Al-Mustansiriyah Journal of Science
ISSN: 1814-635X (print), ISSN:2521-3520 (online) Volume 32, Issue 4, 2021 DOI: http://doi.org/10.23851/mjs.v32i4.1012

Research Article **Open Access**

Analysis of the LST and Vegetation Indices relationship using Landsat-8 data in Duhok Governorate, Iraq

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Article Info

Received
02/06/2021

Accepted
27/08/2021

Published
20/11/2021

ABSTRACT

Vegetation cover considered as one of the most important factors that affect weather, climate, and the environment. This paper aims to study the correlation between land surface temperature and the Vegetation Indices using Landsat data in Duhok Governorate, Iraq. Landsat-8 images were taken for December, April, July, and October in 2019. Geographic Information System ArcGIS 10.2 package has been used to calculate the results. The Normalized difference vegetation index NDVI, Green ratio vegetation index (GRVI), and land surface temperature (LST) have been computed. The results showed that were a strong positive relationship between vegetation indices during winter, spring, summer, and fall seasons. The correlation coefficient values ranged from (0.9) in winter, (0.96) in spring, (0.95) in summer and (0.89) in autumn seasons. In addition, the results showed a strong inverse correlation among LST and NDVI, GRVI indices during winter, spring, summer, and autumn seasons. The strongest correlation between land surface temperature and the Vegetation Indices was in the Spring Season. These correlations can be used to study vegetation health, drought.

KEYWORDS: LST, NDVI, GRVI, Duhok, Iraq.

الخلاصة

يعتبر الغطاء النباتي من أهم العوامل المؤثرة على الطقس والمناخ والبيئة. يهدف هذا البحث إلى دراسة الارتباط بين درجة حرارة سطح الأرض ومؤشرات الغطاء النباتي باستخدام بيانات لاندسات في محافظة دهوك ، العراق. تم التقاط صور Landsat-8 لشهر ديسمبر وأبريل ويوليو وأكتوبر في عام **2019**. تم استخدام حزمة نظام المعلومات الجغرافية ArcGIS 10.2 لحساب النتائج. تم حساب مؤشر الفرق الطبيعي للغطاء النباتي NDVI ودليل الغطاء النباتي للنسبة الخضراء (GRVI) ودرجة حرارة سطح الأرض (LST). أظهرت النتائج وجود علاقة موجبة قوية بين مؤشرات الغطاء النباتي خلال مواسم الشتاء والربيع والصيف والخريف. تراوحت قيم معامل الارتباط بين (**0.9**) في الشتاء و (**0.96**) في الربيع و (**0.95**) في الصيف و (**0.89**) في مواسم الخريف. كما أظهرت النتائج وجود علاقة عكسية قوية بين مؤشرات LST و NDVI و GRVI خلال مواسم الشتاء والربيع والصيف والخريف. أقوى ارتباط بين درجة حرارة سطح الأرض ومؤشرات الغطاء النباتي كان في فصل الربيع. يمكن استخدام هذه الارتباطات لدراسة صحة الغطاء النباتي والجفاف.

INTRODUCTION

The weather circumstances near and over a specific city and many regions composite of buildings and factories are varies because it differs in their non-natural efficiency of urbanization. [1]. several studies have evaluated the relative heat over the buildup areas via calculating and registering the temperature of the air, employing land founded monitoring stations. [2]. The feature of using remote sensing information is the existence of the high resolution, symmetrical, continuous covering and the ability of evaluation over the situations of earth surface. The information obtained from the remote sensing are useful for agriculture supply beside that it provides the prerequisite information to valuation of the crops [3].

