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Investigating urban thermal islands in relation to land use (case study of Tehran)

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Abstract

The urban heat island is one of the most obvious consequences of the expansion of urbanization and the development of metropolises. The effects caused by the formation of heat islands can play a fundamental and important role in air quality and consequently public health. The present research was carried out with the aim of investigating the role of covering elements of the earth's surface, i.e. land use in urban heat islands in Tehran metropolis. The tools of this research were processing in Google Earth Engine and ArcMap software. The results showed that the urban heat island effect was more in the northern areas of this city, which is caused by the existence of an industrial town and mountainous topography. Also, there is a relationship between the temperature of the earth's surface and the vegetation index of Tehran in such a way that the surface temperature of this city has increased with the decrease of the vegetation cover. Finally, according to the research findings, practical suggestions have been presented.

Keywords: thermal island, Tehran, land use, Google Earth Engine

1. Introduction

In recent years, the thermal environment, including the greenhouse effect and global warming, has received much attention. This not only refers to the air temperature, but also the temperature of the earth's surface (Zhang et al., 2006). The temperature of the earth's surface is an important parameter that can indicate changes in the earth's surface (Mousavi et al., 2013), which has recently been used in many regional studies, such as global climate change, hydrological and agricultural processes, and urban land use and cover as a factor. It is important (Rozenstein et al., 2014). Cities often experience special climatic conditions, which are called urban climate. Urban climate is determined by the difference in the city's climatic variables (air temperature, humidity, wind speed and

direction, amount of precipitation) with less dense areas around it. Research shows that urban places are hotter than the surrounding rural areas and this phenomenon is generally called urban heat island (Sadeghinia et al., 2013), the term heat island was first proposed by Howard about a century ago in 1833. After that, many researches were conducted in the big and industrial cities of the world, which shows that urbanization has caused significant changes in meteorological parameters and the characteristics of the earth's surface, and as a result, it has caused many changes in the weather and local climate (Majjard et al., 2014) The increase in the surface temperature of the earth and the formation of heat islands in areas that have become cities or metropolises without prior planning is one of the basic environmental problems (Alavipanah et al., 2015). The surrounding village refers to the occurrence of urbanization (Yuan and Bair, 2007). The change of land use from green spaces to newly built structures has led to changes in the natural surface of the earth, which causes the absorption of solar energy and changes in the shape of the earth's surface (Omija, 1991) two distinct categories of the urban heat island are often defined:

Atmospheric urban heat island, which is determined by measuring the temperature in the canopy layer of the city through ground, airborne and sensors installed in tall towers for the boundary layer in urban areas, is the second category of urban heat islands and is based on remote sensing thermal data (Hu and Brunsell, 2015). By increasing reflectance from urban surfaces, the former strategy helps remove solar radiation that would otherwise be converted to heat. In the second strategy, increased vegetation cover increases evaporation and transpiration, which allows the conversion of absorbed solar radiation into latent heat instead of sensible heat (Bretz et al., 1998). Landsat TM and TIR data is one of the satellite images that is widely used for retrieving the surface temperature of the Earth due to its high resolution (120 and 100 meters) and free access to download on the website of the United States Geological Survey (USGS). is used (Liu and Zhang, 2011). In this research, we will examine the changes of thermal islands in the city of Tehran, and we will study the relationship between the changes of thermal islands in these areas in relation to land use changes, and we are looking for this to know the relationship between land use changes and changes in thermal islands in the study area. Whether or not these analyzes will be done using Landsat 5 and 8 satellite images in the 5-year period from 2016 to 2021. In order to carry out this research in the considered method, we must have full access to the satellite image databases related to the Landsat sensor and ArcGIS software and Google Earth Engine system to investigate land use and urban heat islands, and in these cases there is no obstacle in the current research. Does not exist.

