ASSESSMENT OF RELATIONSHIP BETWEEN LAND SURFACE TEMPERATURE AND NORMALIZED DIFFERENT VEGETATION INDEX USING LANDSAT IMAGES IN SOME REGIONS OF DIYALA GOVERNORATE

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ABSTRACT

Agriculture is the most important and most dependent economic activity and influenced by climatic conditions as the climate elements represented by solar radiation, temperature, wind and relative humidity. Therefore, is necessary that analyze and understand the relationship between climate and agriculture. The aim of this study to assessment the relationship between land surface temperature (LST) and normalized difference vegetation index (NDVI) for three regions of Diyala Governorate in Iraq (Al Muqdadya, Baladrooz, and Baquba) by through using of remote sensing techniques and geographic information system (GIS).The Normalized difference vegetation index NDVI and land surface temperature (LST) were used in two of the Landsat-5 ETM + and Landsat-8 OLI satellite imagery during the years 1999 and 2019. The results showed that increased in NDVI and decreased in LST for 2019, while for 1999 increased in LST and decreased in NDVI for the three regions. Finally, the regression was used to obtain that correlation between LST and NDVI. It was concluded that the correlation coefficient between NDVI and LST is negative, where the strongest correlation was 0.76 for Baquba and weakest correlation was 0.55 for Muqdadyia.

.Keyword: NDVI, LST, Remote Sensing, GIS, Landsat Images, Iraq.

تقييم العلاقة بين درجة حرارة سطح الأرض ومؤشر الغطاء النباتي المختلط الطبيعي بإستخدام صور لاندسات في بعض مناطق محافظة ديالى

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المستخلص

الزراعة هي النشاط الاقتصادي الأكثر أهمية والأكثر اعتمادًا وتتأثر بالظروف المناخية مثل العناصر المناخية التي تمثلها الإشعاع الشمسي ودرجة الحرارة والرياح والرطوبة النسبية، لذلك من الضروري تحليل ودراسة العلاقة بين المناخ والزراعة. تهدف هذه الدراسة إلى تقييم العلاقة بين درجة حرارة سطح الأرض (LST) ومؤشر اختلاف النبات القياسي (NDVI) لثلاث مناطق في محافظة ديالى في العراق (المقدادية، بلدروز، وبعقوبة) من خلال استخدام تقنيات الاستشعار عن بعد ونظام المعلومات الجغرافية GIS. تم استخدام مؤشر اختلاف النبات القياسي NDVI ودرجة حرارة سطح الأرض (LST) في اثنين من صور الأقمار الصناعية Landsat-5 ETM + و Landsat-8 OLI خلال عامي 1999 و 2019. وأظهرت النتائج أن هناك زيادة في NDVI وتناقص في LST لعام 2019، بينما بالنسبة لعام 1999 زيادة في LST وتناقص في NDVI للمناطق الثلاث، وأخيرًا، تم استخدام تقنية الانحدار للحصول على الارتباط بين LST و NDVI. أستنتج أن معامل الارتباط بين NDVI و LST هو سلبي, حيث اقوى ارتباط هو 0.76 في بعقوبة وأضعف ارتباط هو 0.55 في المقدادية.

الكلمات المفتاحية: مؤشر التغير الطبيعي للغطاء الخضري (NDVI)، درجة حرارة السطح (LST)، التحسس عن بعد ،نظم المعلومات الجغرافية, صور الاقمار لاندسات, العراق.

