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Investigating the relationship between NDVI and EVI vegetation indices with ground surface temperature in Tehran

Amir Nazarinejad [a*], Mehrdad Nourbakhsh [b]

[a] *Department of Civil Engineering and Surveying, Ramsar Branch, Islamic Azad University*

[b] *Department of Civil Engineering and Surveying, Ramsar Branch, Islamic Azad University*

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Abstract

Cities became one of the main centers for conducting research due to the fact that they are the main places where people gather. One of the problems that plague the city today, especially the big cities, is the phenomenon of the city's heat island. Many things play a role in the spatial changes of the heat island, among them are human activities and changes in the earth's surface cover, which often lead to the reduction of green space. Several vegetation indices have been developed, and in this research, NDVI and EVI indices were investigated. Earth's surface temperature for Mordad 27, 1400 was retrieved from Landsat images using a single-channel algorithm and the mentioned indices were extracted for the above date. The results showed that most of the city surface was covered by a temperature layer of 305-310 degrees Kelvin. By comparing the indices and the temperature of the earth's surface, it was found that the temperature of the earth's surface and vegetation have an opposite relationship so that in the south and east the temperature is lower and the vegetation is more; But this issue is the opposite for the south and west. Also, the relationship between the surface temperature of the earth and the EVI index was equal to -31.23%, and its relationship with the NDVI index was about -24%; This shows that these two indicators are similar with a slight difference. (DOI:**https//doi.org/10.52547/JCER.5.2.29**)

Keywords: Earth surface temperature, Tehran, single channel algorithm, EVI, LST

1. Introduction

The global temperature has increased continuously in recent decades, in connection with population and economic growth, and global warming has become an international challenge for the 21st century (Feng et al, 2019; Zhao et al., 2018 Urban microclimate has undergone severe changes due to land use changes and rapid urbanization and has caused global warming (Guo et al., 2020) Urban heat island (UHI) has serious negative effects on urban ecosystems and human well-being. (Wu et al., 2019).

A recent report by the United Nations estimates that 55% of the world's population is urban and projects that the urban population will increase to 68% by 2050 (Mukherjee & Singh, 2020 Earth surface temperature (2) LST is an important parameter in investigating surface features, surface energy exchange, and surface physical and chemical processes, and it is currently widely used in soil, hydrology, biology, and urban geochemistry.

* Corresponding author. Tel.: 989111932123; e-mail: amirnazarinejad@gmail.com.

(Tomlinson et al., 2011; Hao et al., 2016; Qiao et al., 2020) Although the data from ground meteorological stations have a higher temporal resolution than remote sensing data, it is difficult to use them in large-scale research. Easy access, better spatial resolution, and more spatial coverage encourage more researchers to use remote sensing data to measure UHI.

Due to the issues of global climate change, the temperature of the earth's surface has increased, which has affected land use, land cover, vegetation areas, water resources, etc. (Solangi et al, 2019) The resulting expansion of modern cities through The change in urban land cover to artificial levels as a key factor has caused the LST of the urban environment to increase compared to its surrounding environment (Mensah et al, 2020). The most widely used spectral index in LST is the normalized differential vegetation index (3). NDVI is used in the extraction of green vegetation (Guha & Govil, 2020). Meanwhile, the first application area that most researchers have focused on is the study of the relationship between 1 ULST and the abundance of vegetation (ZHANG et al, 2009).

In this regard, several types of research have been conducted, among which some cases can be mentioned. In research, the relationship between ground surface temperature and environmental characteristics was investigated, and the results showed that the highest temperature was in bare soil and residential areas, and the lowest temperature was in garden areas. The highest and lowest values of surface temperature were related to Pabdeh-Gorpi and Asmari formations (Vali et al., 2018). A study conducted between 2003-2018 in Arsanjan City, it showed that during that period, the vegetation index decreased, but the temperature changes increased. According to the results, the highest negative correlation between crop cover and surface temperature was obtained, which was equal to -94.0 (Ebrahimi et al., 2019). In a research paper, the analysis of the spatial and temporal relationship between land surface temperature (LST) and normalized vegetation density index (NDVI), and built density index (BDI) was in Bala-Hill, Nairobi, Kenya. Land cover changes with analysis Two indices NDVI and BDI are shown. Land cover changes are shown by analyzing two indices, NDVI and BDI. The results showed the highest temperature increase at the top of the hill up to 96.3 degrees Celsius between 2015 and 2017 (Mwangi et al., 2018). The results of another paper showed a strong negative correlation between LST and both NDVI and EVI. In general, the 3 classes of LCZ with lower vegetation cover show higher day and night LST. Building area fraction and impervious surfaces showed a positive correlation with nighttime LST and transient area fraction presented a negative correlation with nighttime LST (Ferreira & Duarte, 2019).