2. History of research

Mousavi et al. (2013) to investigate the role of location and morphology in Tehran's air quality, first, using the data of the Environmental Organization, extracted the average

concentration of pollutants at different hours of the day and night for a period of one year. Then, according to the structure and morphology of the city, which creates different environmental conditions from one street to another, and also considering the lack of measuring stations in Tehran to prepare an accurate map of the distribution of pollutants, they used remote sensing optical and thermal data, and the surface temperature map Tehran city and CO pollutant distribution were extracted using these data.

In a research entitled "Study of thermal islands of Urmia city" by processing satellite images, Sadeghinia et al (2013) investigated the thermal islands of Urmia city in two seasons, summer and winter, and came to the conclusion that the heat island is more in summer than in winter, and the lands Without vegetation and barren are considered as specific uses in creating thermal islands.

Yavari et al. (2014) compared three different methods of radiative transfer based on the split window equation and single band to calculate the surface temperature of the Earth. For validation, four balanced areas were selected in terms of energy intake and merged with MODIS images. The results showed that the radiative transfer method based on the equation has the highest accuracy, the split window method has average accuracy, and the single band method has the lowest accuracy.

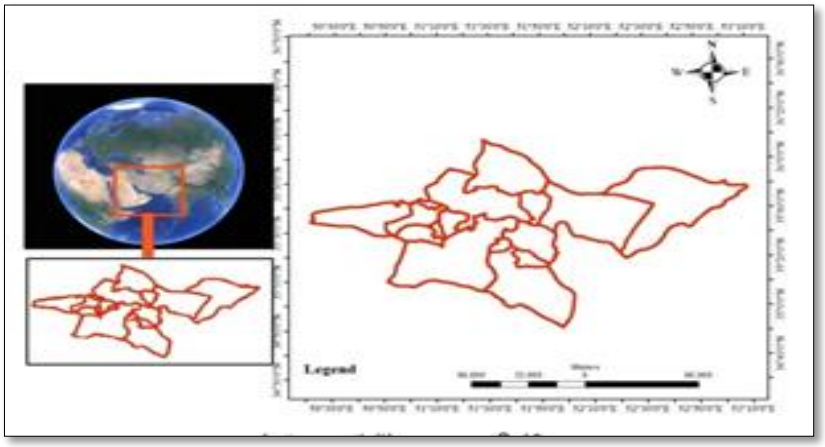

Figure 1- Map of Tehran province

Urban heat island

The use of satellite images to extract surface temperature dates back to the 6th decade of the 21st century and the launch of the Tiros II satellite. With the passage of time and the development of remote sensing technology and its diverse applications, various methods were developed to extract surface temperature from satellite images by approximating the radiative transfer equation, such as single-window and double-window methods and

other different methods. The Landsat TM sensor is considered one of the most widely used satellites in the field of environmental studies and applications, whose band 6 in the spectral range of 10.4 to 12.5 micrometers can be used to analyze the radiation of the earth's surface and the temperature of the earth's surface. This sensor with ground resolution of 100 meters in the thermal band is able to provide more details than NOAA and MODIS sensors, although this sensor does not have the ability to take pictures at night (Liu, 2011). Research shows that urban locations experience higher temperatures than their surrounding rural areas (Qnig, 2009). In recent years, with the further development of societies and the acceleration of the urbanization process, the urban heat island phenomenon has become more important (Yuan, 2007). Construction, concrete, asphalt and industrial activities have a high contribution to the creation and expansion of urban heat islands. Replacing natural ground covers with paving, high-rise buildings and other urban constructions destroy the cooling effects of natural surfaces. Also, tall buildings and narrow streets will reduce the air flow and increase the surrounding air temperature. In addition to these heat issues of vehicles, factories and air conditioners increase the heat of the environment and intensify the heat island effects. By changing the pattern of local winds, strengthening the growth of clouds and fog, increasing the number of thunderstorms and affecting the amount of precipitation, heat islands affect the local weather conditions and climate, and by reducing the air quality of cities as a result of increasing energy consumption for cooling, causing discomfort and lack of It provides the comfort of the residents of urban areas and by affecting human health, it increases the probability of asthma and other types of respiratory diseases (Sadeghi Nia, 2013).