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INTRODUCTION

Remote detecting information has become a significant wellspring of data for considering vegetation on territorial, mainland and worldwide scale (21). Remote sensing is a concise means of both effort, money and time as well as the possibility of using it on a wide range of areas (13). The largest advantage of remote sensing data is their synoptic and repetitive coverage of a region that lets near real time, year round and repetitive researches and thus is very useful for the spatial-temporal patterns understanding of different physical properties such as vegetation cover and surface heat (15). Studying vegetation using remote sensing data required for different vegetation indices. Vegetation indices are a numerical indicators simple, who obtain directly from remote sensing photographs, such as normalized difference vegetation index (NDVI) is one of the most commonly important used vegetation index, which depend on the absorption of radiation by vegetation in the red band and its reflectance in near-infrared (NIR) band (16,8). Land-surface temperature (LST) may be defined as the emission thermal from the surface, comprising the top of the canopy for vegetated surfaces as well as other surfaces (such as bare soils). LST is an important factor in the atmospheric sciences as it collect the product of all surface-atmosphere reaction and fluxes energy between the land and the atmosphere. Therefore, LST is a good index of the balance energy at the Earth's surface (24). LST have ability provide important information about the physical characteristic of the surface and climate which plays a role in numbers environmental processes (5). Many researchers have studied LST and vegetation indices for example, Eder Paulo Moreira studied in the year 2016 topographic effect on spectral vegetation indices from Landsat TM data in an agricultural region of Brazil in the south of Minas Gerais State, the results indicated that vegetation indices are less sensitive to topographic effect than the uncorrected spectral band. Among vegetation indices, NDVI and RVI were less sensitive to topographic effect than EVI and SAVI. All vegetation indices showed to be fully independent of topographic effect only after correction. It can be concluded that the topographic correction is required for a consistent reduction of the topographic effect on the vegetation indices from rugged terrain (21). The paper Sara Afrasiabi Gorgani, Mahdi Panahi and Fatemeh Rezaie, 2013 studies the correlation between the Normalized Difference of Vegetation Index (NDVI) and Land Surface Temperature for urban area of Mashhad, using a satellite images from Landsat 5 TM and Landsat 7 ETM+, the results showed that the correlation between NDVI and LST and regression coefficient from NDVI to LST is negative (7). In 2018 Nusrat Parveen and Abdull Ghaffar stadies spatial and temporal relationship between NDVI and land surface temperature of Faisalabad city from 2000-2015, the results indicated that the vegetation area decreases from 34 to 14.3 percent with average increase in LST mean from 39.8 to 44 degree Celsius from 2000-2015 (19). In 2002 k. ichii, a. kawabata and y. yamaguchi analysed the relationship between the normalized different vegetation index (NDVI) and climatic variables on a global scale using the Pathfinder AVHRR Land NDVI data set, and observed climate data for the period 1982–1990 and they concluded that there is a significant correlation between interannual NDVI and temperature variation in the northern mid- to high latitude areas between spring and autumn, and a significant correlation was also identied between the NDVI, temperature and precipitation in northern and southern semiarid regions (10). In 2016 Varinder Saini , Manoj K. Arorab and Ravi P. Gupta studied relationship between surface temperature and SAVI using data collected by the Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM+) and Optical land imager (OLI) and thermal infrared sensor (TIRS) from 1991 to 2013 in a coal mining area in India, they concluded that peak SAVI values are in areas having dense vegetation and peak surface temperature values correspond to areas under fire and these show an obvious negative correlation (17). The study aims to apply a model for calculating land surface temperature and normalized difference vegetation index (NDVI) and find the relationship between them.

MATERIALS AND METHODS

The governorate of Diyala is located in eastern-central Iraq, bordering Iran and sharing internal boundaries with the governorates of Baghdad, Salah Al-Din, Sulaymaniyah and Wassit it is located approximately 57 km^2 northeast of the governorate's capital of Baghdad "figure 1". Its area is about (17.685 km 2) and it includes 6 districts, including the governorate center Baquba district (12). Iraq is located in the range of semi-tropical latitude in the Northern Hemisphere (11), so Diyala Governorate is located within the moderate warm range in the northern half, which makes its climate transitional between the desert climate and the Mediterranean climate, which is a continental climate characterized by drought and high temperatures in the summer and low with little rain in winter and characterized by a large temperature range between night and day and between summer and winter and relatively humidity is low in summer and its high in winter With little seasonal rain and prevailing northwest winds for most of the year (9). Average temperatures in Iraq range from 50 C° in summer, and in winter range 0 C°. Most of the rainfall occurs between December and April and the annual rainfall rate is "100-180 mm" (1), so in the study area the average annual temperature is 22.8°C and the average annual rainfall is 186 mm (18). Agriculture has traditionally been one of the main economic activities in Diyala. The governorate is famous for its production of dates and citrus, and livestock and poultry farms are also to be found in the governorate. The Khanaqin area is the location of an oil field and an oil refinery (15).=

