanced very high resolution radiometer (AVHRR) which is justified with measured temperatures on the land. It knows a set of coefficients which are identical to the split-window coefficients, classically utilized for sea surface temperature (SST) The mono - window is different algorithm utilized in (Qin et al. 2001). This algorithm utilizes three parameters: incoming surface emissivity, solar radiation, and brightness temperature. Advancements in LAST calculations saw the suggestion of the single-track approach by (Jimenez-Munoz and Sobrino 2003). In this study it employs the use of original brightness temperature of the satellite sensor to calculate the value of the surface temperature.

The approach applied in gaining brightness temperature proceeds in three steps. They include converting digital values from the Landsat images to radiance values, carrying out atmospheric corrections, and converting the radiance values to Kelvin values. Applying an atmospheric correction to the satellite image is commonly an optional step but is beneficial when local values have been sourced for a number of meteorological parameters. This process of atmospheric correction will not be loaded in this study because the Landsat data utilized were sourced from Glovis website, has already been radio metrically corrected (Pancroma 2011).

3.2.6.1. Digital Numbers (DN) To Radiance Ronversion

Landsat images downloaded from the USGS website is in the GeoTIFF with metadata format, come with metadata describing the software (ENVI) the configuration and mapping included in the downloaded package. From ENVI automatically load the Landsat data as multiple files. The ENVI Landsat calibration tools must be open with all of the calibration parameters. Landsat calibration has two types' radiance and reflectance value calculation, click on the Radiance, after radiance selected, it needs an additional step using ENVI band math to convert the radiance temperature in kelvin.

These steps attempt to introduce the theoretical background of thermal remote sensing. Digital numbers are manually converted to sensor radiance by using band math tools.
The spectral radiance (Lλ) is calculated using the following equation:

$$L_{\lambda} = LMIN_{\lambda} + \left(\frac{LMAX_{\lambda} - LMIN_{\lambda}}{QCALMAX}\right) QCAL$$

3.2.6.2. Atmospheric Correction

, Arguably the most primary step in satellite remotely sensed data pre-processing, it is particularly applied in situations where images from various time periods are compared and resolved (Hadjimitsis et al. 2010; Guide 2004). İn applying sence specific atomspheric correction, the formula to use is:

$$CV_{R2} = \frac{CV_{R1} - L\uparrow}{\varepsilon\tau} - \frac{1-\varepsilon}{\varepsilon} L\downarrow$$

WhereCVR1 is the radiance cell value from step A; CVR2 is the cell value atmospherically corrected as radiance; L↓ is down welling Radiance; L↑ is upwelling Radiance; τ is transmittance; and ε is emissivity (typically 0.95) (Ghulam 2010).

3.2.6.3. Radiance To Kelvin Conversion

Another step is to perform the opposite of the Planck function to gain the values of temperature. The Planck function terms the quantity of black body spectral emission radiated at a fixed temperature and wavelength. The thermal emission it describes matches with the maximum probable radiance from any structure of the same temperature (Ghulam 2010; Kabsch 2009). In converting radiance to temperature, this equation can be reformed as:

$$T = \frac{K_2}{\text{In}\left(\frac{K_1}{L_\lambda} + 1\right)}$$

Where:

T = at satellite brightness temperature (K)

L_λ = TOA spectral radiance (Watts/ (m$_{2*}$ srad * μm))

K_1 = band specific thermal conversion content from the TM metadata (K_1 _ constant (607.76) _x, where x is the band 6).

K_2 = band specific thermal conversion content from the TM metadata (K_2 _ constant (1260.56) _x, where x is the band 6).

K_1 = band specific thermal conversion content from the OLI metadata (K_1 _ constant (774.89) and (480.89) _x, where x is the band 10 or 11).

K_2 = band specific thermal conversion content from the OLI metadata (K_2 _ constant (1321.08) and (1201.14) _x, where x is the band 10 or 11).

TB = Surface Temperature ^{o}C

$$TB - 273.15$$

ENVI in band math of understands this formula in the TM scene:

$$(1260.56/Alog\ (((607.76 * 0.95)/B1) + 1)) - 273.15$$

ENVI in band math of understands this formula in the OLI scenes:

$$\text{Band 10} = 1321/Alog(774.89/B1 + 1) - 273.15$$

$$\text{Band 11} = 1201.14/Alog(480.89/B1 + 1) - 273.15$$

3.2.6. Extracting urban Temperature Data Based On Land Use/Cover Classes

To extract the temperature data on the basis of land cover have used different methods, calculate the average temperature for each land cover type in order to analyses their relationships, in an attempt to link the land / cover changes with the use of the urban heat island using Remote Sensing. By applied surface temperature parameter and Land use/Land cover classification data technique as well, extraction of maximum and minimum variance are useful to gained data details for each land cover class including the average (Amiri et al. 2009; Chen et al.2006).This study is hard and adopted a complex methodology therefore the objectives study of relate to particular land cover data, in the study land cover , data probable to be made so that accuracy analysis can be performed with it and therefore this makes the dataset created significant to the study. In the first stage, during the use of supervised classification technique, five land cover classes were derived namely built-up land, barren land, and open land and water body, vegetation lands. Secondly, the Land surface temperature values were calculated in the study area relies on using brightness temperature from satellite sensor to gain accuracy values. In the third step, the NDVI values were computed perform on the whole study area using the values of Land surface temperature. In the fourthly step, the pixels fixed as urban areas are extracted from the whole study area and appoint to a separate shapefile. The same process is performed for other classes of land cover. In another step, for each of the separate pixel represents a different land cover class, Spatial join is performed out with the layer containing the values of the surface temperature of the study area, The shapefile for the land cover classes will now include the LST values occurring in its area, the NDVI map need the same process. In the last step, the results require to designation of datasets for each land cover class that include the LST and NDVI values set in the area covered by that land cover class. This forms the basis for further analysis of the spatial distribution of the land surface temperature between different land cover types. Figure 3.5 clarify the workflow.

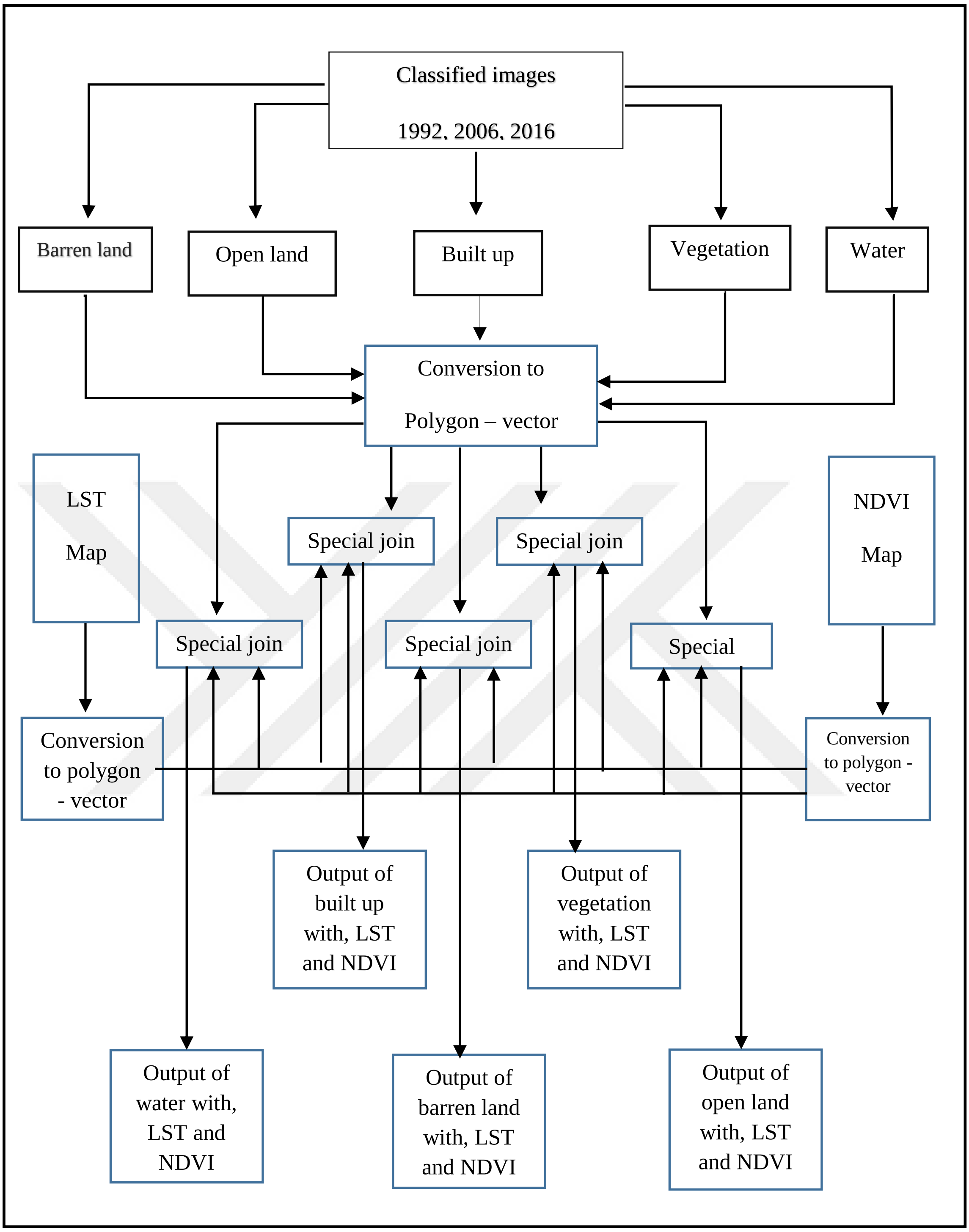


Figure 3.5. Flow chart for the Converting Raster file formats into a Vector file in GIS

4. RESULT AND DISCUSSION

4.1. Result of Classification Images

Landsat 5 TM and Landsat 8 OLI were utilized to detect land cover classes and estimate the changes in each class in 1992, 2006 and 2016 by applying maximum likelihood of supervised classification technique (see Figure 4.1, 4.2, 4.3) imagine the land cover classes. Blue color shows water body, yellow colures represent barren land or empty land such as (rock, soil and sand). The cyan represents open land which without built up, this region identified in the methodology and data processing. Green color represents all of type's vegetation such as agriculture areas, grass land and green regions. Bold red color shows built up areas (building roads and other structure man made).The result of classification image the largest region in 1992 was open land that composed about 64.92% and this proportion it decreased to 54.76% in 2006 while it became to 32% in 2016. Significant changes have occurred in the vegetation region, with this growing land cover class from 10.21% 1992 to 15.43% 2006 than the proportion to become 24.18 % in 2016. It can be seen that in the period 2006 and 2016, the rate vegetation region increased especially agriculture type controlled the vegetation and food cover concentrated around the city, because of occurred development in the economy, however, built up regions accumulated significant changes during this period, with an increase 14.61% in 1992 to 23.83% in 2006 and 35.06% by 2016. This is a large and quick change in built up regions as related to political alterations and economic developments that have occurred in this area. On the other hand, barren land area was increase from 10.03% to 5.88% in 1992, 2006 than barren land areas, it has increased again to 9% in 2016. Water area was decreased from 0.23%, 0.07% and 0.03% in the 1992, 2006 and 2016(see Figure 4.4, 4.5, 4.6 and Table 4.1). Therefore this result is significant point of justifying the objective of this study. Wei Chen (2015) indicated that the changes that occur in land cover classes have a negative impact in the procedure of observation of solar radiation by

Specific land surface, for this propose, the result of the image classification is significant in the study of land surface temperature.

