Influence of Changes of Land Cover Typeson The Surface Temperature Distribution for Al- Najaf City Using Remote Sensing Data.

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Abstract

This study has been carried out to assesses the relationship between land surface temperatures (LST) and changes of land cover (LC) for a part of Najaf Governorate, by using Landsat TM/ETM+ data over the period from1990 to 2009. Landsat TM/ETM+ images have been acquired for deriving the land use/land cover (LULC) maps and land surface temperatures (LST) for two different dates afterwardsanalysistheir temporal and spatial variations. (LST) maps have been derived from thermal infrared (TIR) bands of Landsat TM/ETM+ dataaccording to Planck's function. Satellite images for 1990, and 2009 have been classified into four classes (building up, vegetation, bare land, and water bodies) based on the supervised classification by using Maximum Likelihood algorithm.Normalized Difference Vegetation Index (NDVI) and Normalized Difference Built-up Index (NDBI) have been calculated from both the original image in order to extract a particular (LC) for study area. The results of study showed that built-up area increased from 22.1% to 41.8 % between 1990 and 2009, while vegetations, bare land and water bodies decreased from 57.5% to 39.9%, 16.9% to 15.3% , and 3.5% to 3% respectively , due to urbanization that resulted from growing of urban population and economic evolution, . In general the negative correlation between LST and NDVI confirm that the reduction in vegetarian cover to built-up would leadto increase in (LST). Whereas the positive correlation between LST and NDBI implying that the increasing built-up land can increase (LST). The results indicated that the stronger negative correlations between LST and NDVI (R^2=0.918) was in 2009 year , and the stronger positive correlation between LST and NDBI (R2=0.909) was in 2009.The results showed that the maximum temperature in study area increased from 32 ºC in 1990 to 37ºC in 1990 .This research has been confirmed the strong influence of changes in (LC) on (LST).

KeyWords

Land Surface Temperature(LST), Land use/Land Cover (LULC) , NDVI, NDBI.

1.Introduction

The rapid development of economics, urban areas are expand as a result of increasing population growth and migration .Processes of urbanization leads to LULC change, where the natural vegetationareas are replaced by impervious surfaces, such as metal, asphalt and concrete .The unexpected land cover changes adjusts amount of absorption of solar radiation, averages of evaporation, thermal storing of surfaces and wind clamor [1]. This leads to the growth of urban heat island (UHI) phenomenon in urban centres, which defined as a climatic phenomenon in urban areas whereby having higher air temperature than their rural surroundings, it is considered as one of the main problems in the 21st century [2][3] .UHI is primely seem in the spatial distribution of land surface temperature (LST), which is governed by surface heat fluxes and clearly impacted by urbanization [4,5,6]. The LST difference is usually larger at nighttime than during the daytime, also, difference of the seasons influence the LST [7]. In fact, UHI distribution not only in large cities but also in medium and small cities, hence, this study has been investigated to explicate the significant relationship between (LULC) types and LST even though the range small somewhat [8]. The study methodologies mainly concentrating on the changes in land cover and related LST changes .To quantify relationship between LST and land cover change , normalized indices such as (NDVI), and (NDBI) have been used to explain landcover change. Currently available satellite thermal-infrared sensors provide different spatial resolution and temporal coverage data that can be used for estimating land surface temperature. Thermal infrared band (10.44-12.42 μm) offers in TM/ETM+ with spatial resolution (120 m for TM and 60 m for ETM+) is much advantages for local and regional thermal infrared study [9]. The aims of this research is to investigate the influence of land cover changes on surface temperature via analyzing of the LST, NDVI, NDBI and LULC using Landsat TM and ETM +for a period of 19 years.

2. Study Area

The study area include a part from Al-Najaf

Governorate that is located at the edge of the western plateau of Iraq with total area about 28824 km^2 , at160 km south of Baghdad , it has an average elevation of about 70 m above sea level .The estimated population in 2014 was 1.4 million.The study area is restricted to latitudes (31º 55′- 32º 7′ N) and longitudes (44º 19′- 44º32′E) with an area of about 346.35 km^2approximately . The climate of Al-Najaf city is dry and hot in summer , cold and mean of rains in winter . The annual average of temperature is about 26 ºC, in summer days reaches up to 51ºC and in winter nights it is down to less than 0 ºC . The annual average of rainfall was largely decreased from (91mm) in 1990 to (60mm) in 2009. Figure 1 shows the geographical location of the study area .