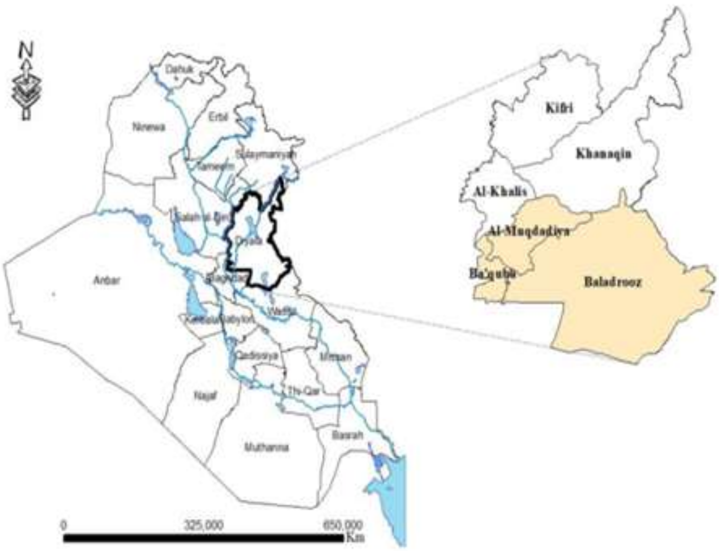


Figure 1. The location of study area

Remote Sensing Data and Processing

Satellite data of Landsat is the most commonly used data for both vegetation and surface temperature related studies. The satellite data have been downloaded from the United States Geological Survey (USGS) image catalogue. The Landsat 5 data of 14/3/1999, with the bands "3, 4, 6", and Landsat 8 data of 21/3/2019, with the bands "4, 5, 10" were used in this study. Information Systems (GIS) is a computer-based system that collect, enter, process, analyze, display, and output spatial and descriptive information for specific goals, and help in planning and decision-making regarding agriculture, city planning, and expansion of housing, this system includes entering geographic information (maps, aerial photos, space visuals) and descriptive (names and tables), processing them (correcting them wrongly), storing, retrieving, querying, analyzing spatial and statistical analysis, and displaying them on a computer screen or on paper in the form of maps ,reports, and graphics (22). In this study, the ArcGIS 10.4.1was used. Then the extraction for study area will be made on all images. After this there are 6 steps to calculate land surface temperature (LST) and normalized difference vegetation index (NDVI):

Step 1. The images can be converted to Top of Atmospere (TOA) radiances using the following expression (4):

$$L\lambda = MLQcal + AL \quad .... \quad 1$$

where L**λ** = TOA spectral radiance [Watts/(m2*srad*μm)]; ML = band-specific multiplicative rescaling factor "RADIANCE_MULT_BAND"; AL = band-specific additive rescaling factor "RADIANCE_ADD_BAND"; Qcal = quantized and calibrated standard product pixel values (DN).

Step 2. The effective at sensor brightness temperature (in Kelvin) is obtained from the spectral radiance using approximation formula (6):

$$T_B = \frac{K_2}{\ln(1+\frac{K_1}{L\lambda})} \quad .... \quad 2$$

The calibration constants K_1 and K_2 btained from Landsat user's manual are given in the Table 1 below

Table 1. calibration constants for the bands used

Landsat	The bands used	K_1	K_2
Landsat5	6	607.76	1260.56
Landsat8	10	774.8853	1321.0789

Step 3. Calculated NDVI from the values of reflectance of radiation in near-infrared spectral bands and the absorption of radiation in the red spectral band as the following formula (23,2):

$$NDVI = \frac{pNIR - pred}{pNIR + pred} \quad .... \quad 3$$

For Landsat5 NIR=band 4 , Red=band 3

For Landsat8 NIR=band 5 , Red=band 4

Step 4. Calculated vegetation proportion (Pv) according to Carlson and Ripley (6):

$$Pv = \left(\frac{NDVI-NDVImin}{NDVImax-NDVImin}\right)^2 \quad .... \quad 4$$

Where NDVI is the NDVI value of a pixel

Step 5. Determination of ground emissivity (ε) by the following equation (20):

$$\varepsilon = 0.004 \cdot Pv + 0.986 \quad .... \quad 5$$

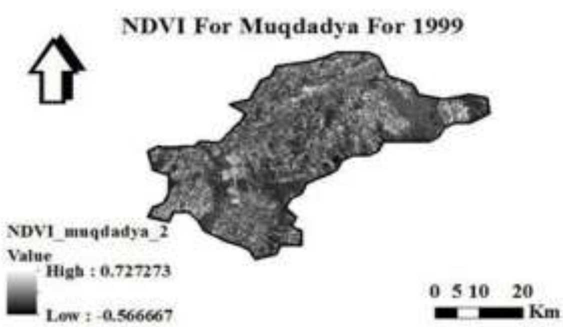
Step 6. The final Land Surface Temperature (LST) is calculated by following equation (3):