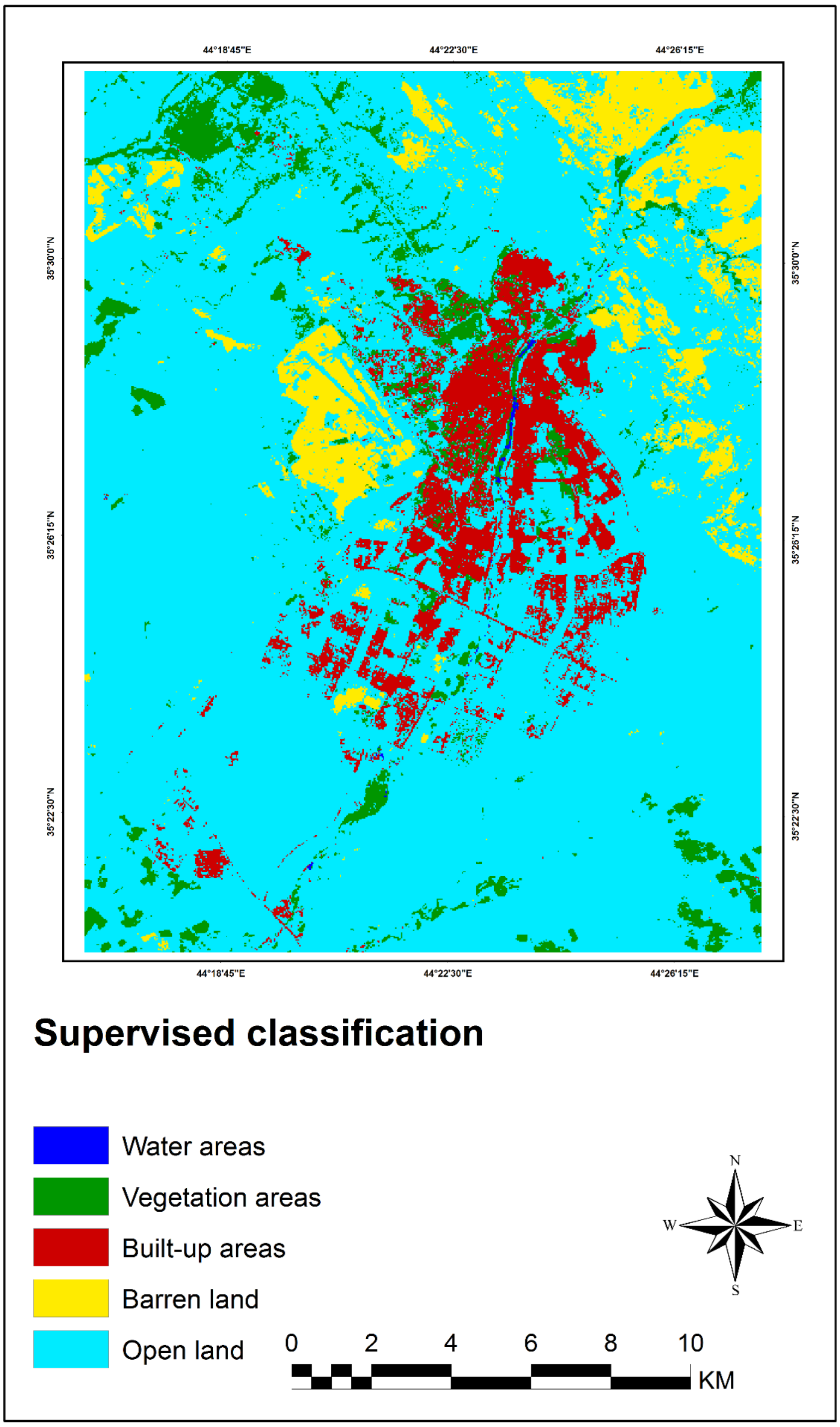


Figure 4.1. Supervised classification of land use/cover map for 1992

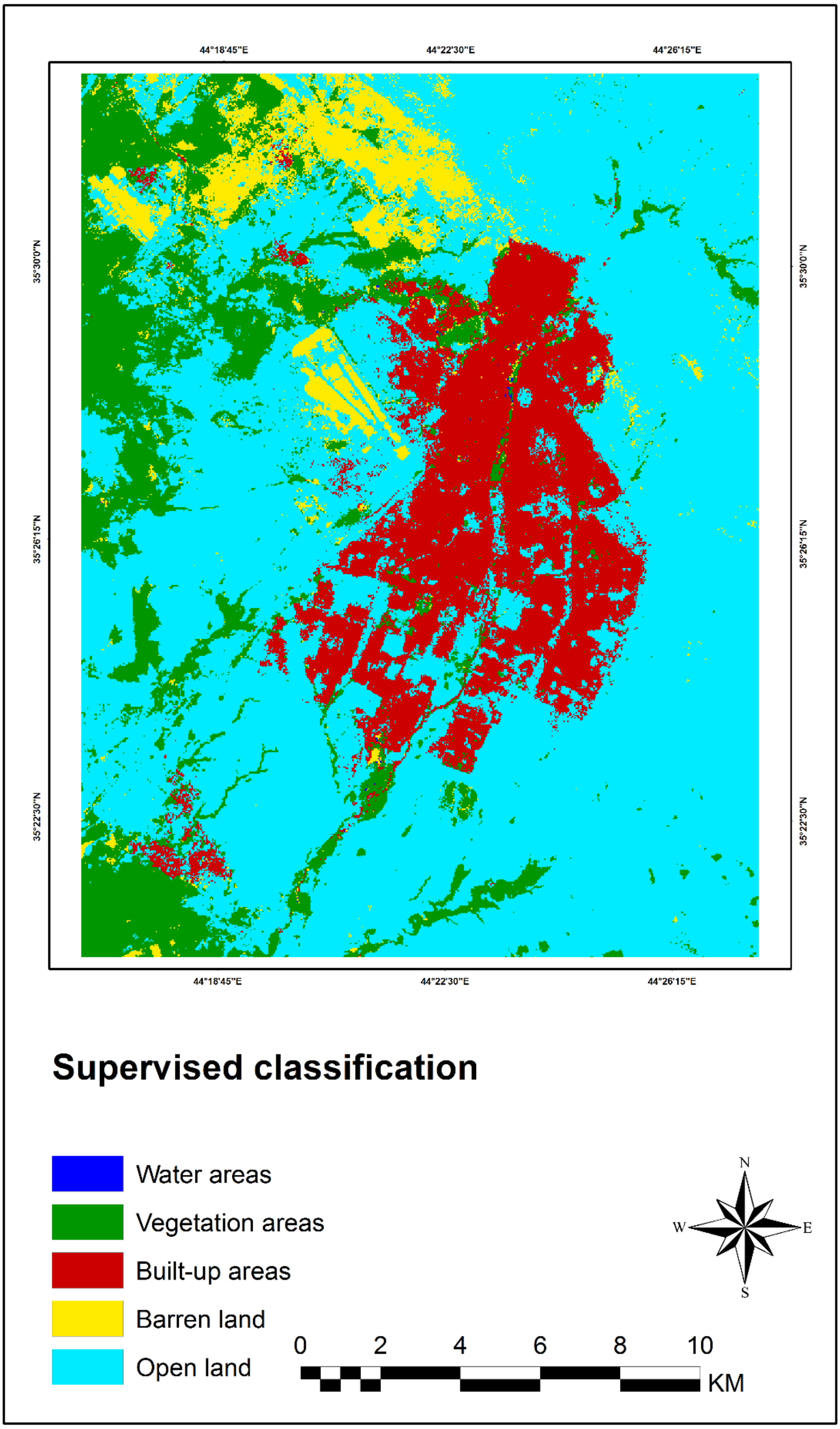
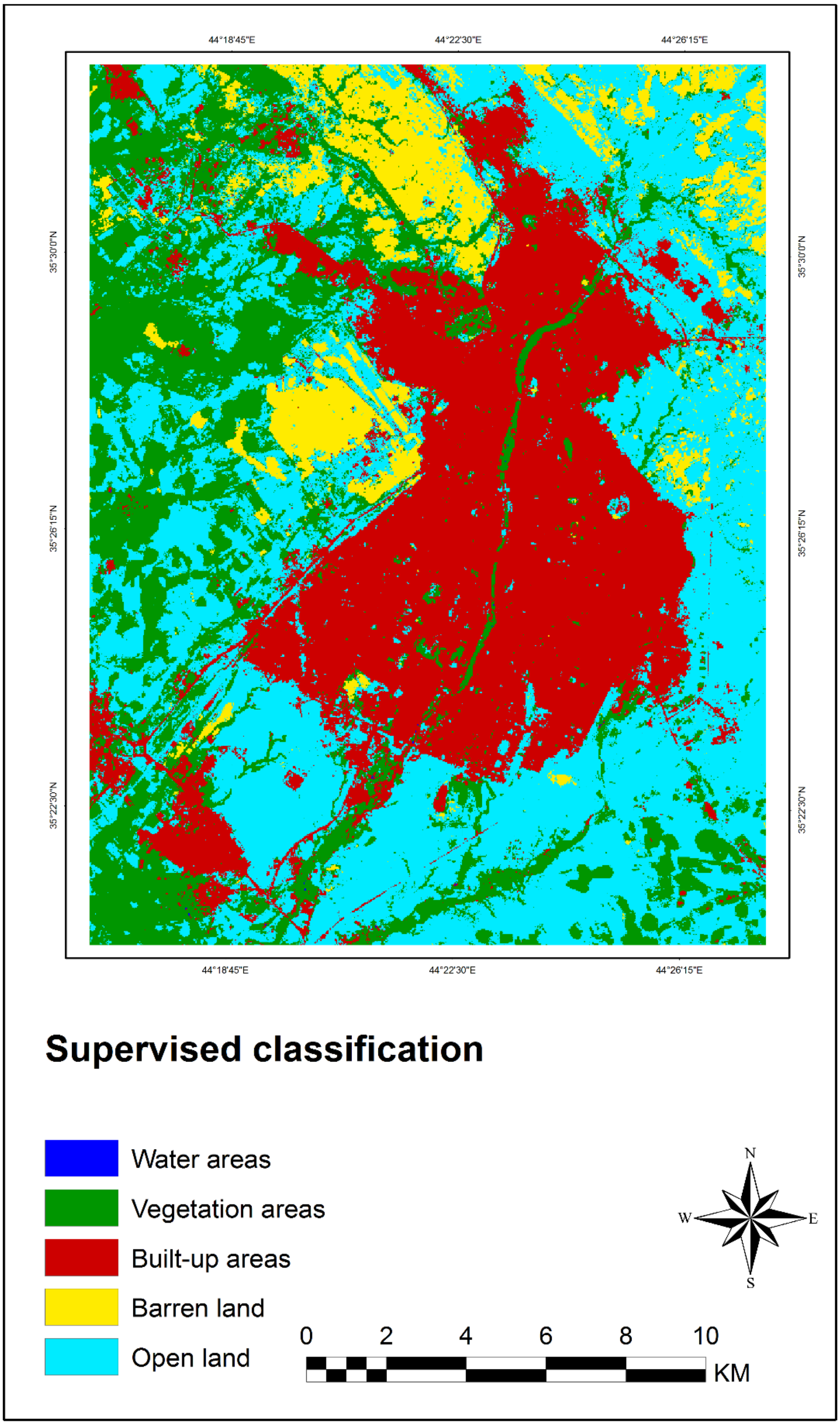


Figure 4.2. Supervised classification of land use/cover map for 2006



+Figure 4.3. Supervised classification of land use/cover map for 2016

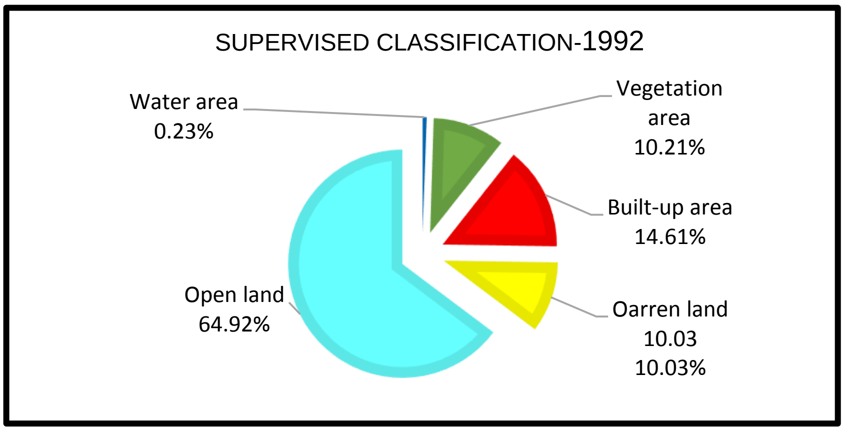


Figure 4.4. Percentage of supervised classification for 1922

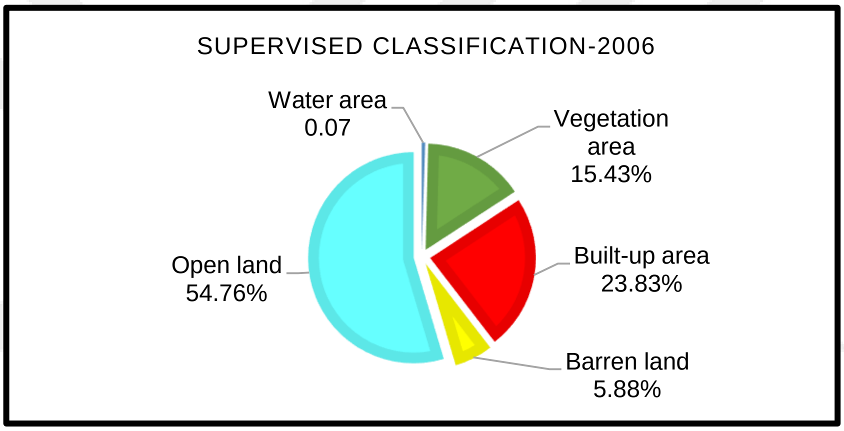


Figure 4.5. Percentage of supervised classification for 2006

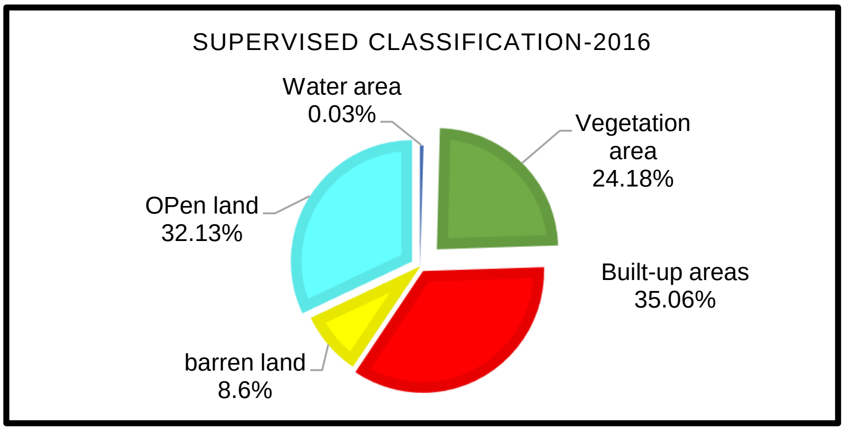


Figure 4.6. Percentage of supervised classification for 2016

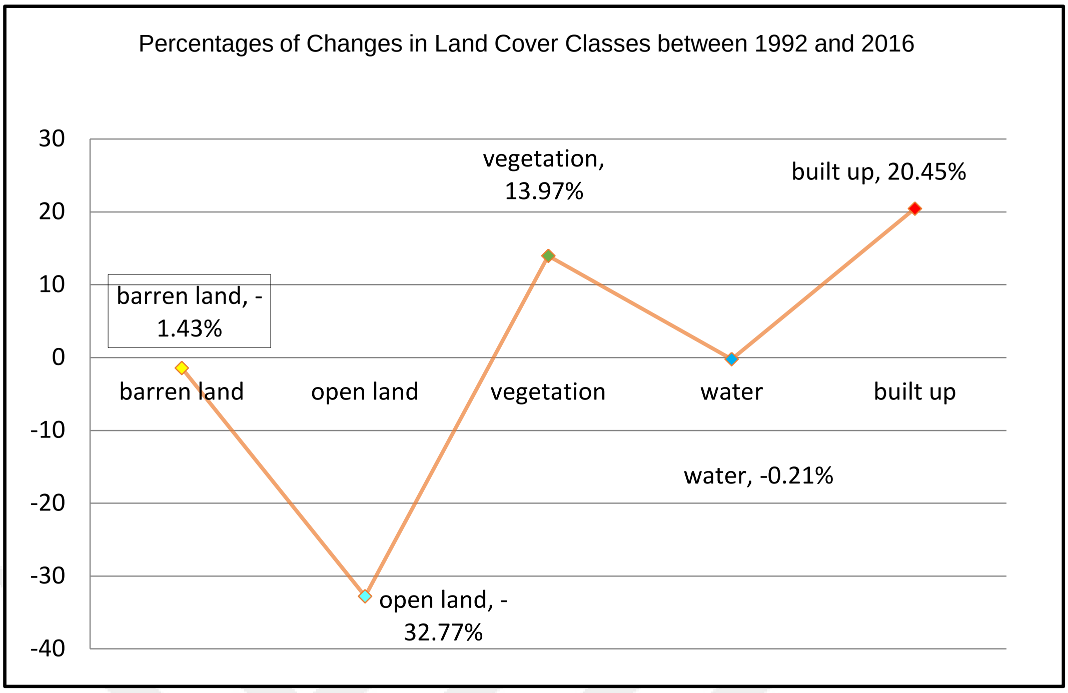


Figure 4.7. Percentages of Changes in Land Cover Classes between 1992 and 2016

Table 4.1. Result of Changes in Land Cover Classes in 1992, 2006 and 2016

class name	Area Sq. 1992	Area % 1992	Area Sq. 2006	Area % 2006	Area Sq. 2016	Area % 2016	Changes % 1992 - 2016
water areas	0.28	0.23	0.07	0.07	0.05	0.03	-0.20
vegetation areas	22.55	10.21	45.2	15.43	86.04	24.18	13.97
built-up areas	28.02	14.61	54.48	23.83	109.98	35.06	20.45
barren land	21.47	10.03	21.17	5.88	30.52	9	-1.43
open land	293.94	64.92	240.98	54.76	146.49	32.13	-32.77

4.2. Classification Accuracy Assessment

Image classification needs to another step such as accuracy assessmenat of the proses complete, to applying accuracy assessment the most common utilizing method confusion matrix was performed(Congalton 2001), to display a confusion matrix report using regions of interest for ground truth, the output report shows the overall accuracy, kappa coefficient confusion matrix, errors of commission (percentage of extra pixels in class), errors of omission, in the table(4.2) shows example explains the items calculated for the confusion matrix, including the overall accuracy, kappa coefficient, for this purpose return to attached in appendix (1,2 and 3).