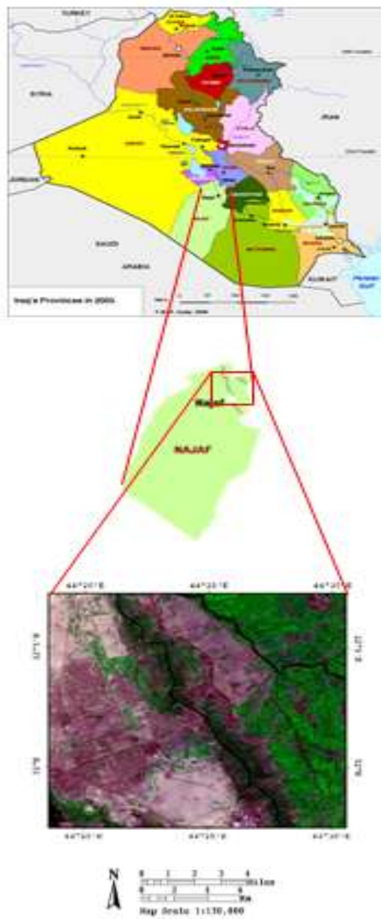


Figure 1: Location of Study Area

3. Methodology

This study has been included four phases: 1) data acquisition, 2) data processing which involves subset the multispectral and thermal infrared bands and image classification , 3) LST retrieval, and 4) data analysis. For this study, two satellite images (i.e.; Landsat 5 TM and Landsat 7 ETM+) have been used for generatingthe maps of land surface temperature. The LST has been calculated using Planck's equation and the atmospheric effect is not regarded in this study.

3.1 Data Acquisition and Data Processing

A cloud-free LandsatTM, and ETM+ images acquired on march 17, 1990 and march 24 2009 , for (path 168 and row 38) have been used in this research . The images have been rectified to a Universal Transverse Mercator (UTM) projection with WGS84 datum and UTM zone 38. The data acquisition date has very clear atmospheric condition, and the images have been acquired through the USGS Earth Resource Observation Systems Data Center, which has corrected the radiometric and geometrical distortions of the images to a quality level of 1G before delivering. As TM images, Landsat ETM+ images has the same bands, but the TIR band measures energy for two gain (low and high) settings . Low gain mode is utilise to image surfaces with high brightness, whereas high-gain mode is utilise to image surfaces with low brightness[10] .In this studythe high-gain setting has been selected . The data pre-processing has been performed using ERDAS Imagine 8.4 , ENVI 4.7, and Microsoft Excel 2010 software. Inasmuch TM/ETM+ file is composed of the separated of single-band images, therefor firstlyshould be combine the single-band images to a multi-bands image of TM/ETM using a layer stacking tool in order to extract NDVI , and NDBI of the study area . Secondly subset tool has been used to clip the image for study area .Thirdly, the supervised classification method has been used to generate land use/land cover maps and finaly the percentage of different land use/land cover classes has been calculated. Four land cover types identified from these two Landsat images are; (1) water bodies, (2) vegetations (palm trees and crops), (3) built-up area (commercial centers, residential and administrative building), and (4) bare -land.

3.2 Retrieval of Brightness Temperature

The Landsat 5 TM andLandsat 7 ETM+ , TIR band 6 have been used to calculate the surface temperature of the study area . The TIR sensors can measure radiances at the top of the atmosphere (TOA) from which brightness (or black body temperatures) can be derived by using Planck's Law [10]. Inasmuch area of study is consider relatively small , so the content of water vapour in the atmosphere has been supposed to be constant and therefor the atmospheric condition may be considered as uniform and its impact on temperature radiance can be neglected. Therefore, the at-satellite brightness temperature can be used to reflect the distribution of the surface temperature fields. The following equations have been used to retrieve the land surface temperature (LST) of Landsat5 TM and Landsat7 ETM+ TIR band [11] . Equation (1) has been used to convert the digital number (DN) into spectral radiance L_λ(W/(m^2*srad*μm)) by using the bias and gain values.

L_λ = Gain × DN + offset ---------- (1)

The header file that associate with image is contained the gain and offset values.