The reflection of the visible light spectrum from vegetation depends on the plant species, the amount of water in tissues, and many essential elements [4]. The continuous surveillance for previous parameter will provide the necessary data to investigate on the climate change [5]. Vegetation indices usually used to identify LST changes and observing aridity by the adjustment of the radiant temperature of the surface to realize the influence of green cover variation off the surface temperature [6]. The land surface temperature considers a great index to refer to the energy balance on the ground due to the essential variables in the physics of land-

surface operation over local and international scales [7].
Land surface temperatures normally measured in the remote sensing mechanisms which recover satellite thermic infrared information; however traditional temperatures of the surrounding are measured via thermometers on earth [7]. Increasing of civilization and urban growth related to the energy intensive land utilizes which displace naturalist land cover. The increase in the number of air conditioners, shorten air stream of tight roads and high buildings [8]. Many studies in last few years prevail by the description, health consequences, and policy modulation of the urban heat island [9]. Many studies that connected between Temperature and health studies depend on temperatures that reflect the Human micro Environmental showing in their exposure-response evaluation [10]. Many researches have headed to employ the remote sensing data for the analysis of the urban heat island [11].
In this research, we took advantage of the satellite information over Duhok governorate in the north part of Iraq during 2019 to show the relationships among NDVI and GRVI vegetation indices and the correlation between LST and vegetation indices during winter, spring, summer, and fall season. These correlations can be used to study vegetation health, drought, and areas where Urban Heat Island can occur.

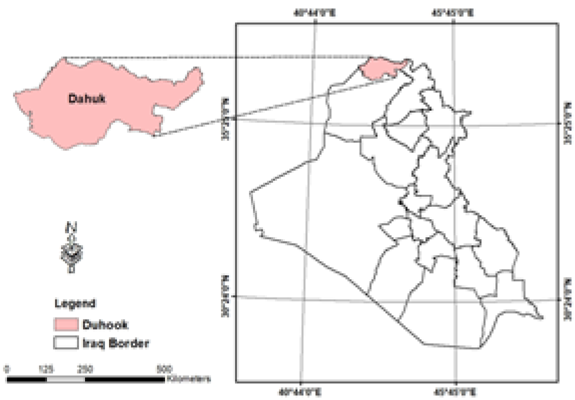


Figure1. Location of the study area

MATERIALS AND METHODS

Study Area and Data Sources

Dohuk governorate is located at the north part of Iraq, which situated among latitude (36°53-36°48N) and longitude (43°0-42°55E) [12] as shown in Fig. 1. The Duhok governorate divided into four regions Amedi in the east, Sumel in the west, Zakho to the north and Duhok in the center. The summer months from June to September are very hot and dry. In July and August, the hottest months, mean highs are 39-43 degrees, and often reach nearly 50 degrees. Autumn is dry and mild, and like spring is an ideal time of year to travel in the Region. Average temperatures are 24-29 degrees in October, cooling slightly in November. Winters are mild, except in the high mountains. Mean winter high temperatures are 7-13 degrees Celsius, and mean lows are 2-7 degrees Celsius. In the colder months, precipitation occurs and is heaviest in late winter and early spring. For heavy falls in the uplands, the city can get about two to three snowy days a year. Summers are nearly dry, and rain returns in late autumn. The images of Landsat-8 which her path was 170 and row was 34 have been downloaded from the U.S. Geological Survey server. During four selected intervals so that every image represents specific season in 2019. The first image was taken on 04th of April which represent spring season, then 09th of July represent summer season, the 13th October to represent the fall season and 16th December that represent winter season. The preprocessing of the images included geometric corrections. The Landsat images were projection UTM zone N 38.

Normalized Difference Vegetation Index (NDVI)

The NDVI used to calculate the healthful green cover. Mixture of its Normalized difference formula with the area of high reflection and absorption for chlorophyll make it powerful through a broad range of terms [13].

$$NDVI = \frac{(NIR -)}{(NIR +)} \quad (1)$$

Where NIR is near infrared (Band 5) with wavelength (0.85–0.88μm) and Red is (Band 4) with wavelength (0.64–0.67μm). The NDVI index domain between -1 to 1. Generally, for green plants range 0.2 to 0.8.