Table 4.2. Shows the Result of Classification Accuracy in 1992, 2006 and 2016

confusion matrix,	Satellite Image 1992	Satellite Image 2006	Satellite Image 2016
overall accuracy	0.96 %	0.98 %	0.95 %
kappa coefficient	0.9372	0.9743	0.9315

4.3. Land Surface Temperature Retrieval

In this study, mapping out has been to produce spatial variation of LST for 1992, 2006 and 2016. The techniques were used in driving a statistical analysis and geographical analysis of LST spatial distribution, to obtain that the correct answers to the research questions in this research, With regards to the images for 1992,2006 and 2016, land surface temperature analysis was conducted, and they can be seen in sequential colors in degrees centigrade (°C). This is illustrated in Figure (3.8, 3.9 and 3.10).

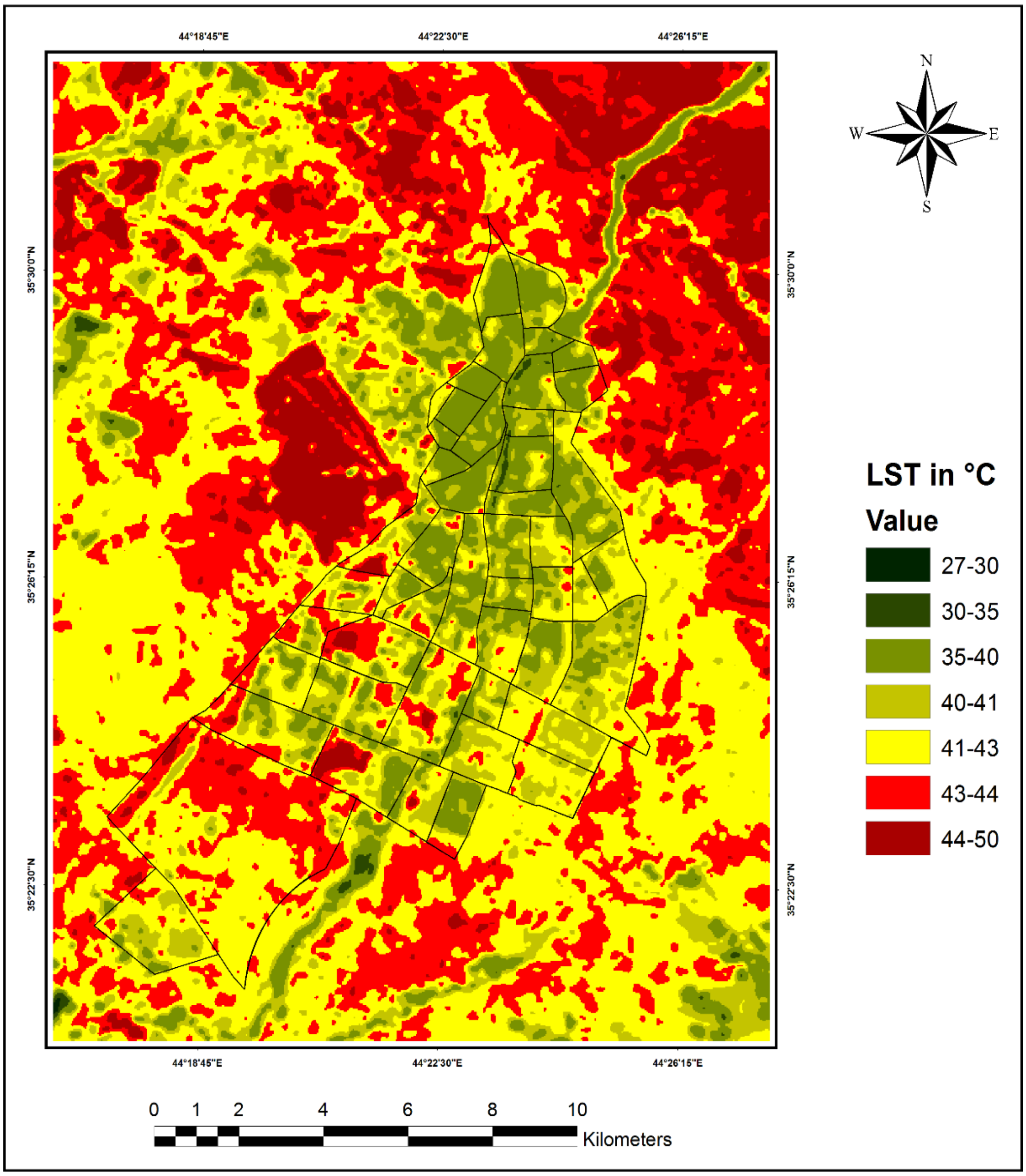


Figure 4.8 Land surface temperatures for 1992

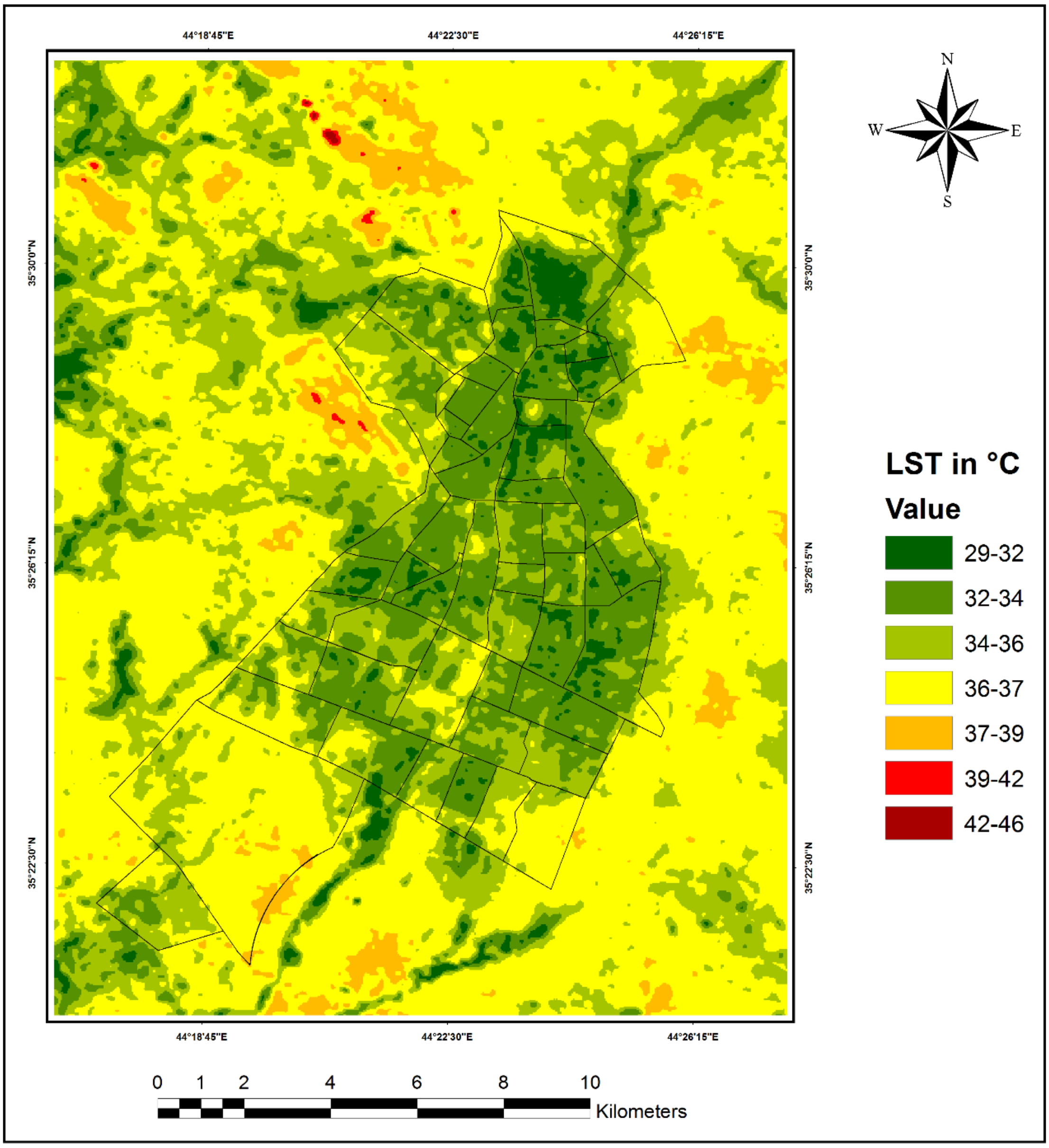


Figure 4.9. Land surface temperatures for 2006

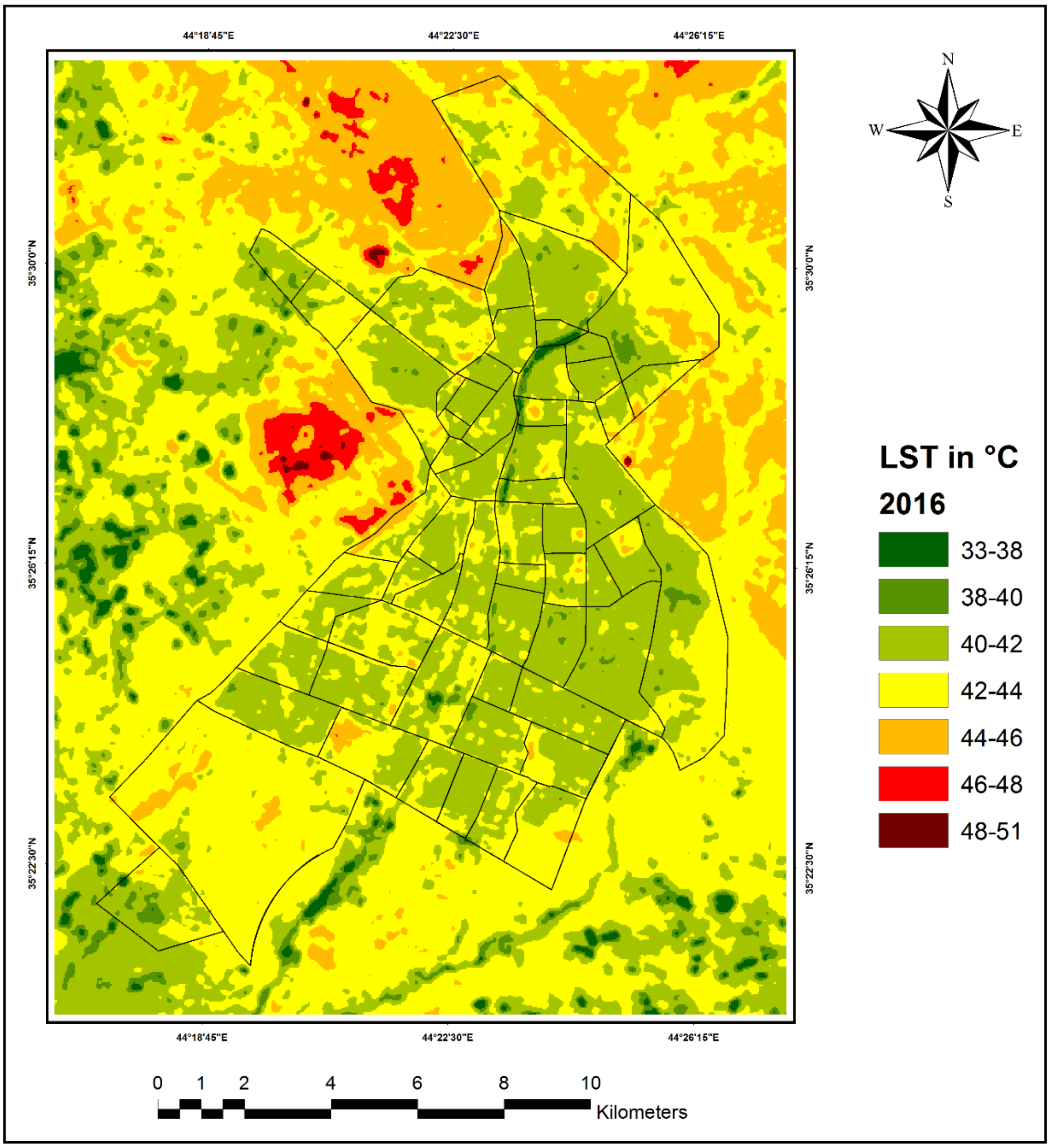


Figure 4.10. Land surface temperatures for 2016

The results above clarify the temperature distribution for the years 1992, 2006 and 2016. The colour schemes shows that the hottest topographic point surface temperature are concentrated outdoor the city of the three year period, also, it is cooler inside the city regions, vegetated regions and water areas. The color scheme graduates from dark green to red, cooler temperature in the study area raised especially in urban regions, the mapping out of representing that how effective urban areas are in influencing LST, on the other hands, actually, this might due to two main times: firstly three images were captured in different times as the image in 1992, 2006 and 2016 were captured on 1992-

08-08, 2006-07-30 and 2016-07-25 in summer season of the hottest time. Secondly the city experienced environmental problems, including drought and sandstorms and the study area near field oil during the period under study (Abdullah 2012). The results of explained that in Despite the fact that the maximum LST increased by 2°C in the city from50°C to 52°C in 1992- 2016 and the minimum LST increased by 5°C from 27°C to 32°C in 1992-2016. In June 2012 held conference in Sulaimanyah by the IAU, UNEP, World Health Organization, UNESCO, UNICEF, FAO, the seminar have declared that around 40,000 hectares are lost every year in the whole of Iraq due to climate variation. The Output result of classification, as it shown in (Figure 4.3 and Table 4.1) the vegetation cover increased in the study area, the vegetation areas increased from 10.21% in 1992 to 24.18% in 2016. Explain that mainly the inside, east, north and North West land cover converted to urban area, the North West and south of the city land cover is change to vegetation cover between 1992 and 2016, so thus the hottest surface temperature is concentrated in this area of the city as it shown in red colour.

4.4. Spatial Distribution Of LST In Kirkuk City

Regain the land surface temperature highly dependents on the surface energy budget in urban region (Piringer and Joffre 2005). In another way, measuring the balance of surface thermal is properties on the land surface features (Weng et al. 2004; Cartland 2008). For that reason, many of the types were built with a number of different stone materials such as rock, asphalt, pavement and concrete, add to different types of land cover (green areas, open lands, water body and man-made structure) account the differences in the distribution of LST in the urban regions.

Kirkuk is one of the oldest cities in the Iraq, the city centre consist old area and new developments were constructed around them, So that there are many old and new buildings in the city. There were two small temporary stream but the streams has drought due to climate change, environment variation, especially in the summer season it well be end, while in the last decade the rate of land vegetation decreased around the city but green spaces decrease around the stream within the city. So to determine which areas are hot and cool inside city regarding the LST, Examine the spatial distribution of land surface temperature, by using GIS techniques to convert the data of LST from raster format into polygons data and the LST values within the urban area was determined, so that The mean land surface temperature for each districts were extracted using these techniques, spatial distribution of LST technique displayed only urban area for each city district.