For Landsat-5 TM, equation (1) can also be writing as follows [10]:

L_λ= 0.05518 * DN +1.2378 ---------- (2)

And for Landsat-7 ETM+ can be writing asfollows:

L_λ = 0.0370588 * DN + 3.2 ---------- (3)

Then equation (2) has been used to convert the spectral radiance to at-sensor brightness temperature upon supposing of uniform emissivity [12] .

$$T_B = \frac{k_2}{\ln\left(\frac{k_1}{L_\lambda}+1\right)}\text{---------(4)}$$

Where, T_B is at-satellite brightness temperature in degree Kelvin, K_2 and K_1 are the prelaunch calibration constants,which are listed in Table(1).

Table 1: TM and ETM+ TIR band calibration constants.

	Landsat TM	Landsat ETM+	Units
K_1	607.76	666.09	Wm^{-2} ster^{-1} μm^{-1}
K_2	1260.56	1282.71	°K

Finally the following formula has been used to convert the temperature in degree Kelvin to degree Celsius.

$T_C = T_B - 273$ --------- (5)

Where, T_C is the brightness temperature in degree Celsius,(Kelvin is 273 degrees lower than Celsius).

3.3 Derivation of NDVI and NDBI from Landsat TM/ ETM+ imagery

For studying the relationship between types of land cover and LST, NDVI and NDBI indices have been used to characterize the land cover types in the study region . Normalized Difference Vegetation Index (NDVI) is the best indicator for growth of vegetation and vegetation cover degree.This index depend on the fact that vegetations have a strong absorption in the red band and a strong reflection for the radiation in the NIR band .NDVI has been calculated by using Eq. (6) [13].

$$\mathrm{NDVI} = \frac{\rho_{\mathrm{NIR}} - \rho_{RED}}{\rho_{\mathrm{NIR}} + \rho_{\mathrm{RED}}}\text{-------- (6)}$$

Where:ρ_{NIR} is the surface reflectance of band 4 of TM/ETM+ images ,ρ_{RED} is the surface reflectance of band 3 of TM/ETM+ image.

The NDVI calculation produces a new image map containing NDVI values. NDVI values range from –1 to +1, the negative values is for the cover of cloud, water, high reflectivity of visible light, 0 is for bare land and building, that have approximately equivalent reflectance in NIR and R wavelengths range. Positive values indicate that there are vegetation cover, and with the coverage increases, NDVI will increase too [14].

Another index has been used in this study, that is sensitive to the built-up area is Normalized Difference Build-up Index (NDBI), which use for extracting the built-up land from urban areas, NDBI has been calculated by using Eq(7). [15]:

$$\mathrm{NDBI} = \frac{\rho_{MIR} - \rho_{NIR}}{\rho_{MIR} + \rho_{NIR}}\text{----------(7)}$$

Where:ρ_{MIR} is the surface reflectance of band 5 of TM/ ETM+ images ,ρ_{NIR} is the surface reflectance of band 4 of TM/ ETM+ image.

The development of this index has been based on the unique spectral response of urbanized and bare land areas that have higher reflectance in MIR wavelength range than in NIR wavelength range.

4. Results and Discussion

4.1. patterns Changes of Land cover

To identify the changes in LC for the study area , the images for 1990 and 2009 years have been classified by using supervised classification. Four classes have been considered for the study area are built- up land, bare land, vegetation areas and water . Theresults of classification have been presented in Fig. (2) . Comparison of the land cover maps showed significant changes occurred since (1990 to 2009). Greatest changes have been observed on the built-up land and vegetation areas while the other LC types have roughly similar trends in the 19 years .The changes details of the LC of the study area are listed in Table (2). Vegetation land has reduced dearly , the total area covered by vegetation for the year 1990 and 2009 are approximately 57.5% (i.e. 199.2 km^2) and 39.9% (i.e. 138.5km^2) respectively. This because of ignoring the agriculture , continuation of illegal

cutting for trees , and vast converting from vegetation areas to buildings area.