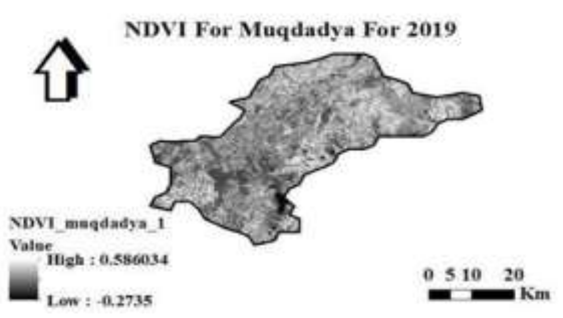
$$LST = \frac{T_B}{1+\left(\lambda\frac{T_B}{\rho}\right)*\ln(\varepsilon)} \quad .... \quad 6$$

where, λ is the central band wavelength of emitted radiance which is calculated in the step 1, ρ = h*c/σ (1.438*10-2 m*K) with: σ is the Boltzmann constant (1.38*10-23 J/K), h is the Planck's constant (6.626*10-34 J*s), c is the light velocity (2.998*108m/s).

RESULTS AND DISCUSSION

NDVI and LST indices were computed, which obtained for multi temporal landsat TM and ETM+ images. Landsat images which obtained were only completely covering three regions of Diyala governorate in Iraq so, the area of interest were extacted for three regions (Al Muqdadya, Baladrooz and Baquba). "Figure 2" shows the NDVI maps of 1999 and 2019 for the three regions, it is clearly shown that all images the NDVI for the year 2019 are much higher than the NDVI for the year 1999 in the three regions. From Maqdadya city the NDVI value is ranges between (-0.56 and 0.72) for the year 1999 and it ranges from (-0.27 to 0.58) for the year 2019. Whereas the NDVI ranges from (-1 to 0.73) for 1999 and for 2019 it is (-0.31 to 0.60) for Baladrooz. Moreover, for Baquba NDVI was calculated between (0.72 and -0.50) for 1999 and it's between (0.57 and -0.24) for 2019.





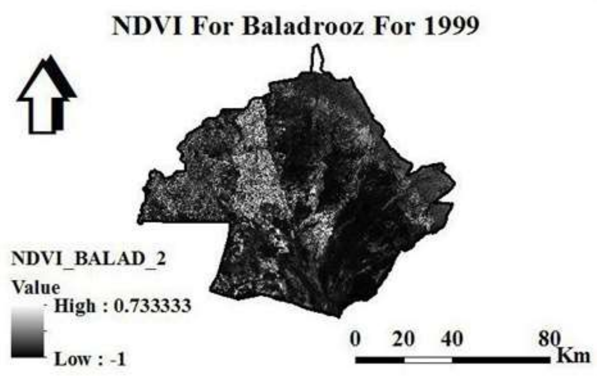
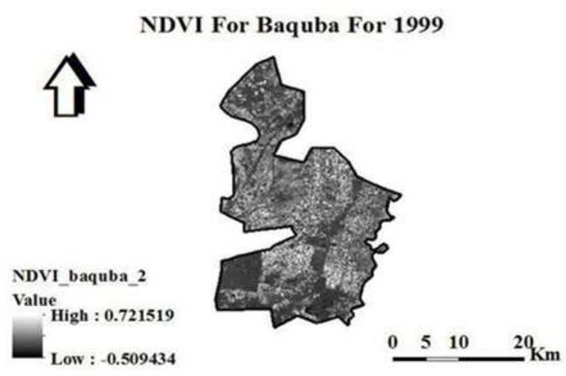
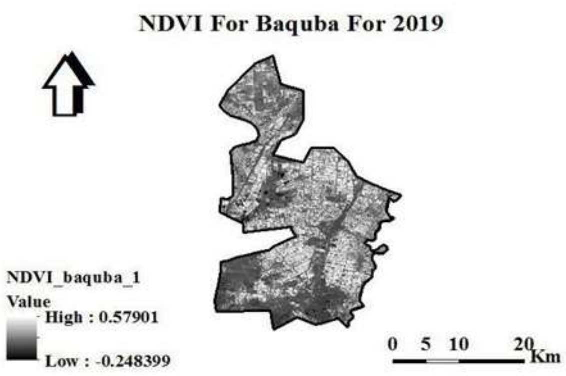


Figure 2. NDVI values for Muqdadya, Baladrooz and Baquba for 1999 and 2019





Followed Figure 2

The study area was classified into two classes a vegetation cover area and non-vegetation area for 1999 and 2019 "figure 3". The vegetation cover area increased for 2019 compared to 1999 for the three regions (table 2).