Due to the wide coverage, timeliness and the ability to obtain information in the thermal range of the electromagnetic spectrum, remote sensing images are a suitable source of information in preparing thermal maps and estimating the radiation energy of the earth's surface. Also, these images have different applications in global research in the field of urban land cover analysis. By using these images, urban heat islands can be depicted in different continental and regional scales with the power of appropriate spatial resolution and produce quantitative data of the features of the earth's surface with heterogeneous distribution and lead to a better understanding of urban and non-urban environments and the temperature relationship. It provided urbanization by increasing and developing (Namdari, 2008)

Urban areas are hotter than their surrounding rural areas for two reasons. First, the structure and morphology of the city has the capacity to absorb and store significant net solar radiation, especially in calm and clear weather conditions in summer. This leads to the creation of nighttime heat on the city center (commercial area) and the formation of a heat island in the summer season. Commercial centers of big cities can be 6 to 8 degrees Celsius warmer than their suburbs. Second, large heat islands occur due to the release of heat by human activities from processes such as fuel (especially in megacities and

especially in winter). In addition, the cover of smoke and water vapor has reduced the loss of heat through long-wave night radiation of the earth in urban areas and as a result; It intensifies the greenhouse effect (Alavipanah, 2012; Teerawong Laosuwan, 2012.

3. Results of analysis and findings

3-1 Introduction

Urban heat islands are one of the most important issues of the 21st century, caused by urbanization and industrialization of human activities. The production of heat from urban structures that cause waste or reflect it and are part of human-made heat sources is the most important reason for the emergence of urban heat islands. Another factor is the large population and large economic activities in cities and capitals. There are many processes among the structural components of the city that are effective in the thermal performance of the city and the formation of thermal islands. Heat islands have harmful effects on the surrounding environment and therefore it is necessary to identify and eliminate them. One of the most important of them is the change of surface characteristics, decrease of surface humidity, change in radiant flux and heat emission of human origin.

3-2 Prohibition of land use map

Landuse or land use is how land is used. In fact, land use planning determines the type of activity that can be established on the land and how to implement that activity. In Iran, municipalities and the General Department of the Ministry of Roads and Urban Development are in charge of preparing comprehensive and detailed plans. The land use in these urban development plans is determined by the consulting engineers of the plan designer. Determining the land use in urban plans is a very complicated task. Urban planning experts consider various criteria as well as the current and future needs of the city and place the uses on the city map. To prepare the land use map of Tehran city, first the border of Tehran city was entered in the Google Earth Engine system. Then, a land use map was prepared for each statistical year. Then all the maps were saved in Google Drive and then downloaded to analyze the results in the next steps.