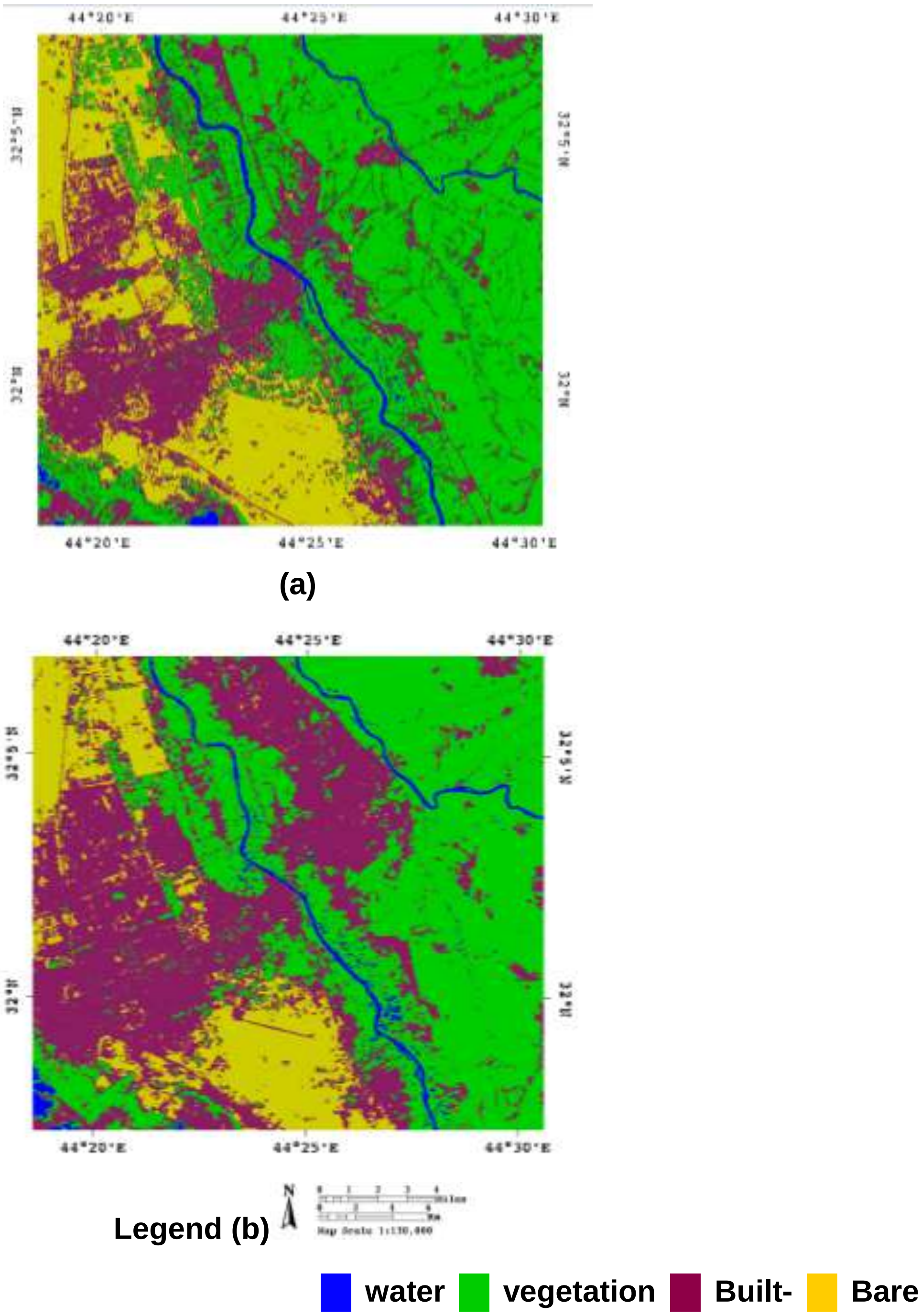


Figure 2: Results of Supervised classification for the study area(a) 1990 , (b) 2009.

Table 2: Change Rate of LU/LC from 1990 to2009

Classes	1990 Area in km²	1990 Percentage (%)	2009 Area in km²	2009 Percentage (%)	Changes in km²	Change rate in Percent
Vegetation	199.2	57.5	138.5	39.9	-60.7	-17.6
Built-up	76.5	22.1	144.5	41.8	68	19.7
Barren Land	58.5	16.9	52.9	15.3	-5. 6	-1.6
Water	12.5	3.5	10.5	3	-2	-0.5

Meanwhile urban area has been occupied 22.1.5 % (i.e. 76.5 km^2) and 41.8 % % (i.e. 144.5 km^2) of the total area in 1990 and 2009 respectively ,this because of continuous increase for population and evolution of the religious tourism that is lead to increment of economical activity . Because of decreasing of rainfall in this period, the surface water body has been receded from 3.5 % (i.e. 12.5 km^2) to 3 % (i.e. 10. 5 km^2) ofthe total study area in 1990 and 2009 respectively.