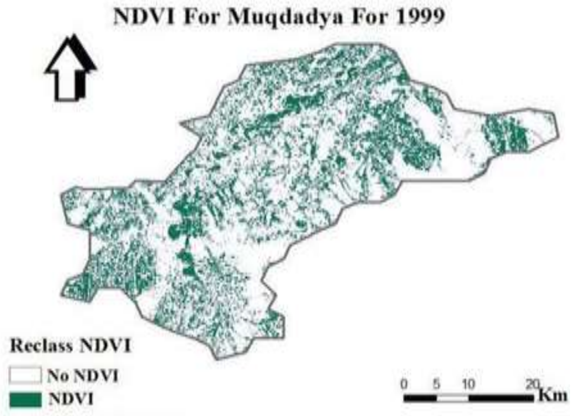
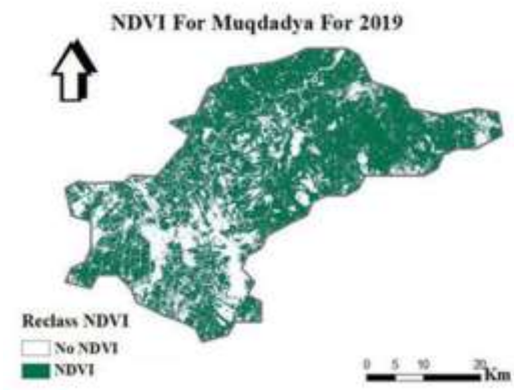
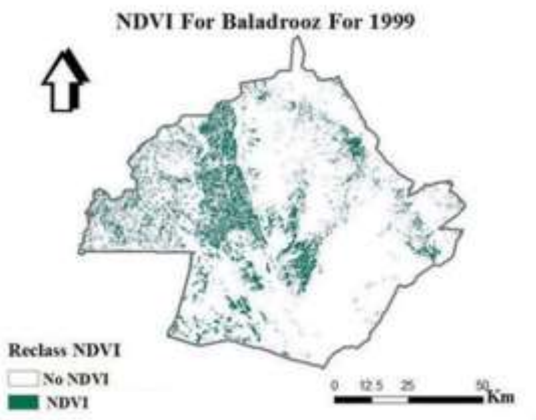
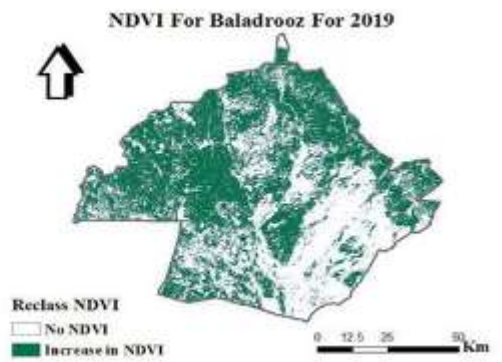
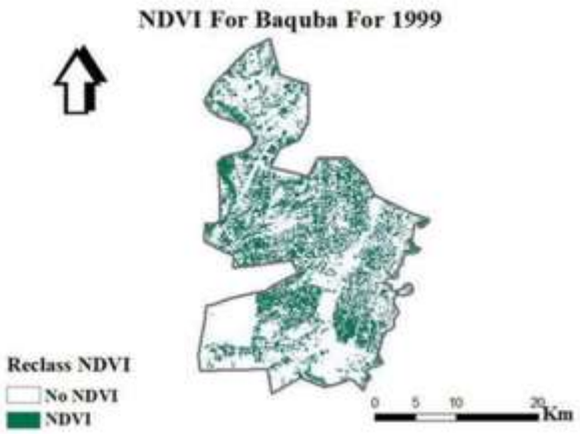