4.4. Special Distribution Of Land Surface Temperature In 1992

The outcome of the spatial distribution of LST displays a various spatial LST pattern (Figure 4.11 and Table 3.3). In general, the side stream, near of the central business districts are characterized the lowest temperature especially north city, while the highest temperature was recording in the districts south and bordering of the city, such as Mohalim, Hamzaliya, Khazraa, shuqakani ghaz, siyada, Zawra, Bahar, Askari, brayati, Rizgari.1, Zanko, Thermal properties of the area have an effect on the LST, for example Siyada, Hamzaliya and Bahar areas which are located in the south and west of the city are known to have a hot surface temperature 40^oC, 41.5^oC and 42^oC because of the energy characteristics of these regions. In addition, these areas are consist by barren open lands, which represents the high emissivity values recorded there. Furthermore, the result of outcome shows small areas are distribute deferens place, such as Rahimawa, Sarcham, Barkhudan, Tapa, Almas, Imam Qasm, where the mean LST was 35^oC, 36^oC, 37^oC, which accounts for the lowest emissivity values recorded there, this decrease was higher than in other Kirkuk districts, subsequently, factors related to the urbanization process like the increase in building surface fraction, vegetation surface fraction, it is well known that, open land or barren land with a shortage, of vegetation cover cannot hold over rainwater during the rainy season. As a result, in the surface empty of increase quickly temperature degree during the hot season when compared to vegetated areas and soil moisture .

Table 4.3. Main districts in Kirkuk City in 1992

NO	Name of districts	Mean LST in ºC	NO	Name of districts	Mean LST in ºC
1	Rahimawa	36	25	New Tisin	38
2	Sarcham	35	26	Mansor	39
3	Tapa	37	27	Sultan	39
4	Almas	37	28	Khazraa	41.5
5	Imam Qasm	36	29	Hamzaliya	41
6	Azadi	36	30	Shuqakani ghaz	41
7	Iskan	39	31	Brayati	42
8	Mohalim	42	32	Skkak	41
9	Shatarlu	39	33	Gullan	48
10	Qarya	40	34	Shar	39
11	Sari	40	35	Zanko	40
12	Baglar	39	36	Bahar	42
13	Cornish	38	37	Hasar	39
14	Bulak	38	38	Domiz	41
15	Musalla	38	39	Siyada	42
16	Shorije	39	40	Pishasazi	41
17	Runaki	39	41	Hawkari	39
18	Slahaddin	38	42	Askari	39
19	Uruba	38	43	Tadhamon	39.5
20	Shahidan	38	44	Zawra	39
21	Rzgari 1	41	45	Barkhudan	37
22	Rzgari 2	38	46	Raparin	39
23	Ashti	39	47	Khasa	38
24	Kasab Hana	39	48	Barzan	40

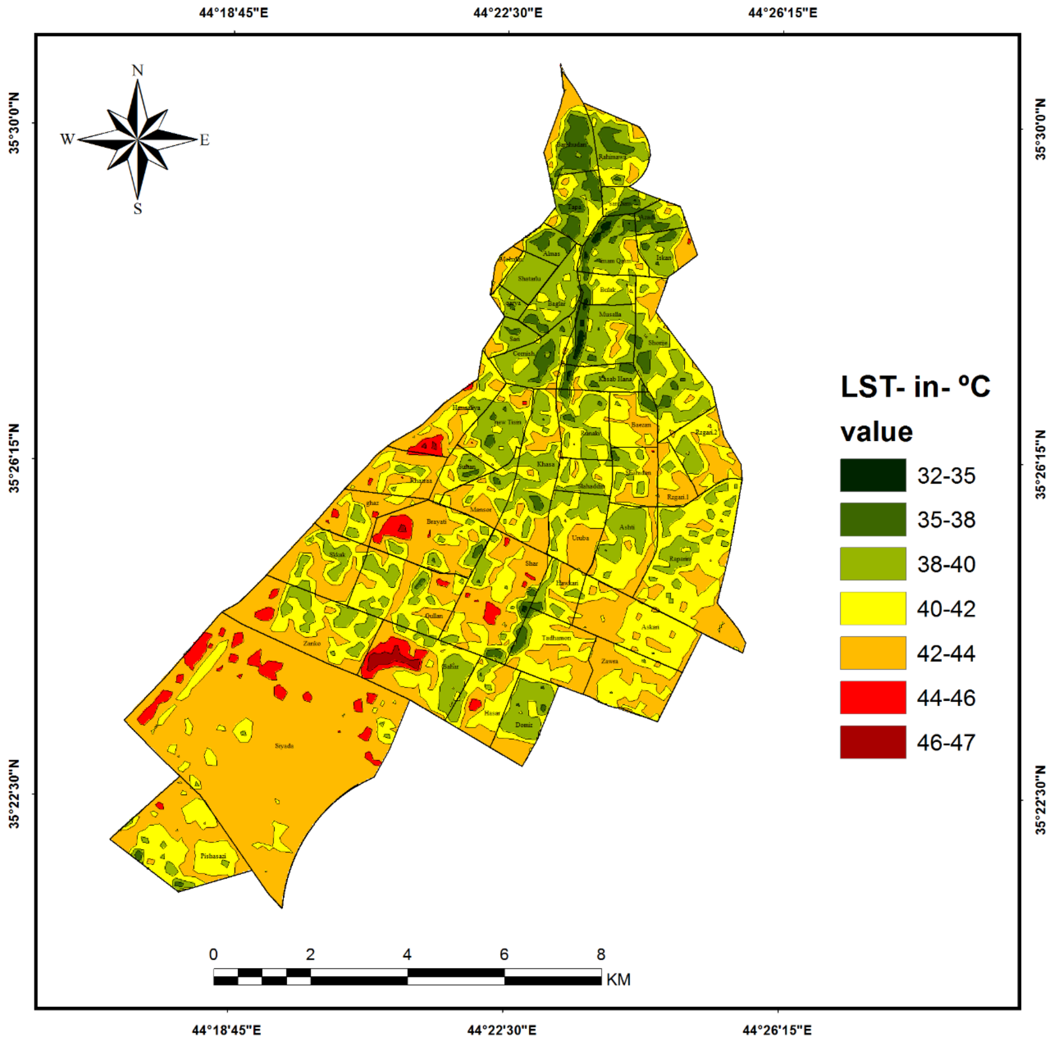


Figure 4.11. LST Spatial Distribution in the Main Districts of the city of Kirkuk on 8-8 1992. Time: 07:01:42

4.5. Special Distribution of Land Surface Temperature In 2016

In 2016, the outcome shows that Due to the rapid and extensive expansion of the city, there are changes in LST were different and a few and land surface temperature throughout the districts had spatial pattern as shown in Figures (4.11 and 4.12). In addition between 1992 and 2016, there were slow some addition in new districts, this changed by 2016, in the during of study, urban expansion occurred of different type, in other hand, urban development in the old districts and with many new districts were occurred, actually, some old district that had lower surface temperature values compared to the new districts being like Sarcham, Azadi, Imam Qasm, Bulak have their mean LST ranging between 34 and 37^{o}C, which is higher than some old district , especially new districts, such as Shoraw, Shahb, Barutkhana, Salhiya, Tolla, Gal, Karama , darwaza, with a mean LST of 39^{o}C and 42^{o}C (see Table6).Also western and south of the city district recorded higher temperature value between 42^{o}C and 45^{o}C a mean LST such as Brayati, Hamzaliya, shuqakani ghaz, Bahar, Zanko, Khazraa, Siyada and Barkhudan. On the other hand, all of the districts recorded an LST of above 35^{o}C, also nearly of the remaining district recorded an LST of around 40^{o}C and 44^{o}C, in the outcome of mapping 2016, distribution land surface temperature of explained. In which dark green represents to the coldest surface temperature and the red refers to the hottest regions. While, in the all of districts of Kirkuk city vegetation cover or green space is very little, therefore in the old or new district no space was left for green garden, If we consider image classification in(Figure 3.3), we can understand the green space very lowering, there is only small vegetable space in the Khasa stream, In addition, almost of the old or new districts have large amount of open barren lands, this lack of vegetation are also closely interconnected, Increased solar radiation for example results in higher average temperatures and higher water vapour content of the atmosphere, when these factors are accumulated in the districts, in fact, it is clear to realize why some districts hotter or absorbs incoming solar radiation faster than other districts, having understood the role of lower vegetation cover due to high surface temperature and high runoff rates through water-drainages, In contrast, a green area has an effect on keeping water in the ground , with lower temperatures. While, green spaces one of factors internal to decreasing temperature degree in the city.

Generally, the mean LST in 1992 was lower than the mean LST in 2016, however, the lower LST in the result of spatial distribution for 1992 was 35^{o}C the higher LST was 50^{o}C, and the mean surface temperature in 2016 was 40^{o}C the max temperature degree in the same LST study was 47^{o}C, This is mainly due to the increasing amount of naked land or open land in the old districts, after 2003, open land was decrease within old districts, it has changed to artificial and green area, green space within city due to reducing risk increasing surface temperature in urban area.

Anyway, the outcome of the LST study to spatial distribution shows the variety of LST values among the districts. The three images were captured at different times of the year:

two in lately July month and one in early august month, In the middle of the summer, which mean the hot summers an effect on the area. At this time of month, summer season, when the sky is clear, heating land surface is faster and the solar radiation due to ratio observed process on the surface land, the surface temperature related to solar radiation and rate of humidity in the air and in the soil. On other hand, increasing surface temperature result of high sunlight and reduction rate moisture in the soil and the air (Abdullah 2012; Coutts et al 2016). Further research was done to analyse the Impact of Urban Expansion the surface temperature in the Kirkuk city during the period under study. Between 1992 and 2006 a period of time, there was no new districts being built, while, mostly 8 new districts were built between 2006 and 2016, in the (Tables 4.3 and 4.4) show that. For this purpose GIS data and techniques were result found the modifications that have occurred from the maps of LST .the result of mapping represented that a decline in LST of about 3^{o}C in some newly built districts was as a result of the urban expansions which had taken place on the open and barren lands neighbouring the city. Urban expansion of the Kirkuk city has not been dominated LST over the barren and open lands. Studies conducted in practically similar geographical status match the results derived from this study. For example, the studies of (Kwarteng and Small 2005; Frey et al. 2005; Habib 2007) they were explained that controlling the increase LST in urban to using desert, dry land of urban region because of due to assist in creating an urban cool island (UCI) and under control the LST in urban region.

Special distribution of land surface temperature has been done by Abdullah (2012), in Erbil, Iraq for the period of 1998 and 2011 and he has found lowest LST to greenery areas 29ºC and 36ºC in 1998 and 2011 respectively, and the highest was found over barren land and was about 33ºC and 39ºC in 1998 and 2011 respectively. Another Special distribution of LST has been done by Ibrahim (2017), in Dohuk, Iraq for the period of 1990, 2000 and 2016 and detected The highest temperatures are associated with barren land and built-up Areas, ranging from 47_C, 50_C, 56_C while lower temperatures are related to water areas and forests, ranging from 25_C, 26_C, 29 respectively, In 1990, 2000 and 2016.

Table 4.4. Main districts in Kirkuk City in 2016

NO.	Name of districts	Mean LST in ºC	NO.	Name of districts	Mean LST in ºC
1	Rahimawa	39	30	new Tisin	43
2	Sarcham	34	31	Mansor	44
3	Tapa	40	32	Sultan	42
4	Almas	40	33	Khazraa	42
5	Imam Qasm	35	34	Hamzaliya	44
6	Azadi	39	35	Shuqakani ghaz	42
7	Iskan	40	36	Brayati	44
8	Mohalim	41	37	Skkak	43
9	Shatarlu	41.5	38	Gullan	43
10	Qarya	41.5	39	Shar	40
11	Sari	42	40	Zanko	40
12	Baglar	42	41	Bahar	45
13	Cornish	40	42	Hasar	44
14	Bulak	41	43	Domiz	41
15	Musalla	40	44	Siyada	44
16	Shorije	40	45	Pishasazi	42
17	Runaki	41	46	Hawkari	40
18	Slahaddin	41	47	Askari	40
19	Uruba	40	48	Tadhamon	40
20	Shahidan	41	49	Zawra	40
21	Rzgari.1	40	50	Gal	43
22	Rzgari.2	40	51	Tolla	43
23	Ashti	40	52	Barutkhana	43
24	Raparin	40	53	Kurdistan	40
25	Khasa	41	54	Arafa	42
26	Shoraw	42	55	Salhiya	40.5
27	Karma	40	56	Darwaza	40
28	Panja Ali	41	57	Shahb	39
29	Barkhudan	43	58	Barzan	40

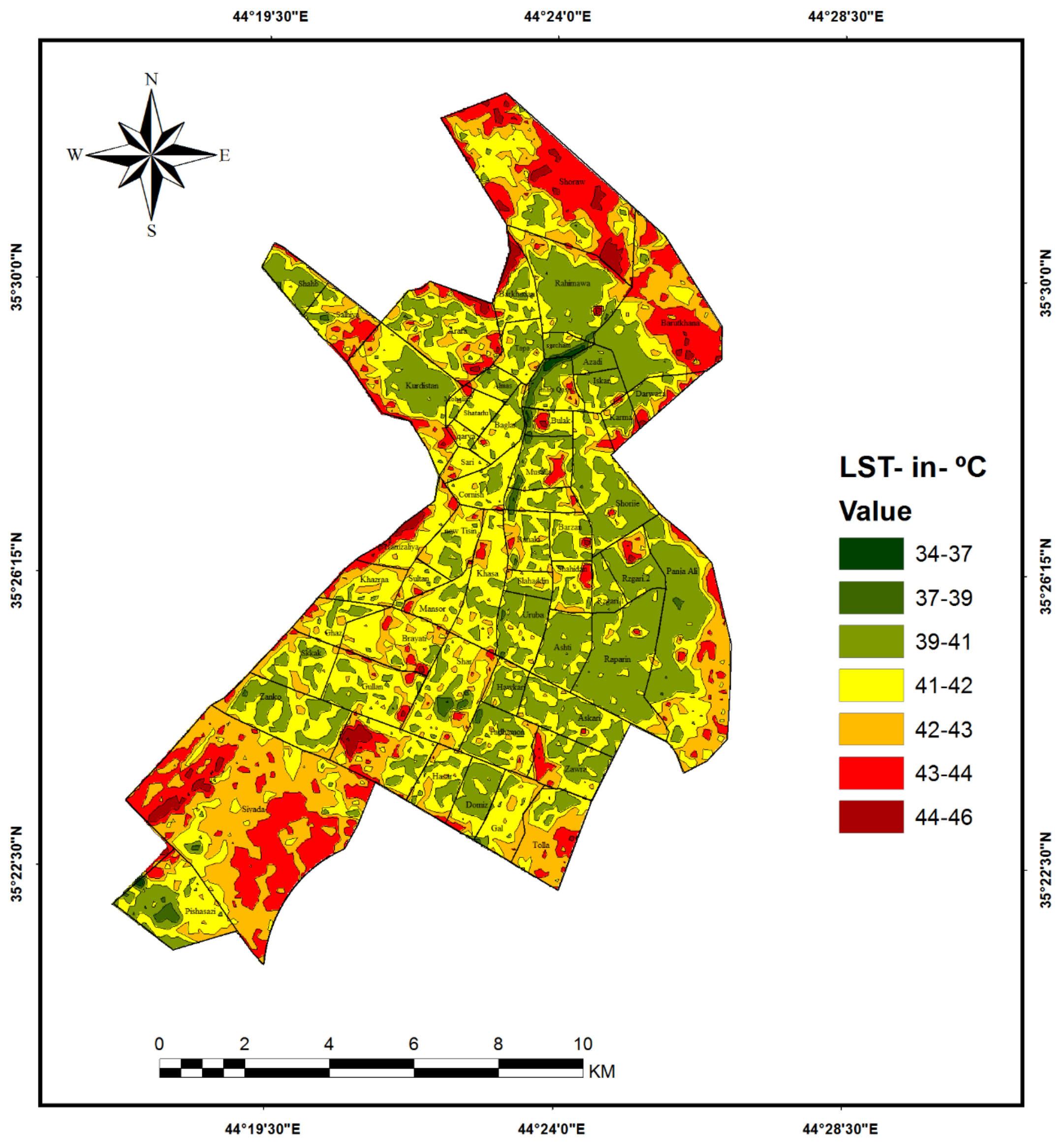


Figure 4.12. LST Spatial Distribution in the Main Districts of the city of Kirkuk on 25-7-2016. Time: 07:39:00

4.6. Relationship Between LST And Different Land Cover Classes

The low and high surface temperature of strongly relate to land cover types which have a significant effect on the process of heating land surface, such as land surface emissivity, soil moisture, vegetation abundance and Albedo (Wing et al. 2004). The relation between land cover characteristics with LST is difference. Hence, to gain a good result of LST for each type land classes and LST can be achieved by transforming the classified images and LST maps from a raster layout into a polygon format using the ArcGIS software.