. Finally the total area for bare land decreased from 16.9 % (i.e. 58.5 km^2) to 15.3 % (i.e. 52.9 km^2) for the total area in 1990 and 2009 respectively. These changes in classes of LC have been influenced the LST pattern for the study area for period from 1990 to 2009.

4-2 The influence of land cover changes on LST

From figure (3) we can notice that , the LST increased for all land cover types over the period of study . Generally, higher temperature has been observed in the center part of city, because this area is active commercial area with

population density is relatively large and human activities are so much and so it is generating more heat, in addition to the buildings are semi crowded in this region , and the heat is not easy to dispersing , therefor the temperature in this area is higher than surrounded areas.

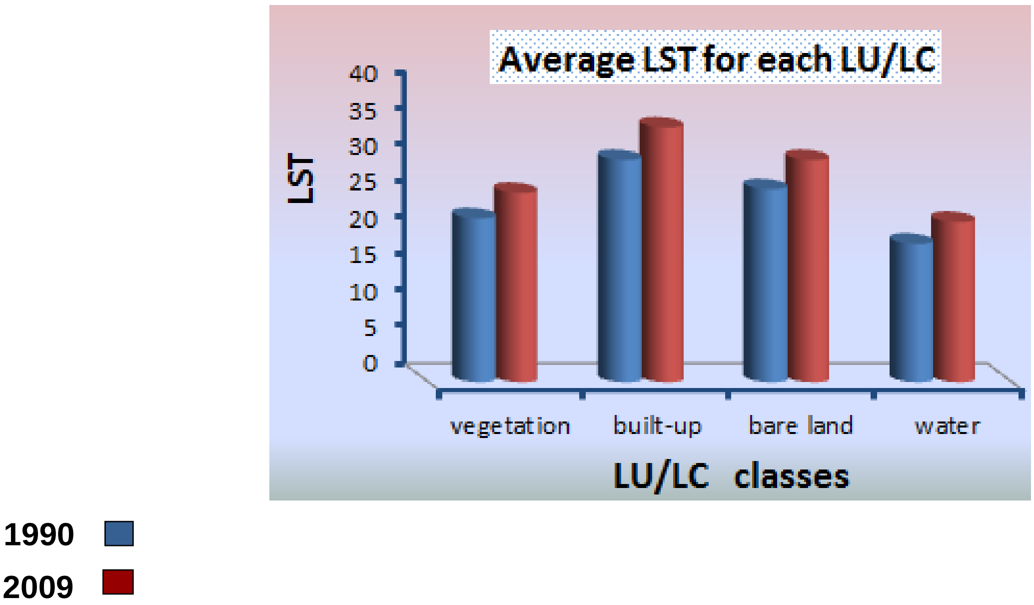


Figure 3: Average LST for each LU/LC of 1990 and 2009

Based on LST map of 1990 (i.e.figure 4) the maximum surface temperature increased from (32° C of 1990) to (37°C of 2009) as are shown in red area (built up area) on the LST map .The maximum temperature of bare land increased from (26.5 C° of 1990) to (30.5 C° of 2009) because of the minimum level of rainfall in winter season and spring at 2009 year in comparison with 1990 year.