2. Area of study

As the capital of Iran, Tehran is the largest and most populous city in Iran with a population of 9 million. The population of Tehran has increased approximately 10 times since 1950. This city is located in the north of Iran and the south of the Alborz mountain range in the longitude of 51 degrees to 40 degrees and 51 minutes east and latitudes of 35 degrees and 30 minutes to 35 degrees and 51 minutes. The height of the city varies between 945 and 2244 meters above sea level (Khoshnoodmotlagh et al., 2020). Figure 1 shows the map of the studied area.

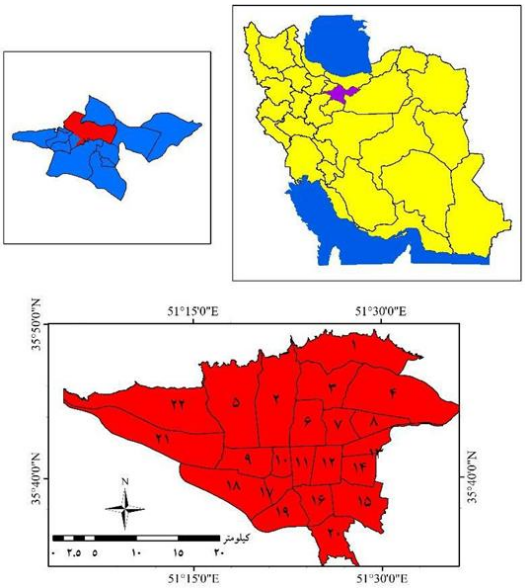

Figure (1). The study area (Mortazavi Asal et al., 1400)

3. Materials and methods

Landsat 8 satellite images were used to investigate the relationship between land surface temperature and vegetation indices, and the date of this image was August 27, 1400. For this purpose, the required pre-processing including geometric correction, radiometric correction, and atmospheric correction was done. The processing included vegetation indices 1NDVI and 2EVI and a single channel algorithm was used for the surface temperature.

4. NDVI Index

The normalized differential vegetation index is derived from equation 1. In this regard; NIR is the near-infrared band and RED is the red band (Hashemi-Darebadami et al., 2019).

$$NDVI = \frac{\mathrm{NIR} - \mathrm{RED}}{\mathrm{NIR} + \mathrm{RED}} \qquad \text{Equation (1)}$$

In this equation, NIR is a reflection in the infrared band and Red is a reflection in the red band.

5. EVI Index

This algorithm has been developed for areas with high biomass. This algorithm improves canopy effects and reduces atmospheric effects (Maleki et al., 2018). This index is obtained using equation 2.

$$NDVI = \mathrm{G}\frac{\mathrm{NIR} - \mathrm{RED}}{\mathrm{NIR} + \mathrm{C1} \times \mathrm{RED} - \mathrm{C2} \times \mathrm{Blue} + \mathrm{L}} \qquad \text{Equation (2)}$$

In this equation, Blue is the reflection in the blue band, L=1, C2=7.5, C1=6, and G=2.5.

6. Earth surface temperature from single channel algorithm

The Tek algorithm was used to determine the temperature of the earth's surface. This algorithm by James-Muñoz et al., 2014, uses the thermal band of Landsat images and is calculated in the same way for all Landsat images with equation 3 (Jiménez-Muñoz et al., 2014).

$$T_s = \gamma[\frac{1}{\varepsilon}(\varphi_1 L_{sen} + \varphi_2) + \varphi_3] \qquad \text{Equation (3)}$$

In this regard, T_s is the temperature of the earth's surface, Ɛ is the radiant power of the earth's surface, and L_{sen} is the radiance on the surface. r and φ are calculated from the relation to 4.

$$\gamma \approx \frac{{T_{sen}}^2}{b_\gamma L_{sen}};\ \delta \approx T_{sen} - \frac{{T_{sen}}^2}{b_\gamma} \qquad \text{Equation (4)}$$

In this, the T_{sen} temperature of the surface brightness of the sensor, b (1324 for Landsat 8) and 1 2 3 are atmospheric functions that reach 8 according to the relation 5 for Landsat (Maleki et al., 2019).

$$\begin{bmatrix}\varphi_1\\ \varphi_2\\ \varphi_3\end{bmatrix} = \begin{bmatrix}0.04019 & 0.02916 & 1.01523\\ -0.38333 & -1.50294 & 0.20324\\ 0.00918 & 1.36072 & -0.27514\end{bmatrix} \qquad \text{Equation (5)}$$

In the end, the coefficient of determination was used to investigate the relationship between the surface temperature and vegetation indices.