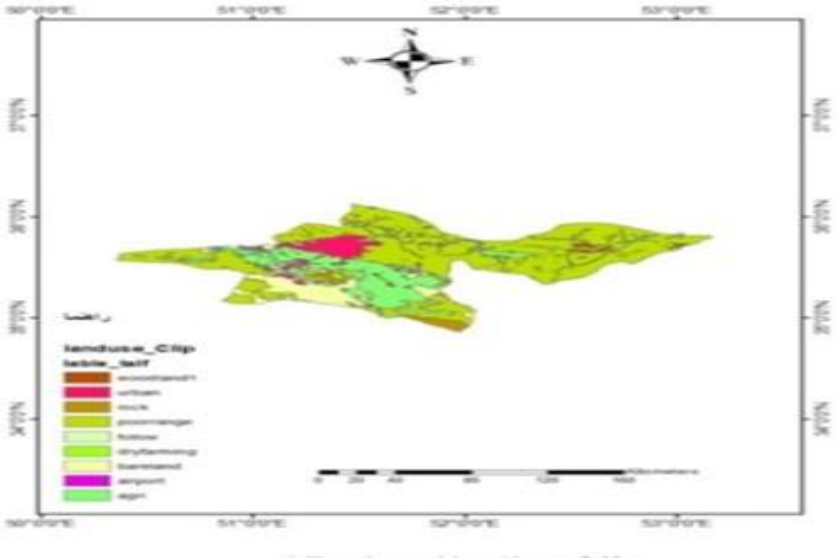

Figure 2- Landuse map

3-3 urban heat island

The thermal bands of the Madis sensor have a wide range of functions, and their application is not limited to the issue of the surface temperature of the earth. These bands are also used in many studies, including evaporation and transpiration, urban heat island, drought, etc. To prepare the map of the thermal island of Tehran, first the border of Tehran was entered into the Google Earth Engine system. Then, a map of the thermal island was prepared for each statistical year. Then all the maps were saved in Google Drive and then downloaded to analyze the results in the next steps. In this regard, first, the day and night temperature map of the province was prepared.

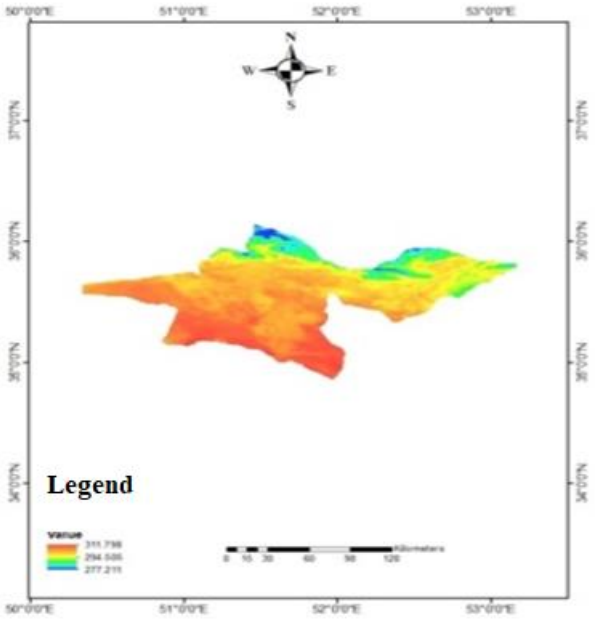

Figure 3- Daytime temperature of Tehran province

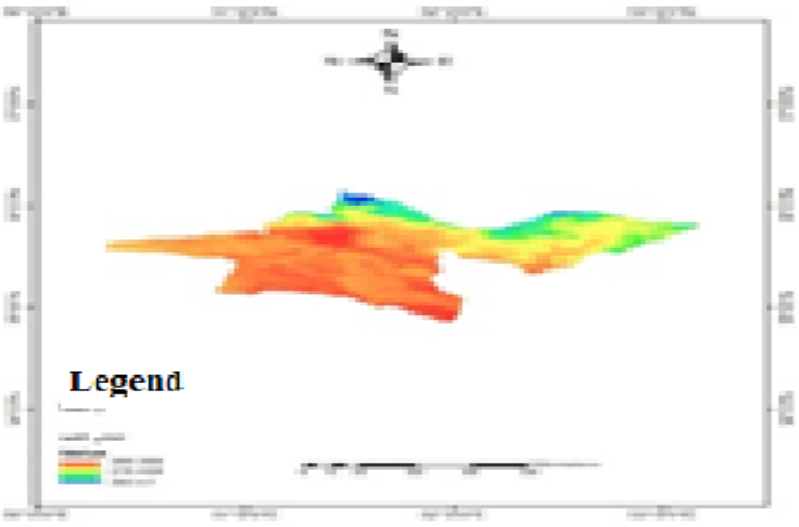

Figure 4- Night temperature of Tehran province

Then night and day temperatures were compared. Finally, the thermal island monitoring map of the province was prepared.