Green Ratio Vegetation Index (GRVI)

The GRVI index is critical with photosynthetic rates in forest canopies, as green and red reflectance are highly affected through variation in leaf tincture [17].

$$GRVI = \frac{NIR}{GREEN} \quad (2)$$

Land Surface Temperature (LST)

The technique used to recover LST of raw Landsat datasets need to transformation of DN values of the thermal bands (Bands 10 and 11 in Landsat OLI/TIRS) first to absolute radiance values [18]. After the process an adjustment is made on the spectral emissivity depend on the nature of the landscape [19] [21]. We applied the pre-processed Band 10 of Landsat-8, including top of atmosphere brightness temperature values represented in Kelvin for output an LST map for all the study areas. After transforming the Brightness temperature values to Celsius (°C), the emissivity-rectify LST counted that shown in Eq. [6] [19] [20].

$$LST(^{o}C) = \frac{T_B}{1 + (\lambda \times T_B/\rho)Ln\varepsilon} \qquad (3)$$

where TB = Landsat-8 Band 10 brightness temperature, λ = wavelength of emitted radiance (λ=10.8μm, the center wavelength of Landsat-8 Band 10, was applied), ρ=h×c/σ (1.438 × 10−2 m K), σ = Boltzmann constant (1.38×10^{-23} J/K), h=Planck's constant (6.626×10^{-34} Js), and c = speed of light (2.998×10^{8} m/s); and ε is the land surface emissivity, calculated in Eq.7 [21]

$$\varepsilon = mP_V + n \qquad (4)$$

Where m= (εv−εs)−(1−εs) Fεv and n=εs+(1−εs) Fεv, where εs and εv are the soil emissivity and plants emissivity, respectively. We utilized the conclusion of Sobrino et al. [21] for m (0.004) and n (0.986). Pv is the vegetation ratio and it obtained by applied this Eq. [8] [22].

$$P_V = \left(\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}\right)^2 \qquad (5)$$

Where NDVI obtained from the surface reflectance of Landsat-8 as shown in Eq. (1).

RESULTS AND DISCUSSION

The NDVI, GRVI, and LST were derived from Landsat OLI images for 2019 using ArcGIS 10.2. Figs 2-3 illustrate the map of vegetation cover for winter, spring; summer and autumn derived from NDVI and GRVI indices over the study area during 2019. The correlation coefficients R among the NDVI and GRVI vegetation indices are calculated. Table 1 reveals the correlation coefficient R between NDVI and GRVI. It can be seen that the strongest relationship of the correlation coefficient R between the vegetation indices the NDVI and GRVI is equal to (0.9668) during summer season, and the weakest relation of the correlation coefficient is between NDVI and GRVI is equal to (0.8929) during autumn season.

The results notice that the vegetation indices has the highest value in the east part of the governorate (Amedi) which most of it consists of mountains and plains. In spring, the vegetation cover generally has the highest values in vegetation indices than other seasons in the study area. Vegetation cover concentrated in the western parts of the governorate including (Sumel) to the center (Duhok) with the west and south parts of (Zakho) which register the highest values of the vegetation indices. In summer the green cover crawl slowly towards the east, which can be noticed in the east and south parts of (Amedi) and east and north parts of (Zakho) vegetation cover during winter and autumn seasons less than its values in spring and summer.

The highest value of vegetation cover were in (Amedi) and (Zakho). Vegetation cover during winter and autumn seasons less than its values in spring and summer. The highest value of vegetation cover was in (Amedi) and (Zakho). Vegetation cover decreases gradually from winter to autumn to register the lowest values of the vegetation indices in autumn season across all the study area and especially in the center and the west parts of the governorate (Duhok) and (Sumel).It can be seen that the green ratio vegetation index GRVI has the highest correlation coefficient with NDVI in all the seasons (0.9668), (0.9535), (0.9014) and (0.8929) in spring, summer, winter and autumn, respectively.

Table 1. Correlation coefficient between NDVI and GRVI vegetation indices for different Seasons