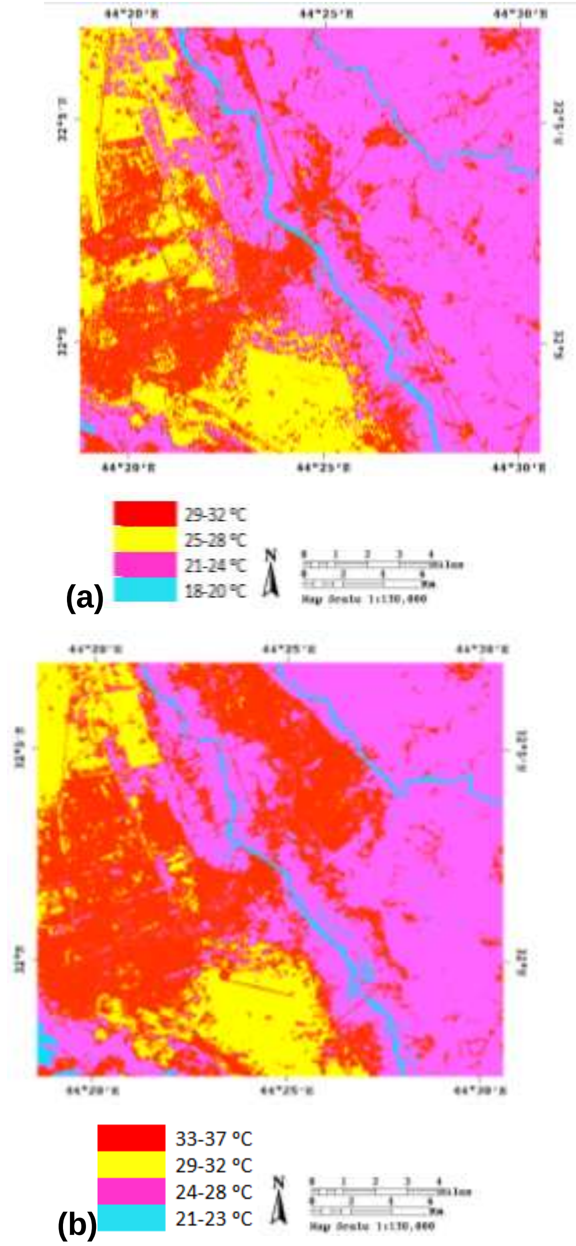


Figure 4 :Maps ofLST distribution ,(a) for TM 1990, (b) for ETM+ 2009

Meanwhile , the rate temperature of vegetation area increased from (22.5 Cº of 1990) to (26 Cº of 2009) that is because of low density for vegetation and exiguity of the raining which led to temperature increase . The mean temperature ofwater is low, because water have small heat conductivity, and it absorbs certain quantity of heat , the rate temperature of water bodies have been increased from (19 Cº of 1990) to (22 Cº of 2009).

4.3 The Relationship between LST and NDVI and NDBI.

Two indices , NDVI and NDBI have been derived in order to found quantifiable relationship between LST and these indices. Fig.(5) show the spatial distribution for, NDVI and NDBI in the study period . In this research, the higher NDVI values have been found over the dense vegetation areas on the NDVI image corresponds the lower LST values on theLST image .While the higher NDBI values have been found over the dense building areas and bare land on the NDBI image which corresponds to the higher LST values on the LST image**.** In 1990, the NDVI ranged between (-0.33 to 0.9), which gradually reduced to between (-0.43 to 0.74), in 2009 as a result for agriculture declining in thisperiod. The results of NDBI show that , in 1990 the NDBI ranged between (-0.72 to 0.65) which increased to between (-0.69 to 0.72) in 2009, this because of increment of construction activity and converting some vegetation areas to building.For finding the relationships between LST and NDVI, and NDBI, linear regression method have been performed by using random sampling values of 1990 and 2009 year datasets of each LC classes with corresponding values of NDVI and NDBI as showing in fig.(6).The results of multiple correlation and regression analyses show that LST appears a positive correlation with NDBI with (R^2=0.8732) for 1990 and (R^2=0.909) for 2009, and negative correlations with NDVI with (R^2=0.8946) for 1990 and (R^2=9178) for 2009.