This will be done to associate the LST values to each types of land cover (Figure 3.5 the flow chart).To correctly understand the characteristic of all land cover class's thermal signature, the average of LST of each class will be extracted. The average LST of the various land cover classes between 1992, 2006 and 2016 are displayed in (Figure 4.13).

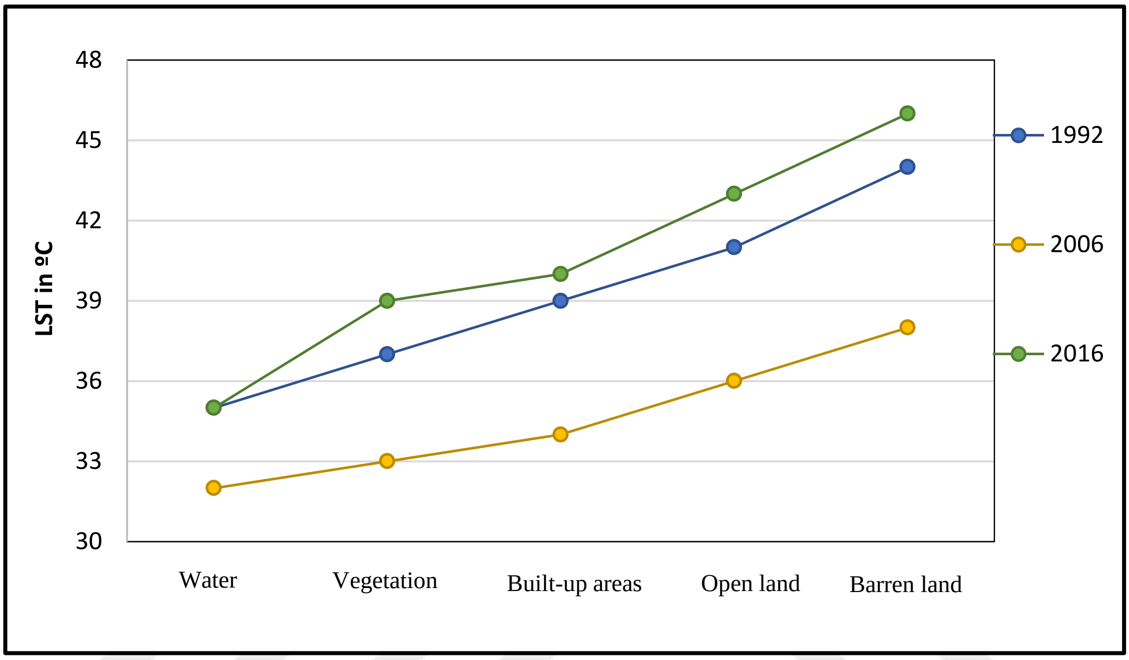


Figure 4.13. Mean LST for Land Cover Types in 1992, 2006 and 2016

The Table and graph above provides evidence that the highest temperature values are found in the barren land areas with values of 44°C in 1992, 38°C in 2006 and 46°C in 2016, in contrast, the lowest LST values were recorded in water areas with values of 35°C in 1992, 32 °C in 2006 and 35°C in 2016, while, 39°C in 1992, 34°C in 2006 and 40oC in 2016 respectively were recorded in the built-up areas. At the same time, in the open land were recorded values of 41°C in 1992, 36°C in 2006 and 43°C in 2016, and the lowest temperature values after water areas were vegetation areas has recorded these values 37°C in 1992, 33°C in 2006 and 39°C in 2016.

Thereby, as temperature the barren land and open land increases much more rapidly than the surface fraction vegetation, therefore give a direct representation of the radiometric temperature of clear sunlight (Wing et al. 2004). It has been estimated that, as a result of the increase humidity rate of fraction vegetation in the naked land, relative humidity is a measurement based on the amount of lack vegetation in barren land. The specific temperature of barren land is more than the temperature of water and vegetation areas, the land cover heating by the sun directly, which explains why LST is higher than those found in other land cover classes (Cao et al. 2008). Furthermore, urban surface features such as pavement, street buildings, concrete etc. have a tendency to soak up heat and release it slowly. In other words, the specific heat capacity of built-up areas is longer than the specific heat capacity of the other land cover classes, with open and barren lands Unable to capacity heat for such long time. This could be as a result of time of the day the Landsat OLI images were captured, which was around 07:39 AM, and Landsat TM 07:1 AM, when the land surface started to absorb of sunlight, in fact of the surface features in the urban areas cool up and warm up Much slower than other land cover classes. This explains why built-up areas record lesser LST valued when compared to barren.

The researchers point out of the impact vegetation on the decrease and controlling land surface temperature (Mildrexler 2011; Zareie et al. 2016; Ibrahim 2017; Salah 2011; Ferdinando 2015; Qihao 2003). As well as, the exploration of the relationship between LST and vegetation was done using NDVI.

In this study, the outcome of the NDVI maps were normalized between (-1<=NDVI<=1). The positive values represent reflective or vegetation cover, non- reflective or non-vegetated surface are represented by negative values the study area's NDVI map is shown in (Figure 4.14, 4.15 and 4.16).