7. Results

The results of this study can be examined in three parts: 1) Distribution and how the temperature classes change, 2) Spatial changes of vegetation indices, and 3) The relationship between the temperature of the earth's surface and vegetation.

Figure 2 shows the surface temperature map. According to this map, the temperature of the earth's surface was between 301 and 326 degrees Kelvin, where the temperature layer of 305-310 has the largest spatial extent and the initial and final layers have the smallest spatial extent. In another division, the eastern half of the city is cooler than the western half, and on the other hand, the north of the city has cooler conditions than the south of the city.

EVI and NDVI indices were used for vegetation, and the values obtained from them were compared in this section. Figure 3 shows the vegetation map using the EVI index. Negative values in the figure are often water areas, which are also shown in blue on the map. The dominant class in this index is values between 0.1 and 0.2. According to the information obtained from this index, the state of vegetation in the north of

the city is better than the south of the city and the eastern half is better than the western half.

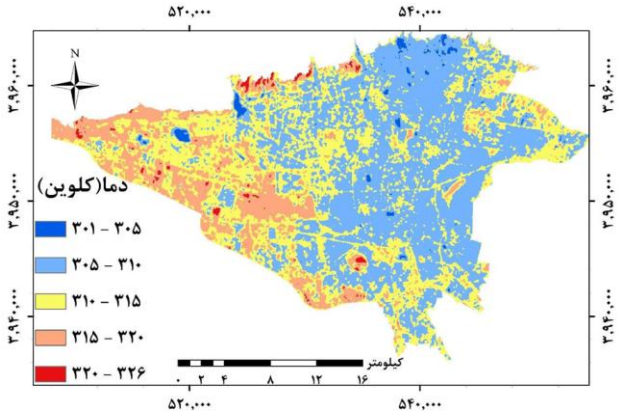

Figure (2). Earth surface temperature map

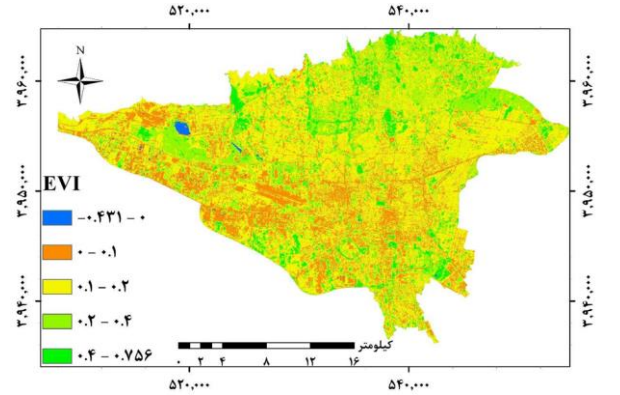

Figure (3). Vegetation map using EVI index

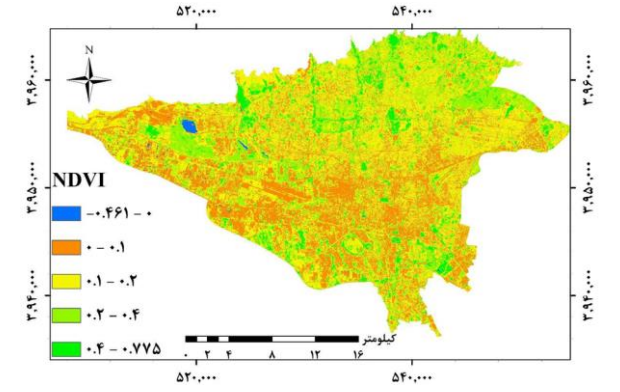

Figure (3). Vegetation map using NDVI index

Another index used was the NDVI index, the results of applying this index are presented in Figure 4. Negative numbers in this index also indicate water areas. The primary difference between this map and map 3 is that the dominant class in this map is 0-1.0. In this map, the north has better vegetation status than the south and the east than the west of the city, with the difference that the intensity of differences between the regions is less than the EVI index.

The coefficient of determination shows the explanatory power of the model. The coefficient of determination shows how many percent of the changes in the dependent variable are explained by the independent variables. It indicates the probability of correlation between two categories of data in the future. Figure 4 shows the coefficient of determination between the surface temperature and the EVI index. According to this graph, the coefficient of determination or detection for these two variables was equal to 31.23%, which indicates that to some extent the control of the surface temperature in the city of Tehran is controlled by the vegetation, but this relationship is not very strong and the temperature of the city of Tehran It is influenced by many factors.