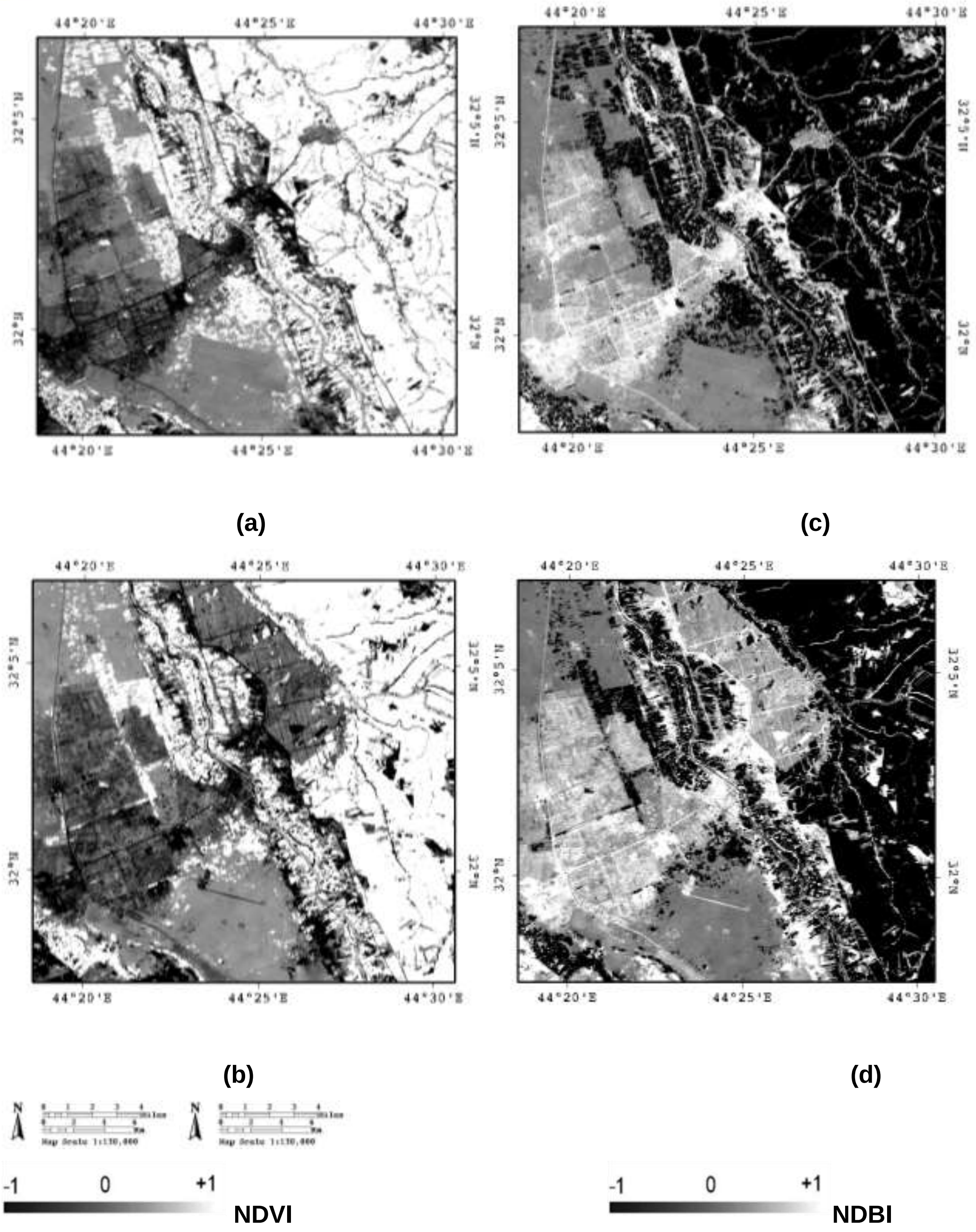
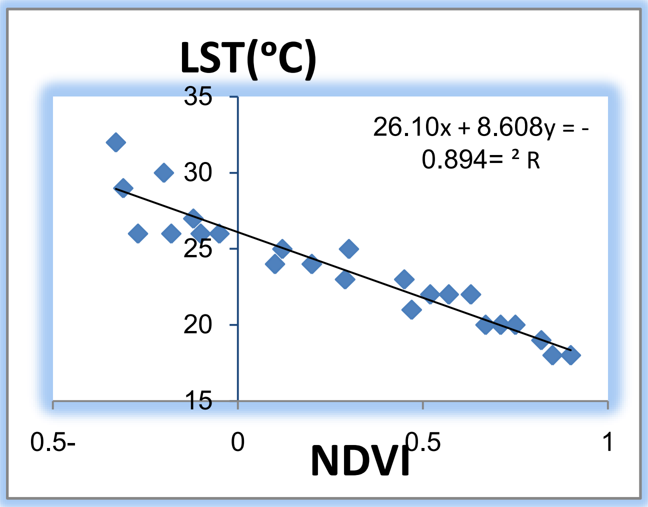
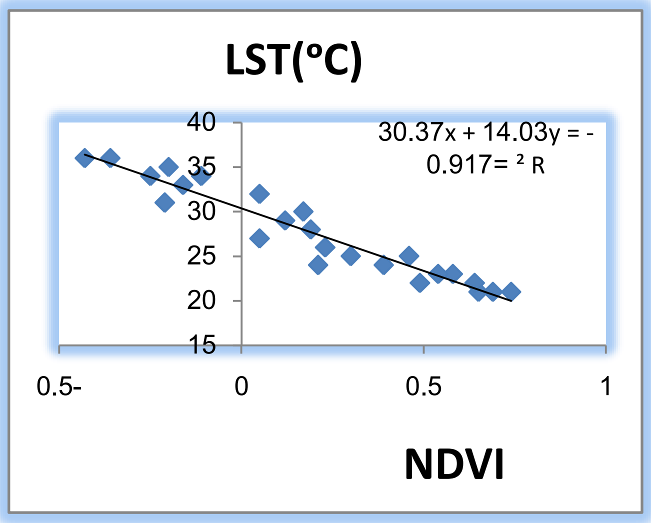