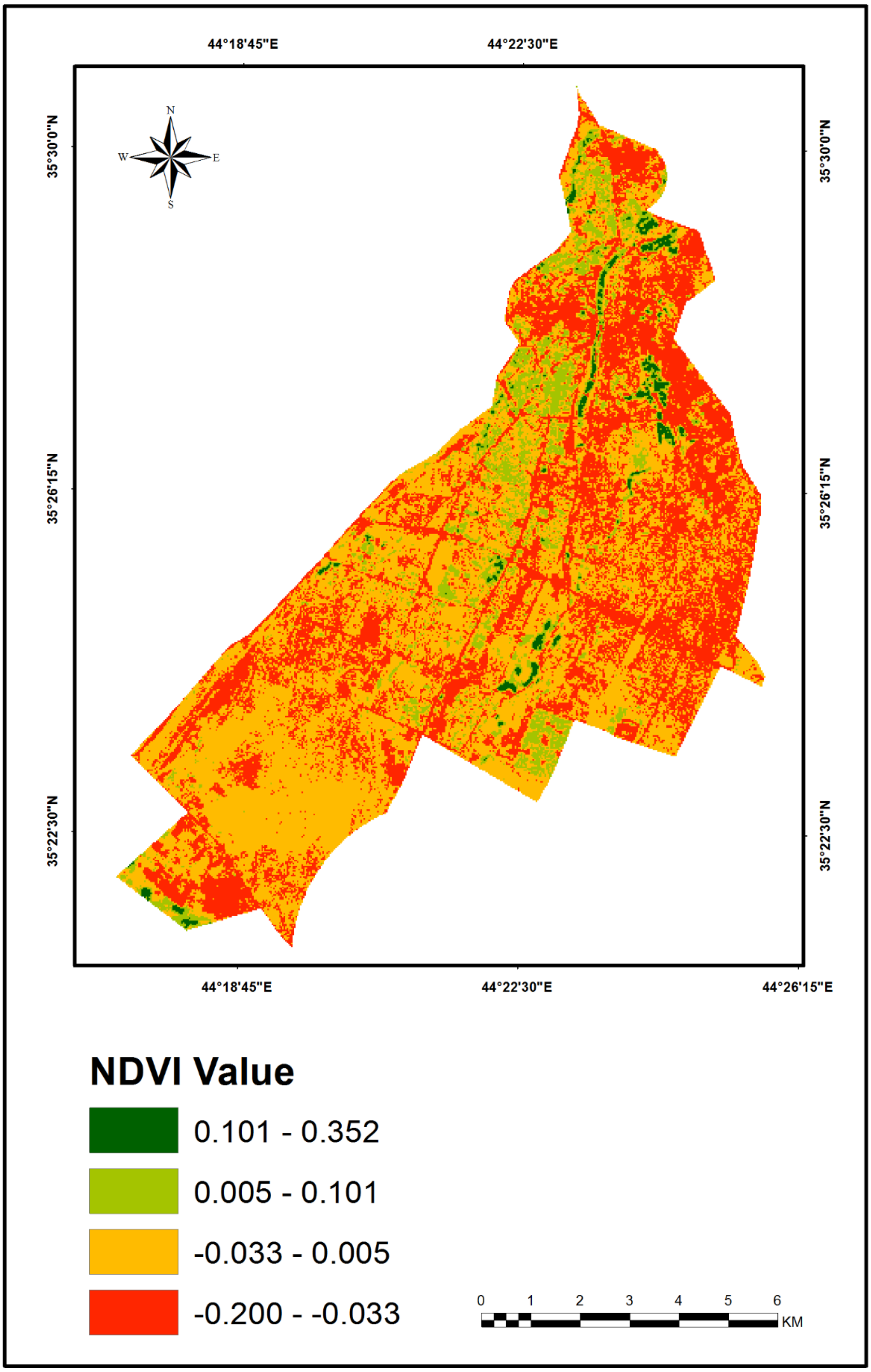


Figure 4.14. Spatial distribution of NDVI for 1992

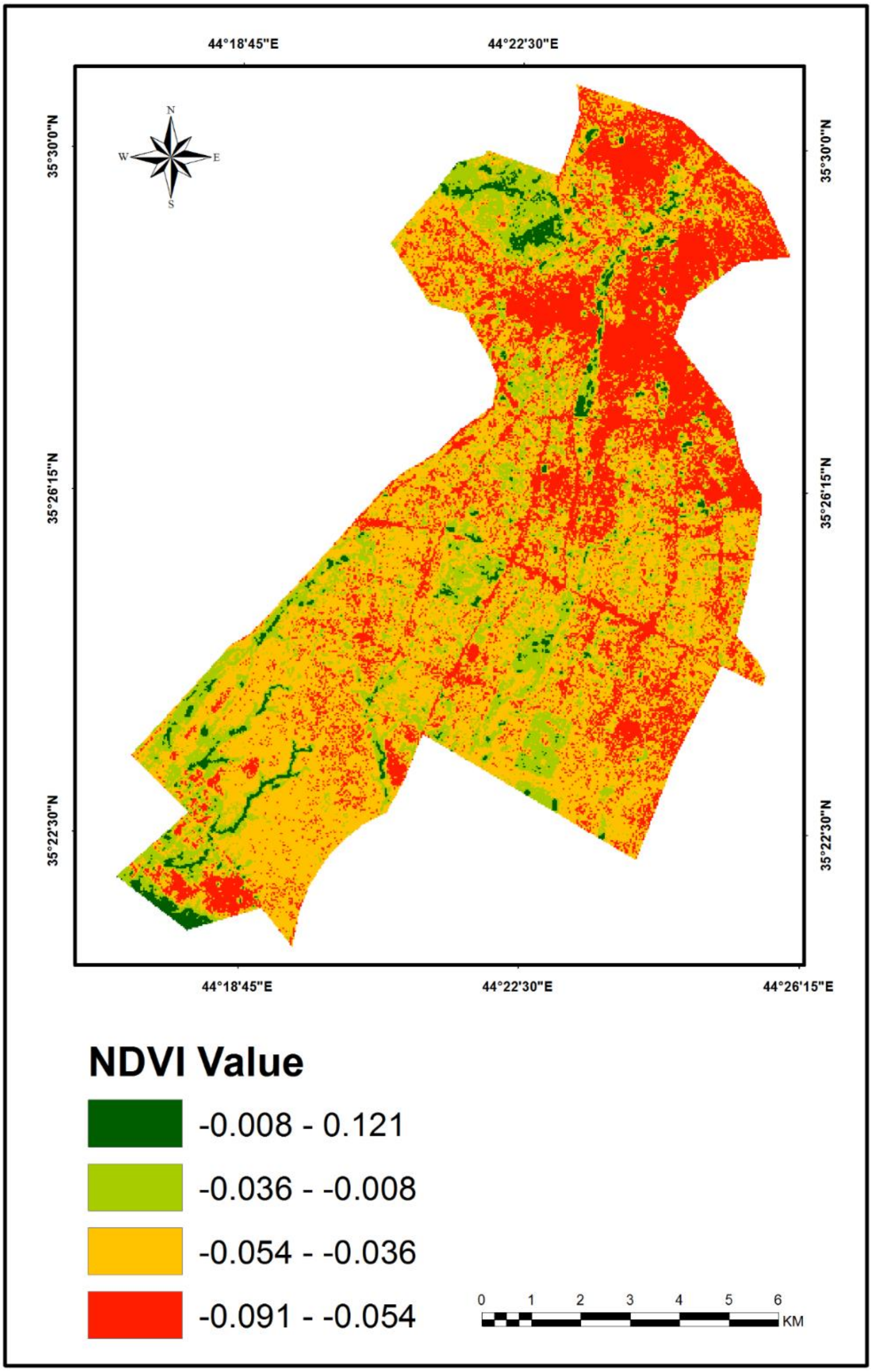


Figure 4.15. Spatial distribution of NDVI for 2006

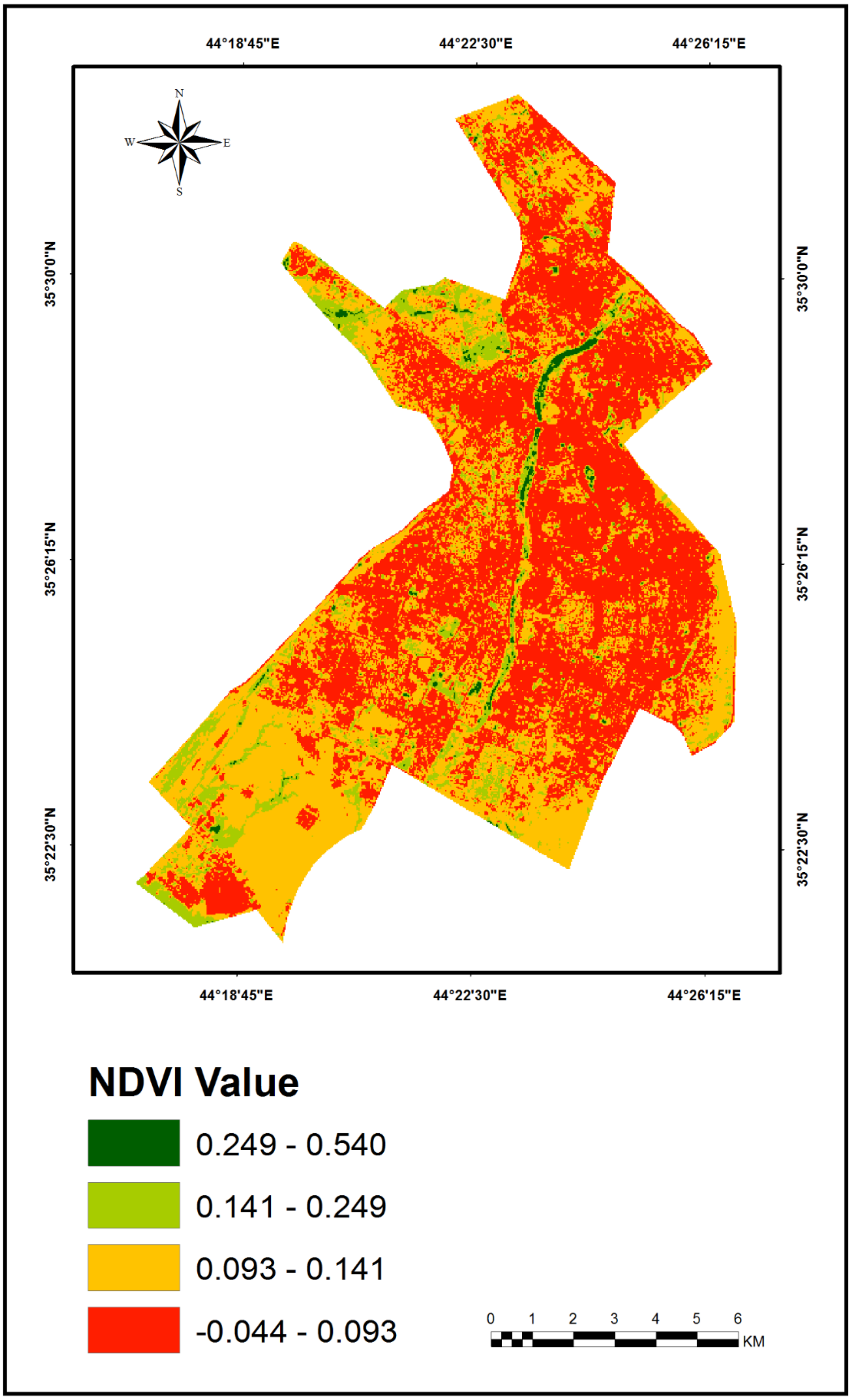


Figure 4.16. Spatial distribution of NDVI for 2016

The results of spatial distribution of NDVI values from the Landsat TM and OLI image can be seen in Figure (16) in 1992 NDVI values are in the range of -0.2 to 0.35, having a mean value of -0.009 and in 2006 NDVI values are in the range of -0.09 to 0.12, having mean value of -0.021, while, in 2016 NDVI values are in the range of -0.04 to 0.54, having mean value of 0.045 (Figure17) In the Figure, it is shown low values of NDVI color red area correspond to waste land, naked soil, and commercial, industrial and residential areas on the various parts mainly in the north toast of the study area. High values of NDVI dark green that were observed in the central and northeast parts of the images correspond to same parks, green space and some types of vegetable in the central parts of the images. The medium NDVI values were observed over fallow land in the central, north, south parts of the study area. By comparing NDVI of three different time periods in 1992, 2006 and 2016. We concluded that NDVI values changed through the studied period of time. The high values of derived emissivity are observed over parks and greens paces. The emissivity values of green spaces, vegetable areas, and asphalt roads, commercial, and industrial, residential and naked land in the year 1992 image are from 0.986 to 0.988, In addition, the emissivity values of green spaces, commercial, and industrial, in the year 2006 map are from 0.986 to 0.986, in 2016 map are from 0.964 to 0.965, The considerable differences less than 0.01 between temperatures and NDVI values of land use types in 1992, 2006 and 2016 cases were gained through statistical analysis of surface temperatures and NDVI values.

This is as an outcome of the increase in green space areas inside the city in recent times. This explains why, the built-up, barren and open lands recording lower values with the green spaces have the maximum NDVI values. It is clear from this result that for studying LST and analysing the relationship between vegetation and LST, NDVI is the most suitable index (Gallo et al. 1993). In this study, data applied was collected from 40 random points, maps from the NDVI and LST images, having the same coordinates, were utilized to find out the relationship between LST and vegetation can be seen in (Table 4.5, 4.6. and 4.7).

Table 4.5. Values Collected from LST and NDVI maps 1992

NO	NDVI	LST	NO	NDVI	LST
1	0.36	35	21	-0.108	36
2	0.171	37	22	-0.018	42
3	0.116	39	23	-0.044	44
4	0.145	38	24	-0.005	36
5	0.68	40	25	-0.035	45
6	0	41	26	0.335	35
7	-0.06	48	27	0.135	38
8	-0.25	43	28	-0.041	48
9	0.216	36	29	0.161	35
10	-0.04	44	30	0.131	38
11	-0.04	48	31	0	37
12	0.87	39	32	-0.113	35
13	0.025	36	33	-0.01	41
14	-0.08	45	34	-0.03	44
15	-0.019	49	35	-0.009	36
16	-0.07	42	36	0.45	40
17	-0.09	46	37	-0.06	45
18		43	38	-0.09	47
19	0.312	36	39	-0.035	50
20	-0.027	49	40	-0.045	50

Table 4.6. Values Collected from LST and NDVI maps 2006

NO	NDVI	LST	NO	NDVI	LST
1	0.015	30	21	-0.078	36
2	-0.068	32	22	-0.068	33
3	-0.057	33	23	-0.053	34
4	-0.009	31	24	-0.047	30
5	-0.049	34	25	0-051	34
6	-0.038	33	26	-0.059	37
7	-0.06	33	27	-0.048	34
8	-0.061	34	28	-0.055	37
9	-0.016	30	29	-0.075	31
10	-0.081	36	30	-0.028	32
11	-0.055	37	31	-0.069	35
12	-0.083	36	32	-0.085	38
13	-0.058	33	33	-0.047	33
14	-0.084	35	34	-0.062	32
15	0.004	30	35	-0.073	35
16	-0.072	35	36	-0.079	38
17	-0.059	31	37	-0.048	30
18	-0.067	34	38	-0.062	38
19	-0.054	33	39	-0.086	38
20	-0.079	36	40	-0.091	38

Table 4.7. Values Collected from LST and NDVI maps for 2016

NO	NDVI	LST	NO	NDVI	LST
1	0.505	34	21	0.437	38
2	0.518	35	22	0.132	40
3	0.458	37	23	0.482	36
4	0.465	36	24	0.193	39
5	0.083	43	25	0.456	37
6	0.113	40	26	0.084	44
7	0.094	45	27	0.528	34
8	0.511	35	28	0.108	41
9	0.072	42	29	0.444	37
10	0.463	37	30	0.498	36
11	0.044	48	31	0.063	43
12	0.448	38	32	0.381	38
13	0.22	48	33	0.071	44
14	0.501	35	34	0.431	37
15	0.022	47	35	0.496	35
16	0.534	34	36	0.097	42
17	0.102	41	37	0.088	46
18	0.431	37	38	0.181	39
19	-0.032	48	39	-0.025	48
20	-0.041	49	40	0.039	49

In the present study, linear regression analysis and the Pearson's correlation coefficient analysis were applied to performing moreover assessment and find out of the relationship between LST and NDVI values, both techniques were used because employing one technique such as correlation analysis alone will not sufficiently depict how the variables correlate and their correlation degree (Salah 2011), (see Figure 4.17, 4.18 and 3.19).

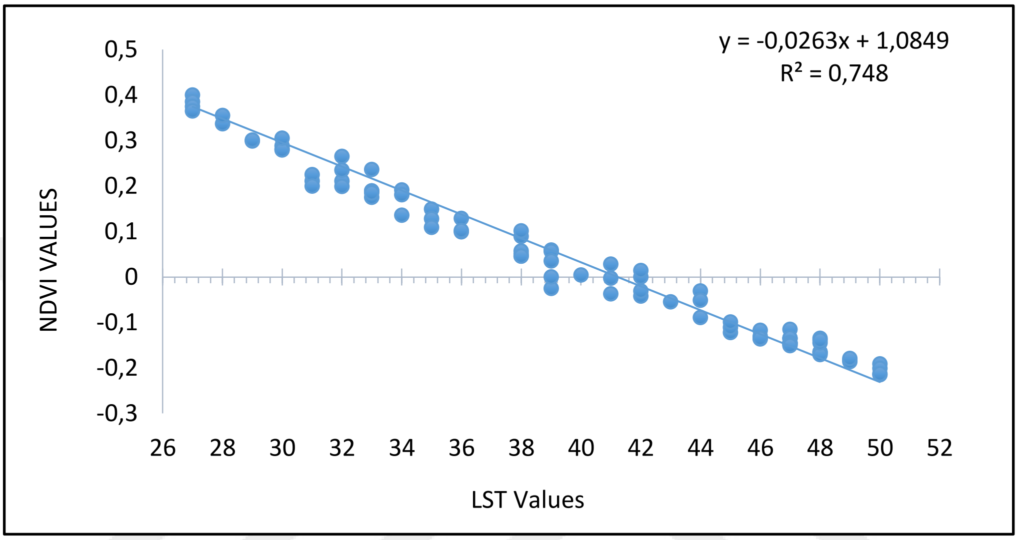


Figure 4.17. Linear relationship between NDVI values and LST of Landsat TM 1992

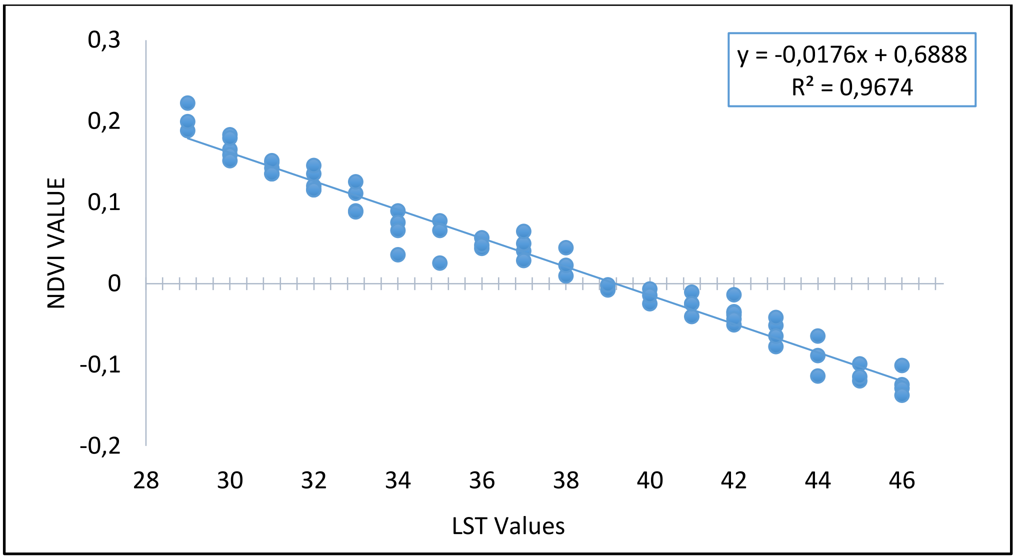


Figure 4.18. Linear relationship between NDVI values and LST of Landsat TM 2006

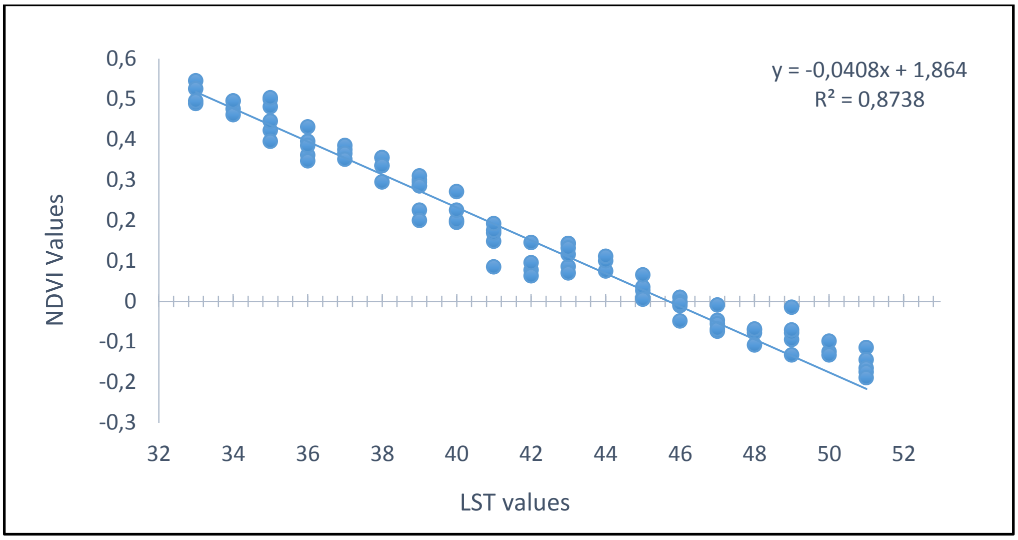


Figure 4.19. Linear relationship between NDVI values and LST of Landsat OLI 2016

The statistical analysis results of the relationship between LST and NDVI, in the present data indicate that there is a negative correlation between LST and NDVI. A significant value of 0.000 was found in 1992, 2006 and 2016, which is less than 0.05significance level, with values of -0.065, -0.075, -0.043 calculated for 1992, 2006 and 2016 respectively, the negative correlation found here between NDVI and LST.

In order to test the ability of NDVI to predict the changes in LST, a regression test was done, from which the R squared value was found to 0.74 for1992, 96 for 0.96 and 0.87, with a significance value of 0.000 for each years, making it statistically significant, in addition, Values of the NDVI have an inverse relation to LST, This means that an increase in NDVI corresponds to a decrease in the temperature of land utilized cover types and vice versa.

In the present study, to analyse the relationship that exists between LST mean values and the mean value of for each land cover type, this approach was carried out normalized difference vegetation index (NDVI) and land use changes using ENVI software, can be seen in (Figure 4.20).