Vegetation indices	Spring	Summer	Autumn	Winter
GRVI	0.9668	0.9535	0.8929	0.9014

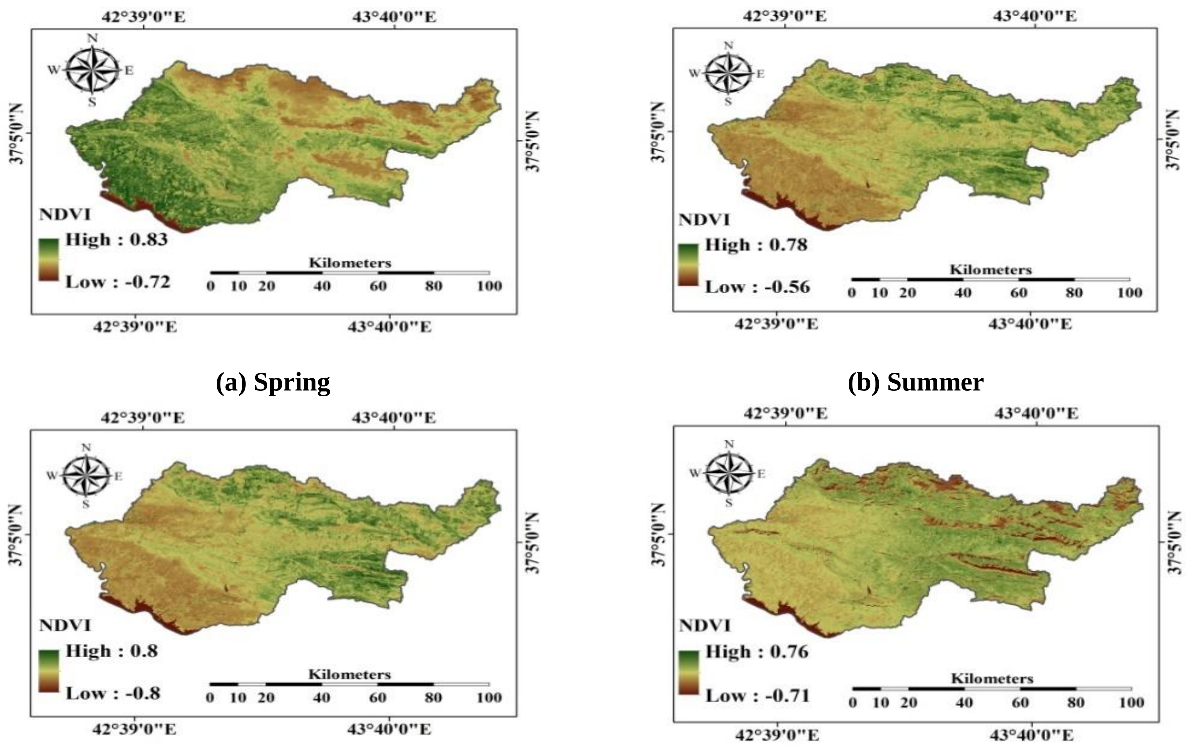
Figure 4, illustrates the map of Land surface temperature for spring, summer, autumn and winter, over the study area during 2019. it can be noticed that the highest LST values in the west parts of the governorate in (Sumel) and the center (Duhok) in seasons and its decrease gradually as move toward north (Zakho) and (Amedi) to the east because of the geographical nature of the governorate. In summer noticed many parts registered temperature exceeded (40 °C). While the temperature decreases toward north and east parts of the governorate toward (Zakho) and (Amedi) which most of it consist of mountains and plains. In spring the temperature ranges between (10-35 ^{o}C) the warmest areas in the west and center and it decrease gradually toward north (Zakho) and (Amedi) to the east. During winter the lowest temperature registered and the temperature range between (0-15^{o}C) in most areas of the governorate with many regions below Zero centigrade especially in the mountains in (Zakho) and (Amedi) and many other regions as shown in Figure 4. At autumn season the temperature range between (10-35^{o}C) less than its values in summer and more than spring season.

In General, the temperature registered the highest values for LST in the west (Sumel) and the center (Duhok) during the summer. The temperature decreased in autumn to spring register the lowest LST values in winter season across all the study area, especially in the north and east parts of the governorate (Zakho) and (Amedi). Figure 5, shows the scatter plot for NDVI and LST. It can be seen that there is a good inverse linear relationship between NDVI and LST.

Table 2, reveals that the relationship between LST and vegetation index (NDVI, GRVI) has a good correlation. Figure 5, represent the correlation between one of the vegetation indices (NDVI) and the LST during four seasons over Duhok in 2019. The strongest correlation coefficient R between LST and the vegetation indices involve LST with GRVI and NDVI was (0.8) during the spring season. LST correlation with the vegetation indices has the highest coefficient values during spring and summer seasons, respectively, rather than fall and winter seasons, and obvious from Figure 5, displays the relation between LST and NDVI. Generally, the highest coefficient values gathering the LST with the five indices (NDVI and GRVI) are in spring and it is decreasing gradually in summer then autumn to register the lowest coefficient between LST and vegetation indices in the winter.