Figure 5: NDVI and NDBI distributions in study area (1990–2009) . (a) NDVI for 1990, (b) NDVI for 2009 , (c) NDBI for 1990 , (d) NDBI for 2009.

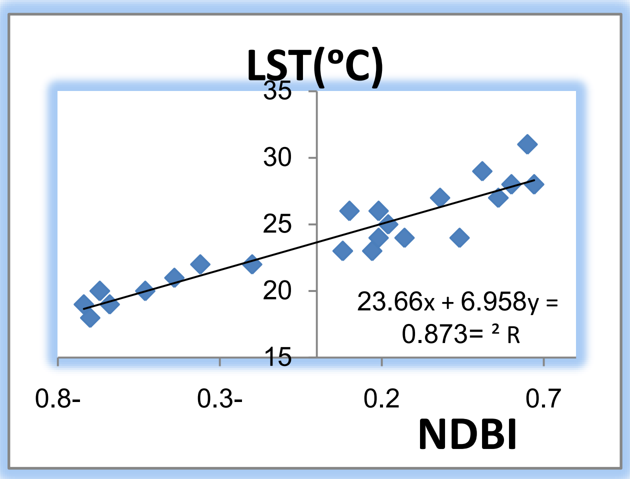


1990

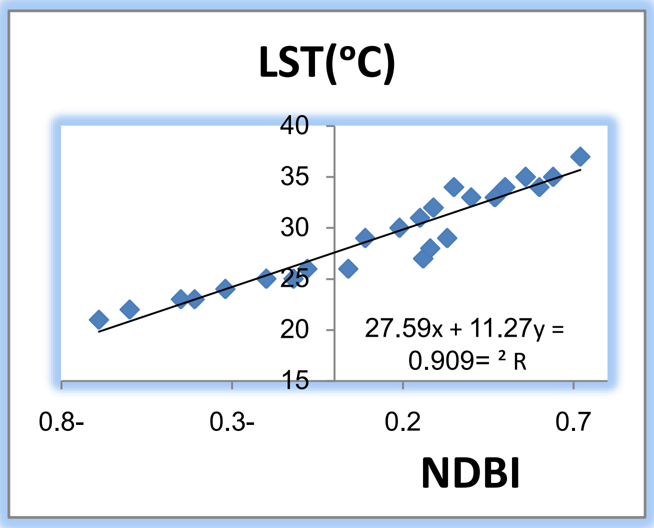


2009

(a)



1990



2009

(b)

Figure 6: (a) Correlation between NDVI and LST for (1990-2009) year , (b) Correlation between NDBI and LST for (1990-2009) year.

Conclusions

Landsat TM/ETM+ have been utilized to observer the changes in land cover, and their impact on the spatial distribution of LST. As a result of urban growth due to increasing of population growth of AL-Najaf City, there have been important changes in the LC for the study area. There have been noteworthy degradation of vegetated areas against an increase in urban areas. The results have been showed that , LST of AL- Najaf city was increased through the period of study , which indicates that the effect of LC changes is very important. The results also shows that, the NDVI and LST appears negative correlation which indicates that, the vegetarian cover decrement have been increased of LST. While NDBI and LST appears positive correlation which confirm that, the dense built-up areas have been mightily increased of LST .Therefore, future city designing must cares more by urban greening .

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