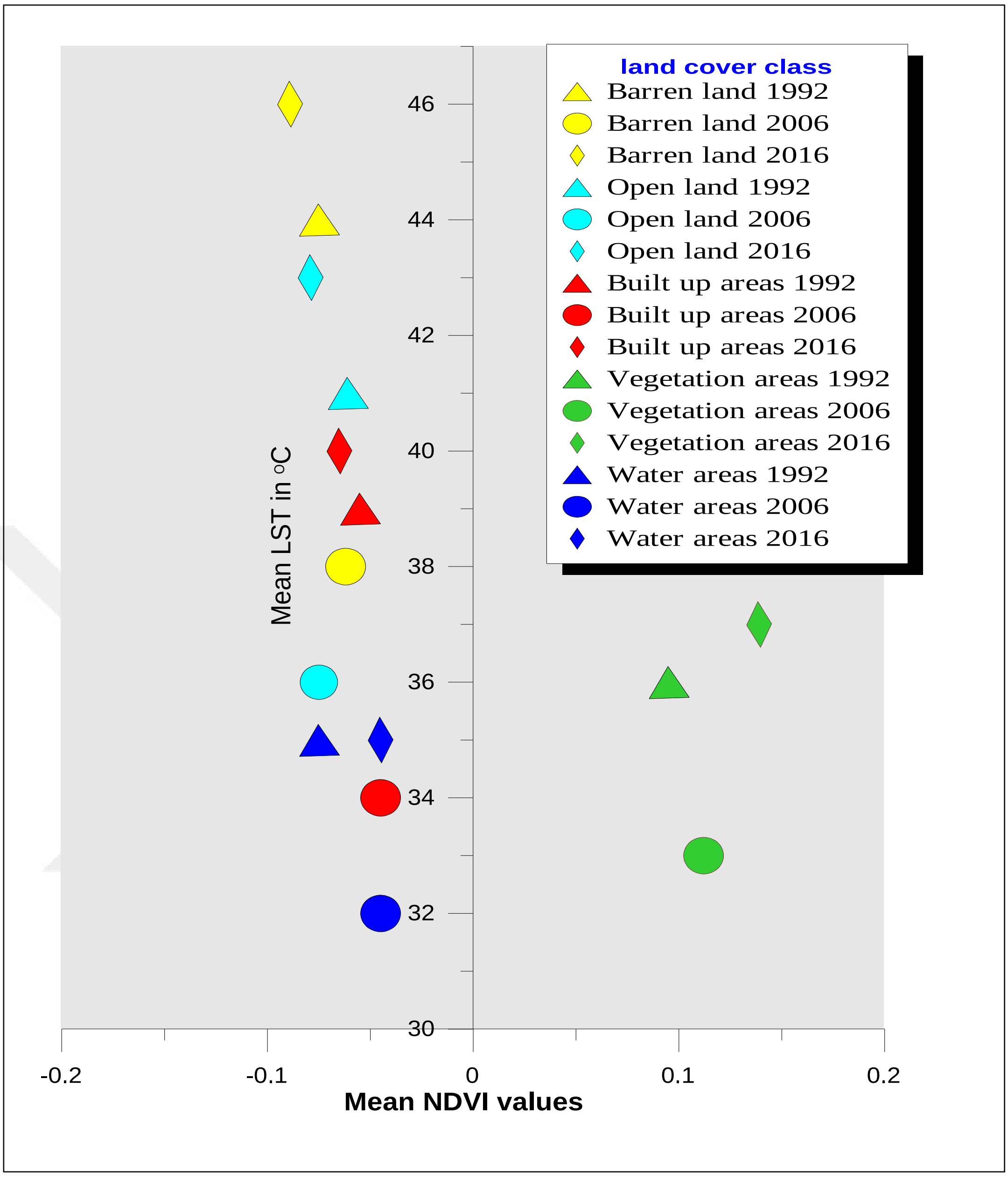


Figure 4.20. Displays differences in Mean LST and Mean NDVI for each Land Cover Class

The Figure above appears the differences in mean NDVI and mean LIST with regard to the differences in mean NDVI and mean LST with regard to diverse land cover categories. The triangle shape is applied to represent the values for 1992, circle indicates 2006, and the kite shapes are for 2016. In addition, It appears that the lowest mean LST is found over water areas and vegetation areas, as it was 35^{o}C in 1992, 32^{o}C in 2006 and 35^{o}C in 2016, With 36^{o}C, 33^{o}C and 37^{o}C in 1992, 2006 and 2016 years respectively, While water areas have lowest mean NDVI which is -0.075, -0.045 and -0.045 in 1992m

2006 and 2016 years respectively, vegetation class recorded of the highest mean NDVI which is 0.095 in1992, 0.0112 in 2006 and 0.139 in 2016 respectively. On the other hand, with regards to the NDVI mean, negative values were found for land cover classes, with barren and open lands having the highest LST in all three years.

Consequently, the cooling effect of vegetation on LST in the study area becomes obvious when the outcome of the relationship between the different land cover types and LST is analysed (Coutts et al. 2016). The vegetation will essentially determine the type of the transpiration, it has a big influence on the reducing surface resistance to evaporation, increasing latent heat transfer that gives rise to lower LST than the other land covers, Put differently, as vegetation rises, average temperature decreases, and moisture is retained better in the green areas of the city than the hard surfaces found in buildings and barren lands. Conversely, areas such as barren and open lands characterized by thin soil, sand, rock and sparse vegetation, have high LST because they directly absorb sun heat radiation (Pandey et al. 1995). Consequently, they warm faster than other land cover classes.

However, urban sprawl is the study of urban areas, therefore, Urban sprawl generally refers to the way cities are continuously expanding outward into other land cover types, and there has been a binary impact on LST in the city of Kirkuk as a result of the expansion of urban areas, First of all, one of the positive result of related to LST changes observed in this study is that there has been a reduction of LST in the dry semi-arid areas rural the city, This is confirmed by a wider literature that have coordinated studies in very similar geographical situations. Previous researches have accepted that a way to control and reduce LST is to construct buildings develop green spaces in semi-arid and desert areas. Secondly, with regards to the negative results of LST change in this study, the variation of vegetated areas to man-made areas or non-vegetated areas. The resultant environmental changes, due to urban expansion, have led to an increase in LST. In addition, the classification of Kirkuk city as an urban heat island is not caused by the urban area itself. This is because the city has a lower LST Than its rural areas. It is however important to reminder that the time of the day that data for this study was taken may have a considerable impact on the detected outcomes.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The objective of this study was to explore how urban expansion effect on land surface temperature and how land cover classes are related with LST by using Landsat 5 and Landsat 8 data for classifying different land cover classes (barren land, open land, built-up, water body, and vegetation land) and to retrieve LST for the study area in 1992, 2006 and 2016. The main sum up of this study is that urban expansion has a thermal signature on LST and impacts the energy balance, the influence can be detected through the thermal band (band 6 Landsat-5 and band 10, 11 Landsat-8) and ENVI 5.2 software, the result of retrieving LST detect that LST had various forms in 1992, 2006, and 2016. In addition, the result of land cover classification displays significant expansion of urban areas and remarkable changes in other land cover classes over the period of the study. The results from the classification displayed between in 1992 and 2016, there was a great change between land cover classes such as open and land is decreased from 64.92% in 1992 to 32% in 20016, while built-up and regions and vegetation areas increased from 14.61%, 10.21% in 1992 to 35.06%, 24.18% in 2016, Generally, land surface temperature was increased due to the drought phenomena, were due to global environmental changes. In terms of the impact of urban expansion on LST, in the present data, the results reveal that urban expansion and building of new districts has led to the control LST and has a positive impact on the LST. This might be due to of the environment city, which is a drought environment particularly in summer season. But main negative impact of the expansion of the city is change in the natural characteristics of land cover such as the conversion of vegetation areas to built-up areas.

In other words, the study depend on the spatial distribution of land surface temperature on districts, and it displays that recorded higher LST than the older districts as they have less green spaces and contain hard surfaces.

The study conducted various examinations in order to find out the relationship between LST and different land cover classes. The results show that vegetation and built up areas are identified as having cooler temperatures, in contrast with open land and barren land during the period of the study. Consequently, vegetation has been detected as a significant factor in this study, because vegetation fraction helps in controlling and decreasing LST. As well as possible, the results explain that garden growth in the within the city more useful to assists in controlling LST. Evidence of this is provided in this study's results that showed that the temperature in most of the districts remained the same, with increase in green space, over time. This is further supported by the results from the linear regression and correlation analysis conducted, which showed a negative correlation between LST and NDVI. However, many researchers such as (Frey et al. 2005; Habib 2007), their studies explaining that expanding urban areas into open and barren lands, will useful to controlling land surface temperature.

2.4. Recommendation

This study to avoid an increase of LST and reduce the risk of environmental changes in the area, the study offers many suggest and recommendations benefit of urban planners in the Kirkuk city.

- The main purpose of the urban planners must be increased vegetation cover in the city ,the green belt land must be performed around of the city, the ratio of green parts in the city should be increased, be close an international standard which requires that 15% of the city total land area be green areas.

- As has been proven for this study that building urban surfaces helps in reducing LST, it is so, suggested that the urban planning must support the development of buildings around the city upon the dry soil, As well as the promotion of tree growth, because it has been detected that lower LST occurs in vegetated built-up areas than in dry surface areas such as the open and barren lands.

- It is important to account the role of choice paint colors and materials in build, play in heat absorption control. Black or dark materials tend to absorb more heat from the sun. Therefore, the government must be encouraged to use materials less capable to heat absorptive, Such as the use of lighter colored materials.

- obtaining from the limitations faced in this study, with regards sort to lack of additional satellite data to upgrade the accuracy of the results of this study, for this purpose, the researchers advises the benefit of different data like as Aqua, Aster and MODIS so that comparisons can be performed between day times and night times, as regards the LST, This is important in evaluating how LST has been affected by building urban surfaces fraction.

- infrared thermometer device manual is utilized for measuring the temperature of the objects land surface from anywhere at any time that is an easy way to obtain a accuracy data and to evolution of thermal band Landsat, because has the similar system to measure but most accuracy than Landsat sensor in measured, that is attribute to use it directly on the land surface. The districts around the city which were newly built.

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APPENDICES

Appendix 1

CLASSIFICATION ACCURACY ASSESSMENT REPORT
Image File : d: Kirkuk images 1992- classification 1992- satellite images
User name : Shamal Hussein Ahmed
Date : Mon Dec 5 21:34:58 2016

Overall Accuracy = (11641/12038) 96.7021%
Kappa Coefficient = 0.9372

Ground Truth (Pixels)

Class	water	vegetation ar	built up area	barren land	open land
Unclassified	0	0	0	0	0
water [Blue]	24	0	0	0	4
vegetation area	0	958	0	0	271
built up area	0	0	1715	0	44
barren land [	0	0	0	1201	6
open land [Cy	0	45	24	3	7743
Total	24	1003	1739	1204	8068

Ground Truth (Pixels)

Class	Total
Unclassified	0
water [Blue]	28
vegetation area	1229
built up area	1759
barren land [	1207
open land [Cy	7815

Total 12038

Ground Truth (Percent)

Class	water	vegetation ar	built up area	barren land	open land
Unclassified	0.00	0.00	0.00	0.00	0.00
water [Blue]	100.00	0.00	0.00	0.00	0.05
vegetation area	0.00	95.51	0.00	0.00	3.36
built up area	0.00	0.00	98.62	0.00	0.55
barren land [	0.00	0.00	0.00	99.75	0.07
open land [Cy	0.00	4.49	1.38	0.25	95.97
Total	100.00	100.00	100.00	100.00	100.00

Ground Truth (Percent)

Class	Total
Unclassified	0.00
water [Blue]	0.23
vegetation area	10.21
built up area	14.61
barren land [	10.03
open land [Cy	64.92
Total	100.00

Class	Commission (Percent)	Omission (Percent)	Commission (Pixels)	Omission (Pixels)
water [Blue]	14.29	0.00	4/28	0/24
vegetation area	22.05	4.49	271/1229	45/1003
built up area	2.50	1.38	44/1759	24/1739
barren land [	0.50	0.25	6/1207	3/1204
open land [Cy	0.92	4.03	72/7815	325/8068

Class	Prod. Acc. (Percent)	User Acc. (Percent)	Prod. Acc. (Pixels)	User Acc. (Pixels)
water [Blue]	100.00	85.71	24/24	24/28
vegetation area	95.51	77.95	958/1003	958/1229
built up area	98.62	97.50	1715/1739	1715/1759
barren land [	99.75	99.50	1201/1204	1201/1207
open land [Cy	95.97	99.08	7743/8068	7743/7815

End of confusion matrix 1992

Appendix 2

CLASSIFICATION ACCURACY ASSESSMENT REPORT
Image File : d: Kirkuk images 2006- classification 2006- satellite images
User name : Shamal Hussein Ahmed
Date : Fri Jan 13 15:10:31 2017

Overall Accuracy = (15536/15786) 98.4163%
Kappa Coefficient = 0.9743

Ground Truth (Pixels)

Class	water areas	vegetation ar	buit up areas	barren land	open land
Unclassified	0	0	0	0	0
water areas [	8	0	0	3	0
vegetation area	0	2376	3	22	34
built up areas	0	0	3763	0	3
barren land [	0	1	0	844	84

open land [Cy	0	0	26	74	8545
Total	8	2377	3792	943	8666

Ground Truth (Pixels)

Class	Total
Unclassified	0
water areas [	11
vegetation area	2435
built up areas	3766
barren land [	929
open land [Cy	8645
Total	15786

Ground Truth (Percent)

Class	water areas	vegetation ar	buit up areas	barren land	open land
Unclassified	0.00	0.00	0.00	0.00	0.00
water areas [	100.00	0.00	0.00	0.32	0.00
vegetation area	0.00	99.96	0.08	2.33	0.39
built up areas	0.00	0.00	99.24	0.00	0.03
barren land [	0.00	0.04	0.00	89.50	0.97
open land [Cy	0.00	0.00	0.69	7.85	98.60
Total	100.00	100.00	100.00	100.00	100.00

Ground Truth (Percent)

Class	Total
Unclassified	0.00
water areas [	0.07
vegetation area	15.43
built up areas	23.86
barren land [	5.88
open land [Cy	54.76
Total	100.00

Class	Commission	Omission	Commission	Omission

	(Percent)	(Percent)	(Pixels)	(Pixels)
water areas [	27.27	0.00	3/11	0/8
vegetation area	2.42	0.04	59/2435	1/2377
built up areas	0.08	0.76	3/3766	29/3792
barren land [	9.15	10.50	85/929	99/943
open land [Cy	1.16	1.40	100/8645	121/8666

Class	Prod. Acc.	User Acc.	Prod. Acc.	User Acc.
	(Percent)	(Percent)	(Pixels)	(Pixels)
water areas [	100.00	72.73	8/8	8/11
vegetation area	99.96	97.58	2376/2377	2376/2435
built up areas	99.24	99.92	3763/3792	3763/3766
barren land [	89.50	90.85	844/943	844/929
open land [Cy	98.60	98.84	8545/8666	8545/8645