Figure 3. Classification of NDVI

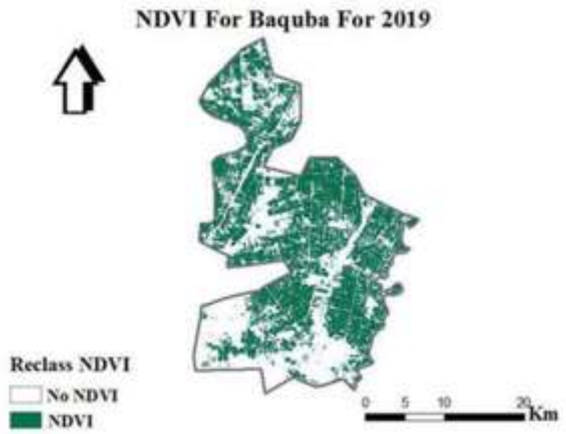








Continued Figure (3)



Continued Figure (3)

Table 2. Area of vegetation cover

Region	1999 km^2	2019 km^2
Muqdadya	409.6017	940.0338
Baladrooz	1046.34	3971.223
Baquba	188.4051	291.8376

While "figure 4" showing the LST maps of 1999 and 2019 and display the minimum and maximum temperature of the three regions. The mean of LST is estimated between (42.16 and 22.49) C° in 1999 and it's between (37.82 and 24.39) C° in 2019 for Muqdadya. While Baladrooz have ranges (23.19 - 39.83) C° in 1999, (13.52 - 33.76) C° in 2019. In addition, the LST mean for Baquba ranges from (23.83 to 42.16) C° in 1999, (24.32 to 38.62) C° in 2019. It was clearly shown that in all images the lowest temperature because of the presence of vegetation density for 2019 in the three regions.

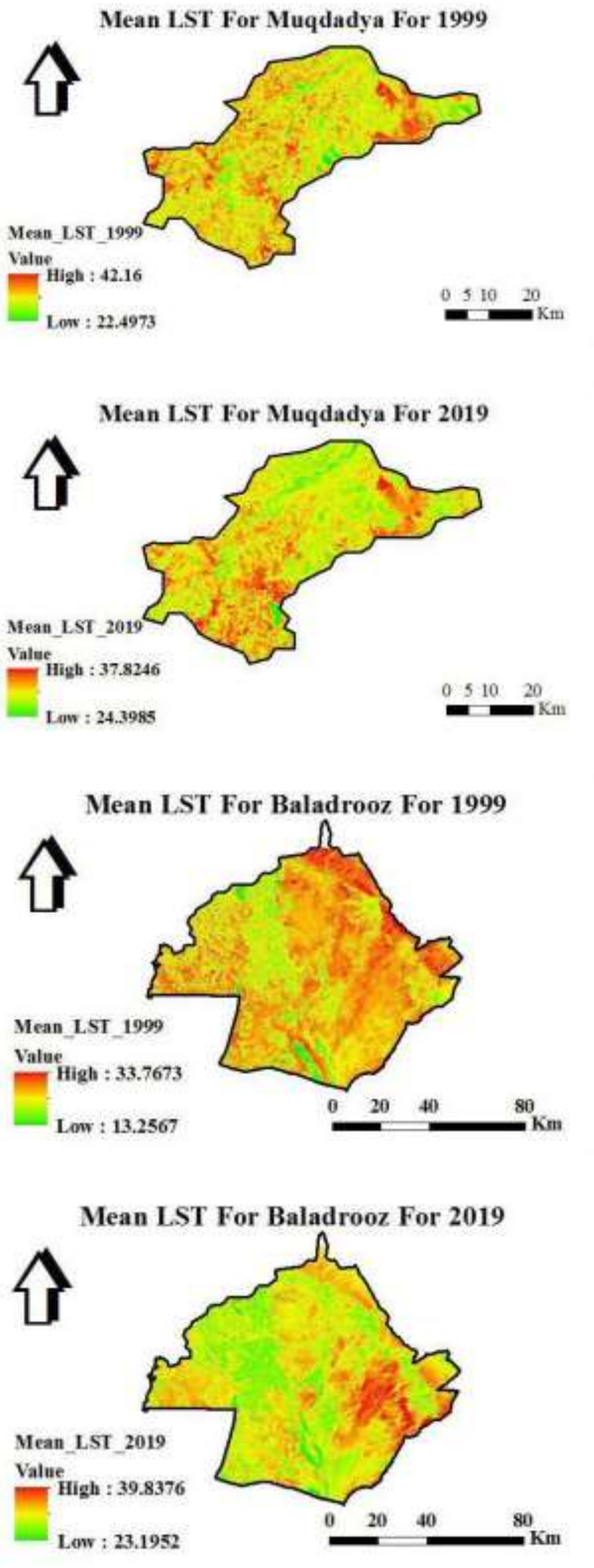
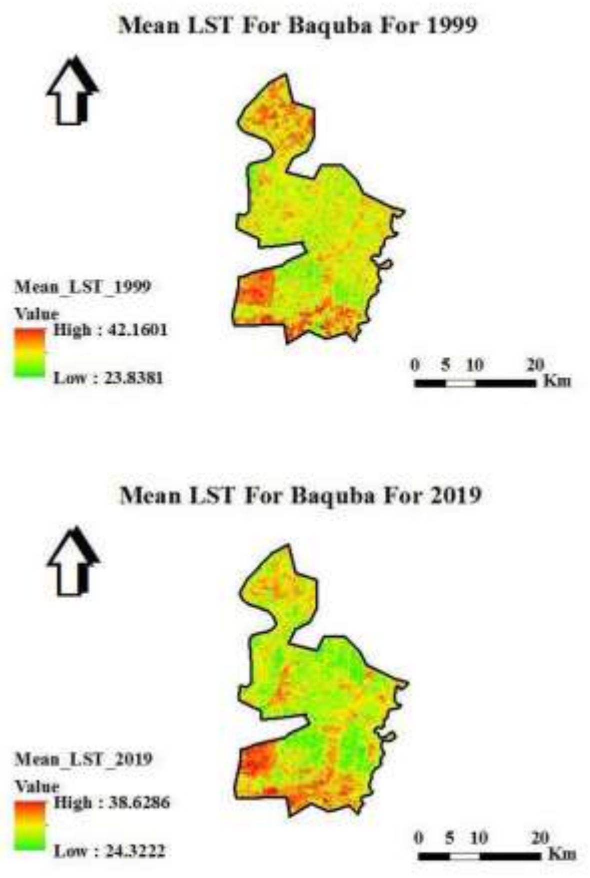