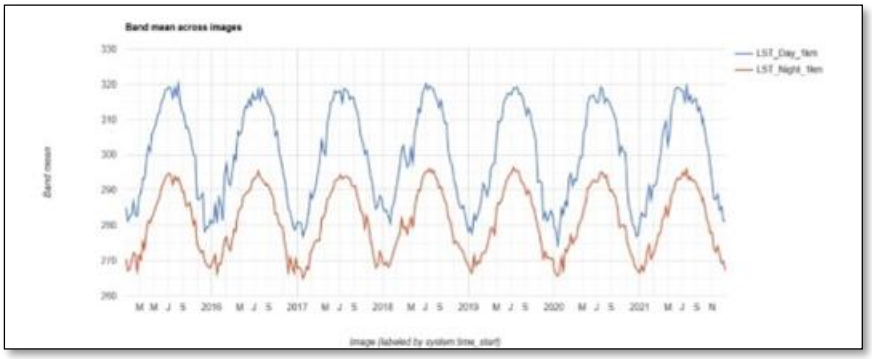

Figure 5- Comparison of night and day temperatures

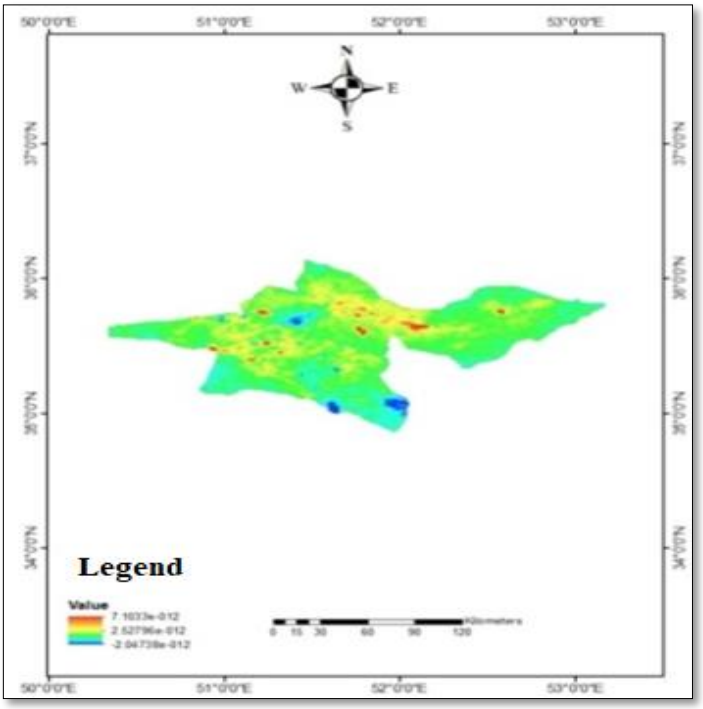

Figure 6- Map of thermal island of Tehran province

4 - Conclusion

Urban heat islands are one of the most important issues of the 21st century, caused by urbanization and industrialization of human activities. The production of heat from urban structures that cause waste or reflect it and are part of human-made heat sources is the most important reason for the emergence of urban heat islands. Another factor is the large population and large economic activities in cities and capitals. According to the research, 3 billion people live in the cities of the world, which are directly affected by this problem. The results of the comparative chart of night and day temperature of the studied area indicate that, as is clear, the night temperature reaches a minimum level compared to the day temperature and has an almost sinusoidal pattern. It also has good accuracy and has shown the peak and minimum temperatures well. It should be noted that this temperature is entered in degrees Kelvin in the map. The results of the heat island monitoring map during the period from 2015 to 2022 show that this factor has not intensified in the outskirts of the city, but it has intensified around the center and north of the city. This is justified by the fact that these areas have mostly been used as pastures, which have already been affected by the change of use and the expansion of urbanization. Tehran's building density, land surface changes, air pollution and unnatural sources with heating characteristics have a high impact on the thermal condition of this city.

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