Table 2. Correlation coefficient between LST and the vegetation indices in different Seasons.

Vegetation indices	Spring	Summer	Autumn	Winter
GRVI	0.87	0.64	0.68	0.44
NDVI	0.86	0.64	0.63	0.59

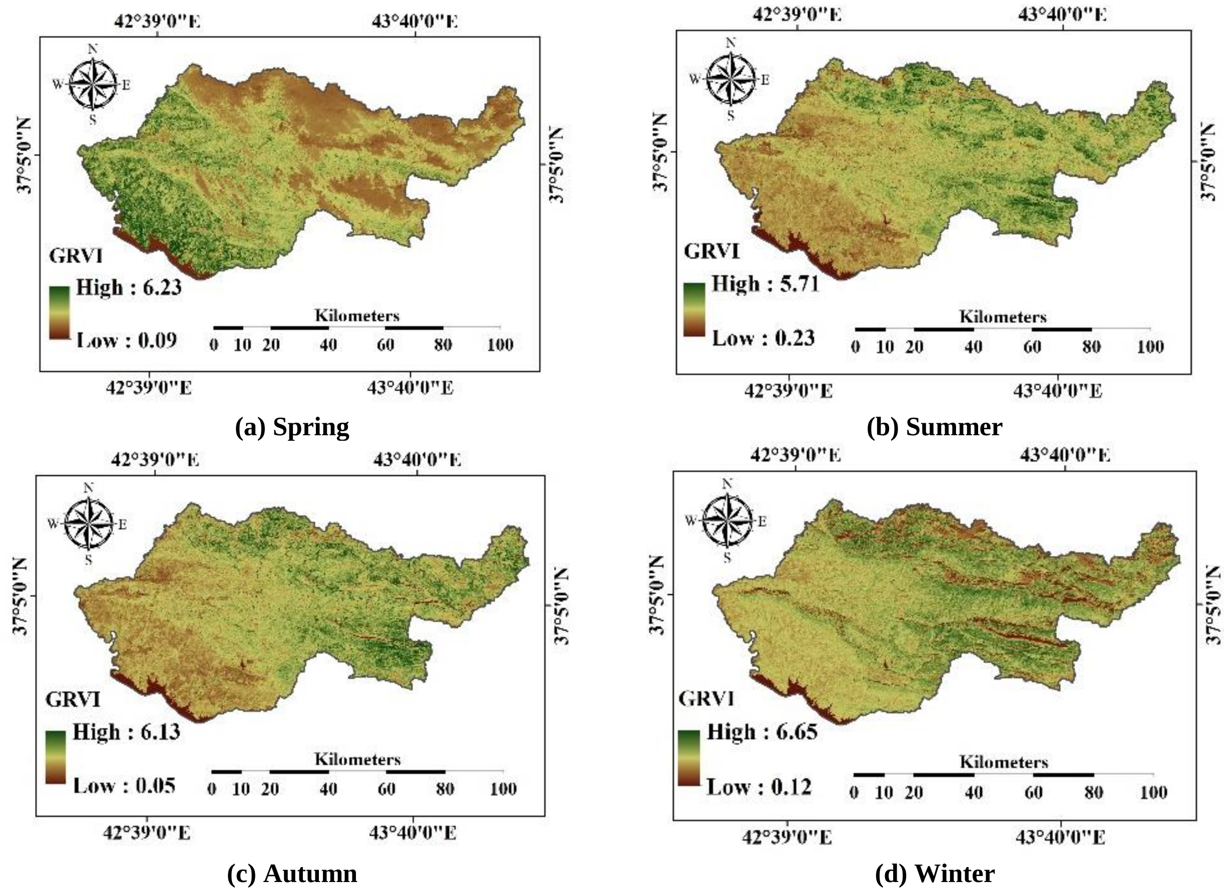


(a) Spring **(b) Summer**

(c) Autumn **(d) Winter**

Figure 2. Normalized Difference Vegetation Index NDVI over Duhok in 2019.