Figure 4. LST values for Muqdadya, Baladrooz and Baquba for 1999 and 2019



Followed Figure (4)

Correlation is a statistical method used to assess a possible linear association between two continuous variables, it can range from -1 to +1 (table 3) (14). The correlation coefficient between LST and NDVI were computed for 1999 and 2019 for study area. The results are presented in (table 4). Its range from (0.58 – 0.60) for 1999 and from (0.55 – 0.76) for 2019. The maximum correlation value was (0.76) in Baquba and the minimum correlation value was (0.55) in Muqdadya

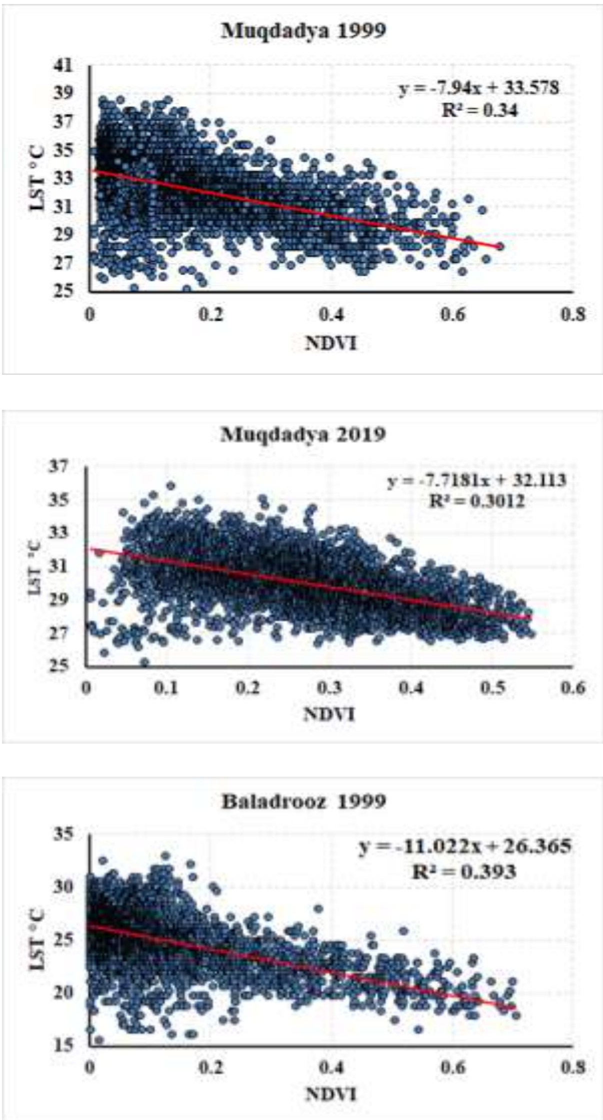
Table 3. The Interpreting the size of a correlation coefficient (14)