Figure 5 shows the coefficient of determination between land surface temperature and NDVI index. According to this diagram, the coefficient of determination between NDVI index and surface temperature is about 24%. This problem makes it clear that even though the relationship between NDVI index and the surface temperature of the earth is somewhat stronger, but as mentioned, several criteria are effective in determining the temperature of the surface of the earth.

The temperature of the earth's surface, followed by the heat island of the city, is one of the issues that urban experts seek to solve as a global challenge. LST reflects the result of interactions between the surface and the atmosphere and the energy flux between the earth and the atmosphere on the earth. (Liu & Weng, 2009) Therefore, it can be said that the temperature of the earth's surface is partially influenced by the physical characteristics of the earth's surface, such as the type of land use. And on the other hand, the energy flow is also affected by atmospheric characteristics such as air pollution. Therefore, investigating the effect of different

parameters on the temperature of the earth's surface can lead to the reduction of the earth's temperature and consequently the reduction of the negative effects of the earth's surface temperature.

Vegetation is one of the land surface covers, which constitutes a small percentage of the city surface in most cities, especially cities in arid and semi-arid regions. Studies have shown that vegetation has a significant effect on reducing the temperature of the earth's surface and usually after water applications in the city, the lowest average temperature is related to vegetation (Mortazaviasal et al., 1400). Therefore, investigating the relationship between vegetation and surface temperature has become one of the most attractive research issues in planning the reduction of surface temperature and heat islands.

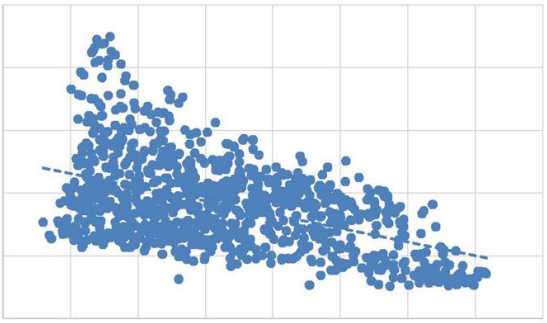

Figure 4. The graph of the coefficient of determination between the temperature of the earth's surface and the EVI index

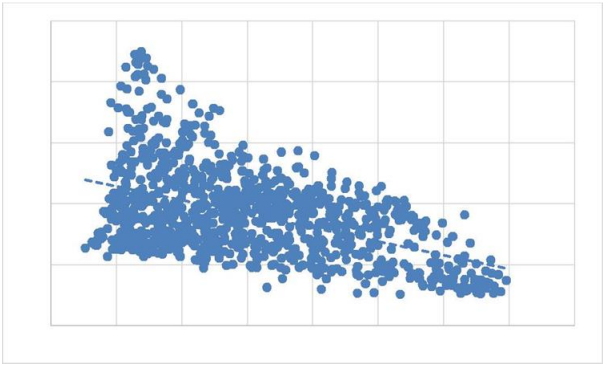

Figure (5). is the graph of the coefficient of determination between the temperature of the earth's surface and the NDVI index

A large number of vegetation indices based on the processing of satellite images have been developed, among which we can mention: normalized differential vegetation index (NDVI), soil-adjusted vegetation index (SAVI), vegetation fraction index (RVI) Improved vegetation index (EVI) and... .

Each of these indicators has a unique feature. This study examined the difference in the effect of two normalized differential vegetation indices (NDVI) and improved vegetation index (EVI) on the spatial distribution of surface temperature changes. The results indicated that the spatial distribution of surface temperature in Tehran city is inversely proportional to vegetation cover so that the temperature of the surface of the earth was higher in the south than in the north and in the east was higher than in the west, which is the case for the opposite indices. The relationship between the temperature of the surface of the earth and the EVI index was equal to -31.23% and its relationship with The NDVI index was around -24%, which indicates that these two indices are similar with a slight difference.

8. Conclusion

The temperature of the earth's surface, followed by the heat island of the city, is one of the issues that urban experts seek to solve as a global challenge. LST reflects the result of interactions between the surface and the atmosphere and the energy flux between the earth and the atmosphere on the earth. (Liu & Weng, 2009) Therefore, it can be said that the temperature of the earth's surface is partially influenced by the physical characteristics of the earth's surface, such as the type of land use. And on the other hand, the energy flow is also affected by atmospheric characteristics such as air pollution. Therefore, investigating the effect of different parameters on the temperature of the earth's surface can lead to the reduction of the earth's temperature and consequently the reduction of the negative effects of the earth's surface temperature.

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