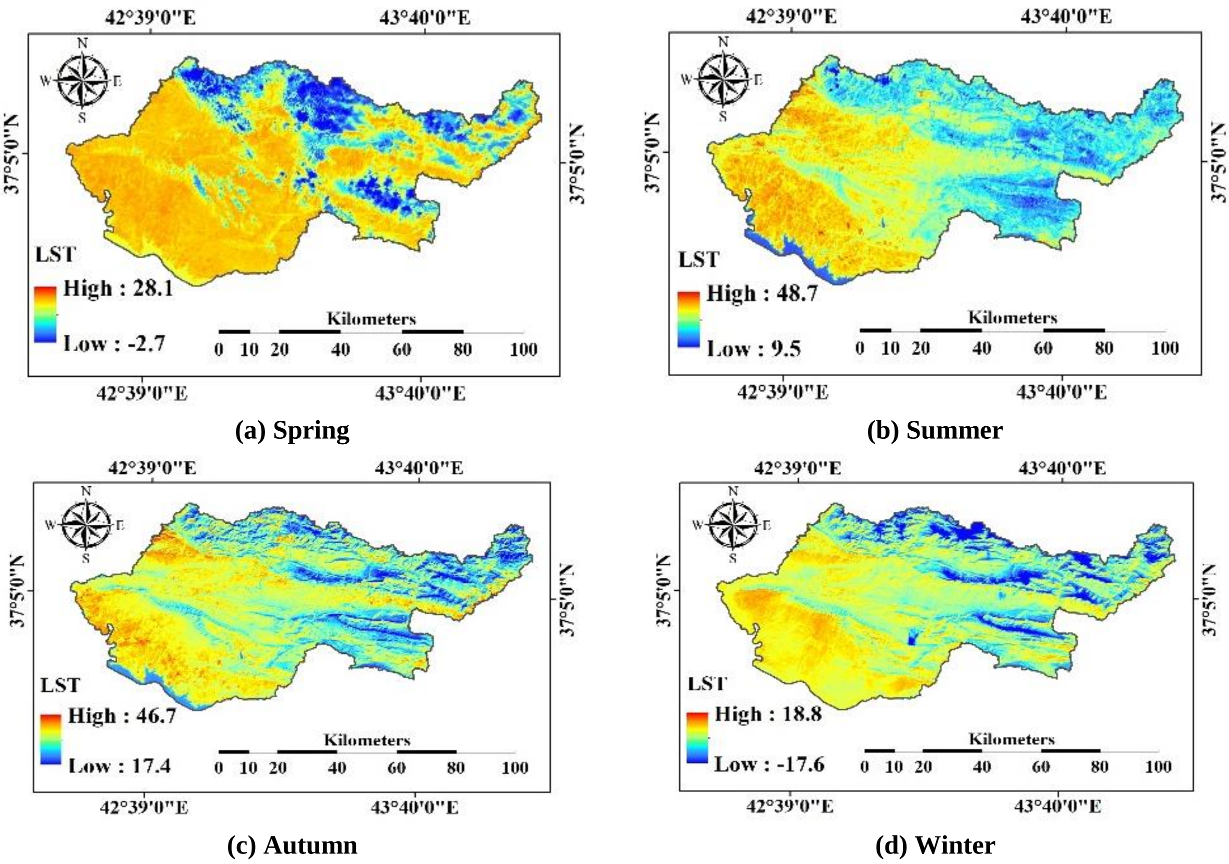
ISSN: 1814-635X (print), ISSN:2521-3520 (online) Volume 32, Issue 4, 2021 DOI: http://doi.org/10.23851/mjs.v32i4.1012



(a) Spring (b) Summer

(c) Autumn (d) Winter

Figure 3. Green Ratio Vegetation Index GRVI over Duhok in 2019.



(a) Spring (b) Summer

(c) Autumn (d) Winter

Figure 4. Land Surface Temperature Index LST over Duhok in 2019.