End of confusion matrix 2006

Appendix 3

ACCURACY ASSESSMENT REPORT (pixel and percent) supervised CLASSIFICATION

Image File: d: Kirkuk images 2016- classification 2016- satellite images

User name : Shamal Hussein Ahmed

Date : Wed Feb 1 24:45:25 2017

Overall Accuracy = (40516/42571) 95.1728%

Kappa Coefficient = 0.9315

Ground Truth (Pixels)

Class	water areas	vegetation ar	built up area	barren land	open land
Unclassified	0	0	0	0	0
water areas [	12	0	0	0	0
vegetation area	0	9777	19	27	472
built up area	0	1	16193	0	7
barren land [	0	47	0	3573	41
open land [Cyan	0	1336	85	20	10961
Total	12	11161	16297	3620	11481

Ground Truth (Pixels)

Class	Total
Unclassified	0
water areas [	12
vegetation area	10295
built up area	16201
barren land [	3661
open land [Cyan	12402
Total	42571

Ground Truth (Percent)

Class	water areas	vegetation ar	built up area	barren land	open land
Unclassified	0.00	0.00	0.00	0.00	0.00
water areas [	100.00	0.00	0.00	0.00	0.00
vegetation area	0.00	87.60	0.12	0.75	4.11
built up area	0.00	0.01	99.36	0.00	0.06
barren land [	0.00	0.42	0.00	98.70	0.36
open land [Cyan	0.00	11.97	0.52	0.55	95.47
Total	100.00	100.00	100.00	100.00	100.00

Ground Truth (Percent)

Class	Total
Unclassified	0.00
water areas [	0.03
vegetation ar	24.18
built up area	38.06
barren land [	8.60
open land [Cyan	29.13
Total	100.00

Class	Commission (Percent)	Omission (Percent)	Commission (Pixels)	Omission (Pixels)
water areas [	0.00	0.00	0/12	0/12
vegetation are	5.03	12.40	518/10295	1384/11161
built up area	0.05	0.64	8/16201	104/16297
barren land [	2.40	1.30	88/3661	47/3620
open land [Cya	11.62	4.53	1441/12402	520/11481

Class	Prod. Acc. (Percent)	User Acc. (Percent)	Prod. Acc. (Pixels)	User Acc. (Pixels)
water areas [	100.00	100.00	12/12	12/12
vegetation area	87.60	94.97	9777/11161	9777/10295
built up area	99.36	99.95	16193/16297	16193/16201
barren land [	98.70	97.60	3573/3620	3573/3661
open land [Cya	95.47	88.38	10961/11481	10961/12402

End of confusion matrix 2016

Appendix 4

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Change detection statistics

      water [Blue] 24 points  vegetation areas [Green2] 1003 points
      built up areas [Red] 1739 points    barren land [Yellow] 1204
points      open land [Cyan] 8068 points  Row Total   Class Total
Unclassified              0           0           0           0
0             0           0
water [Blue] 24 points        309          0           0           0
0           309         309
vegetation areas [Green2] 1003 points             0       25061
0             0           0       25061       25061
built up areas [Red] 1739 points             0           0       31134
0             0       31134       31134
barren land [Yellow] 1204 points             0           0           0
32741         0       32741       32741
open land [Cyan] 8068 points           0           0           0
0        326595      326595      326595
Class Total         309       25061       31134       32741      326595
0             0
Class Changes             0           0           0           0
0             0           0
Image Difference          0           0           0           0
0             0           0

Percentages
      water [Blue] 24 points  vegetation areas [Green2] 1003 points
      built up areas [Red] 1739 points    barren land [Yellow] 1204
points      open land [Cyan] 8068 points  Row Total   Class Total
Unclassified        0.000       0.000       0.000       0.000
0.000    0.000      0.000
water [Blue] 24 points   100.000       0.000       0.000       0.000
0.000  100.000    100.000
vegetation areas [Green2] 1003 points       0.000     100.000
0.000    0.000      0.000     100.000     100.000
built up areas [Red] 1739 points       0.000       0.000     100.000
0.000    0.000    100.000     100.000
barren land [Yellow] 1204 points       0.000       0.000       0.000
100.000        0.000     100.000     100.000
open land [Cyan] 8068 points     0.000       0.000       0.000
0.000  100.000    100.000     100.000
Class Total  100.000     100.000     100.000     100.000     100.000
0.000    0.000
Class Changes       0.000       0.000       0.000       0.000
0.000    0.000      0.000
Image Difference    0.000       0.000       0.000       0.000
0.000    0.000      0.000

Area (Square Meters)
      water [Blue] 24 points  vegetation areas [Green2] 1003 points
      built up areas [Red] 1739 points    barren land [Yellow] 1204
points      open land [Cyan] 8068 points  Row Total   Class Total
Unclassified              0.00                  0.00                0.00
0.00           0.00                0.00                0.00
water [Blue] 24 points      278100.00                0.00
0.00           0.00                0.00        278100.00
278100.00
vegetation areas [Green2] 1003 points                0.00
22554900.00          0.00                0.00                0.00
22554900.00   22554900.00
built up areas [Red] 1739 points                0.00                0.00
28020600.00          0.00                0.00        28020600.00
28020600.00
barren land [Yellow] 1204 points                0.00                0.00
0.00    29466900.00                0.00        29466900.00
29466900.00
```

```
open land [Cyan] 8068 points          0.00              0.00
0.00          0.00      293935500.00      293935500.00
293935500.00
Class Total     278100.00       22554900.00       28020600.00
29466900.00  293935500.00             0.00              0.00
Class Changes              0.00              0.00              0.00
0.00          0.00              0.00              0.00
Image Difference           0.00              0.00              0.00
0.00          0.00              0.00              0.00
```

Reference

Initial State Image: D:\Classify_Kirkuk\Classify_1992\classify92.1\c.15
  Dimensions: (1:565, 1:736), Band 1, Pixel Size: (30.00, 30.00) Meters

Final State Image: D:\Classify_Kirkuk\Classify_1992\classify92.1\c.15
  Dimensions: (1:565, 1:736), Band 1, Pixel Size: (30.00, 30.00) Meters

Equivalent Class Pairings
  water [Blue] 24 points <==> water [Blue] 24 points
  vegetation areas [Green2] 1003 points <==> vegetation areas [Green2] 1003 points
  built up areas [Red] 1739 points <==> built up areas [Red] 1739 points
  barren land [Yellow] 1204 points <==> barren land [Yellow] 1204 points
  open land [Cyan] 8068 points <==> open land [Cyan] 8068 points

Report Produced on: Sun Jun 04 15:47:01 2017

End of change statistics 1992

Appendix 5

Change detection statistics

```
Pixel Counts
      water areas [Blue] 8 points   vegetation areas [Green3] 2377
points      buit up areas [Red] 3792 points     barren land [Yellow]
943 points  open land [Cyan] 8666 points  Row Total   Class Total
Unclassified               0            0            0            0
0            0            0
water areas [Blue] 8 points           77            0            0
0            0           77           77
vegetation areas [Green3] 2377 points            0        63560
0            0            0        63560        63560
buit up areas [Red] 3792 points            0            0        60929
0            0        60929        60929
barren land [Yellow] 943 points            0            0            0
23520        0        23520        23520
open land [Cyan] 8666 points          0            0            0
0        267754       267754       267754
Class Total        77        63560        60929        23520       267754
0            0
Class Changes              0            0            0            0
0            0            0
```

Image Difference 0 0 0 0
0 0 0

Percentages
water areas [Blue] 8 points vegetation areas [Green3] 2377
points buit up areas [Red] 3792 points barren land [Yellow]
943 points open land [Cyan] 8666 points Row Total Class Total
Unclassified 0.000 0.000 0.000 0.000
0.000 0.000 0.000
water areas [Blue] 8 points 100.000 0.000 0.000
0.000 0.000 100.000 100.000
vegetation areas [Green3] 2377 points 0.000 100.000
0.000 0.000 0.000 100.000 100.000
buit up areas [Red] 3792 points 0.000 0.000 100.000
0.000 0.000 100.000 100.000
barren land [Yellow] 943 points 0.000 0.000 0.000
100.000 0.000 100.000 100.000
open land [Cyan] 8666 points 0.000 0.000 0.000
0.000 100.000 100.000 100.000
Class Total 100.000 100.000 100.000 100.000 100.000
0.000 0.000
Class Changes 0.000 0.000 0.000 0.000
0.000 0.000 0.000
Image Difference 0.000 0.000 0.000 0.000
0.000 0.000 0.000

Area (Square Meters)
water areas [Blue] 8 points vegetation areas [Green3] 2377
points buit up areas [Red] 3792 points barren land [Yellow]
943 points open land [Cyan] 8666 points Row Total Class Total
Unclassified 0.00 0.00 0.00
0.00 0.00 0.00 0.00
water areas [Blue] 8 points 69300.00 0.00
0.00 0.00 0.00 69300.00
69300.00
vegetation areas [Green3] 2377 points 0.00
57204000.00 0.00 0.00 0.00
57204000.00 57204000.00
buit up areas [Red] 3792 points 0.00 0.00
54836100.00 0.00 0.00 54836100.00
54836100.00
barren land [Yellow] 943 points 0.00 0.00
0.00 21168000.00 0.00 21168000.00
21168000.00
open land [Cyan] 8666 points 0.00 0.00
0.00 0.00 240978600.00 240978600.00
240978600.00
Class Total 69300.00 57204000.00 54836100.00
21168000.00 240978600.00 0.00 0.00
Class Changes 0.00 0.00 0.00
0.00 0.00 0.00 0.00
Image Difference 0.00 0.00 0.00
0.00 0.00 0.00 0.00

Reference

Initial State Image:
D:\Classify_Kirkuk\classify_2006\classify2.2006\classify.27
Dimensions: (1:565, 1:736), Band 1, Pixel Size: (30.00, 30.00) Meters

Final State Image:
D:\Classify_Kirkuk\classify_2006\classify2.2006\classify.27
Dimensions: (1:565, 1:736), Band 1, Pixel Size: (30.00, 30.00) Meters

Equivalent Class Pairings

water areas [Blue] 8 points <==> water areas [Blue] 8 points

vegetation areas [Green3] 2377 points <==> vegetation areas [Green3] 2377 points

buit up areas [Red] 3792 points <==> buit up areas [Red] 3792 points

barren land [Yellow] 943 points <==> barren land [Yellow] 943 points

open land [Cyan] 8666 points <==> open land [Cyan] 8666 points

Report Produced on: Sun Jun 04 16:01:08 2017

End of change statistics 2006

Appendix 5

Change detection statistics

```
Pixel Counts
      water areas [Blue] 12 points  vegetation areas [Green2] 11161
points      built up areas [Red2] 16297 points  barren land [Yellow]
3620 points open lan [Cyan] 11481 points  Row Total   Class Total
Unclassified               0           0           0           0
0          0           0
water areas [Blue] 12 points         224           0           0
0          0         224         224
vegetation areas [Green2] 11161 points             0      382416
0          0           0      382416      382416
built up areas [Red2] 16297 points           0           0      488813
0          0      488813      488813
barren land [Yellow] 3620 points             0           0           0
135657           0      135657      135657
open lan [Cyan] 11481 points           0           0           0
0     651050      651050      651050
Class Total         224      382416      488813      135657      651050
0          0
Class Changes              0           0           0           0
0          0           0
Image Difference           0           0           0           0
0          0           0

Percentages
      water areas [Blue] 12 points  vegetation areas [Green2] 11161
points      built up areas [Red2] 16297 points  barren land [Yellow]
3620 points open lan [Cyan] 11481 points  Row Total   Class Total
Unclassified         0.000       0.000       0.000       0.000
0.000    0.000       0.000
water areas [Blue] 12 points   100.000       0.000       0.000
0.000    0.000     100.000     100.000
vegetation areas [Green2] 11161 points       0.000     100.000
0.000    0.000       0.000     100.000     100.000
built up areas [Red2] 16297 points     0.000       0.000     100.000
0.000    0.000     100.000     100.000
barren land [Yellow] 3620 points       0.000       0.000       0.000
100.000       0.000     100.000     100.000
open lan [Cyan] 11481 points     0.000       0.000       0.000
0.000  100.000     100.000     100.000
Class Total  100.000     100.000     100.000     100.000     100.000
0.000    0.000
```

Class Changes 0.000 0.000 0.000 0.000
0.000 0.000 0.000
Image Difference 0.000 0.000 0.000 0.000
0.000 0.000 0.000

Area (Square Meters)
water areas [Blue] 12 points vegetation areas [Green2] 11161 points built up areas [Red2] 16297 points barren land [Yellow] 3620 points open lan [Cyan] 11481 points Row Total Class Total
Unclassified 0.00 0.00 0.00
0.00 0.00 0.00 0.00
water areas [Blue] 12 points 50400.00 0.00
0.00 0.00 0.00 50400.00
50400.00
vegetation areas [Green2] 11161 points 0.00
86043600.00 0.00 0.00 0.00
86043600.00 86043600.00
built up areas [Red2] 16297 points 0.00 0.00
109982925.00 0.00 0.00 109982925.00
109982925.00
barren land [Yellow] 3620 points 0.00 0.00
0.00 30522825.00 0.00 30522825.00
30522825.00
open lan [Cyan] 11481 points 0.00 0.00
0.00 0.00 146486250.00 146486250.00
146486250.00
Class Total 50400.00 86043600.00 109982925.00
30522825.00 146486250.00 0.00 0.00
Class Changes 0.00 0.00 0.00
0.00 0.00 0.00 0.00
Image Difference 0.00 0.00 0.00
0.00 0.00 0.00 0.00

Reference

Initial State Image:
D:\Classify_Kirkuk\classifu_2016\classify2016\classify.29
Dimensions: (1:1128, 1:1470), Band 1, Pixel Size: (15.00, 15.00) Meters

Final State Image:
D:\Classify_Kirkuk\classifu_2016\classify2016\classify.29
Dimensions: (1:1128, 1:1470), Band 1, Pixel Size: (15.00, 15.00) Meters

Equivalent Class Pairings
water areas [Blue] 12 points <==> water areas [Blue] 12 points
vegetation areas [Green2] 11161 points <==> vegetation areas [Green2] 11161 points
built up areas [Red2] 16297 points <==> built up areas [Red2] 16297 points
barren land [Yellow] 3620 points <==> barren land [Yellow] 3620 points
open lan [Cyan] 11481 points <==> open lan [Cyan] 11481 points

Report Produced on: Sun Jun 04 16:05:08 2017

End of change statistics 2016

CURRICULUM VITAE

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Nationality : Iraqi – Kurdish
Date of Birth : 1985
Shamalhusen@gmail.com
Current work: Master student in Bingol University Faculty of Agriculture
Department of Soil science and plant Nutrition

Education:

University	College	Department	Type of Certificate	Year
Soran	social science	Geography	BSc	2004-2008

Language:-

Language	**Status**	**Note**
Kurdish	Excellent	Mother tongue
Arabic	Medium	Second language
English	Medium	-
Turkish	Fair	-

Computer skill:-

Program Name	**State Using**
Microsoft word	Good
Microsoft Excel	Good
Microsoft presentation	Good
Internet and Email	Good
AutoCAD	Good

Shamal Hussein AHMED