Size of Correlation	Interpretation
0.9 to 1.0 (-0.9 to -1.0)	Very high positive (negative) correlation
0.7 to 0.9 (-0.7 to -0.9)	High positive (negative) correlation
0.5 to 0.7 (-0.5 to -0.7)	Moderate positive (negative) correlation
0.3 to 0.5 (-0.3 to -0.5)	Low positive (negative) correlation
0 to 0.3 (0 to -0.3)	Negligible positive (negative) correlation

Table 4. The correlation coefficient values of study area

Region	1999		2019	
	R^2	R	R^2	R
Muqdadya	0.34	0.58	0.3012	0.55
Baladrooz	0.393	0.63	0.4616	0.68
Baquba	0.356	0.60	0.5811	0.76

From the "figure 5" it is clear that negative correlation values were observed between LST and NDVI in all the three regions for 1999 and 2019. This means that areas with lower vegetation cover are experiencing higher land surface temperature and vice versa. From this it can be inferred that vegetation has a cooling and regulating effect on the surface temperature of an area. Studies showed that vegetated surface can contribute significantly to human comfort and better health conditions by decreasing the land surface temperature even by 13°C (25).



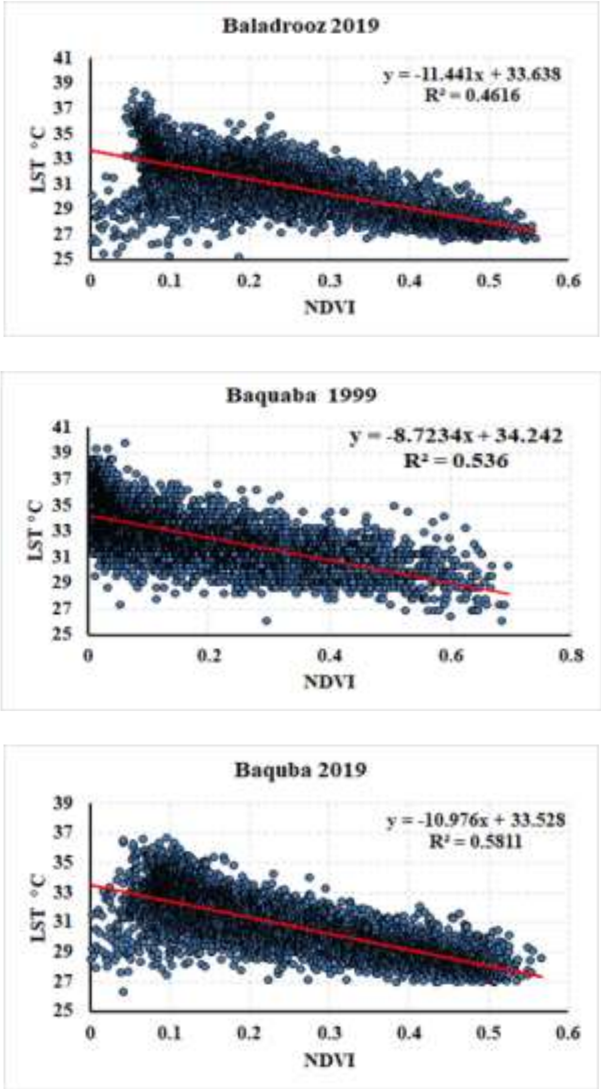


Figure 5. The relationship between LST and NDVI

CONCLUSION

Nowadays, satellite data are becoming important for various applications in different fields including in environmental and ecological studies. This study has demonstrated that the recent advancements in remote sensing and GIS technologies provide powerful tools for mapping and detecting changes in LST and NDVI. In this study, land surface temperature (LST) and normalized difference vegetation index (NDVI) have been calculated for 1999 and 2019 for three regions in Iraq using Landsat images. The results show that there is increasing in NDVI and decreasing in LST for 2019 for the three regions and vice versa for 1999. The strong negative correlation between LST and vegetation is found, this relationship in fact varies with location, season, and vegetation type.

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