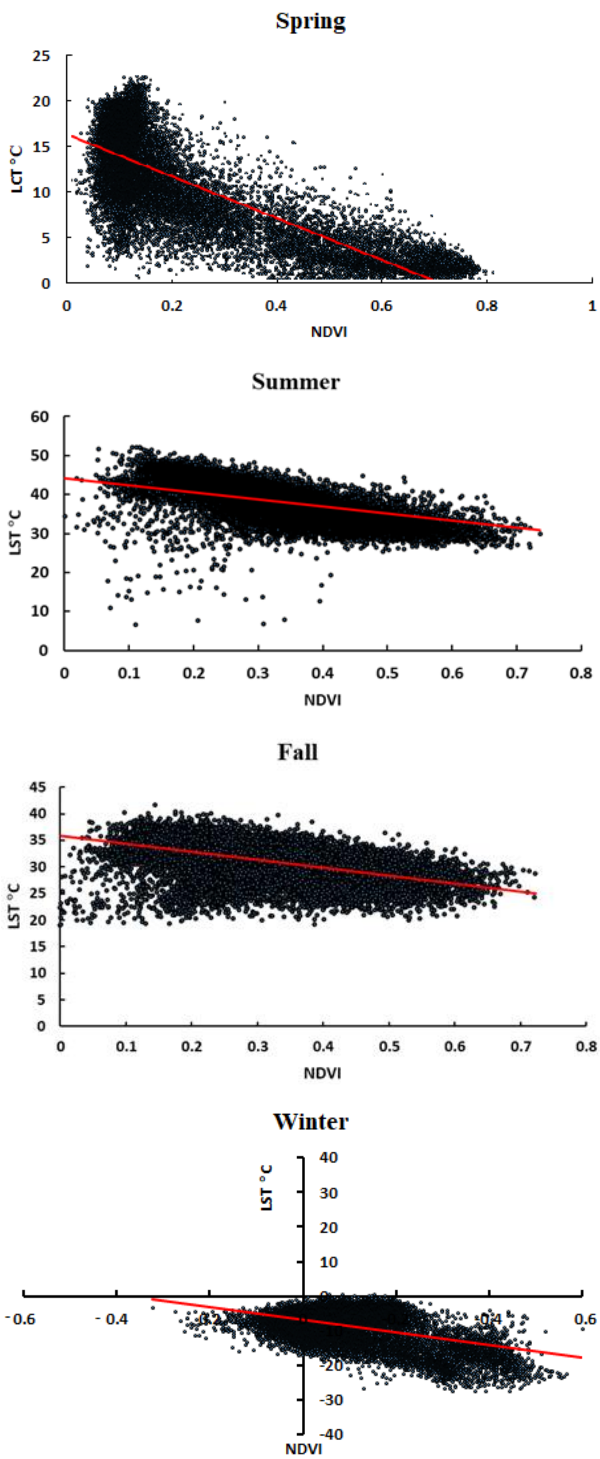


Figure 5. Relation between LST and NDVI using correlation coefficient over Duhok.

CONCLUSIONS

The remote sensing and GIS techniques were employed to evaluate the relationships among vegetation indices land surface temperature during winter, spring, summer, and autumn season. The vegetation indices used in this paper are NDVI, GRVI and LST. They have been computed to find out the relationships among NDVI and other vegetation indices also the relationships between LST and vegetation indices for each season. The correlation results of NDVI with GRVI have shown a strong positive relationship during winter, spring, summer, and autumn season. We noticed the GRVI has the highest correlation coefficient with NDVI in all the seasons rather than the other indexes. The highest values of the correlation coefficient gathering the NDVI with GRVI are in spring and it is decrease gradually in summer then winter to register the lowest correlation coefficient between the vegetation indexes in autumn.
The results showed a strong inverse correlation between LST and vegetation indices during winter, spring, summer, and autumn season. From the relation between LST and NDVI we conclude the highest values of the correlation coefficient gathering the LST with the vegetation indices (NDVI and GRVI) are in spring, and it is decrease gradually in summer then fall to register the lowest correlation coefficient between LST and vegetation indices in winter season.
The temperature registered the highest values for LST in the west (Sumel) and the center (Duhok) during summer and it decreases in autumn to spring to register the lowest values of the LST in winter across all the study area, especially in the north and the east parts of the governorate (Zakho and Amedi).

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