Analysis of spatial- temporal variation of urban thermal islands and landuse based on an environmental approach in Shiraz

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Abstract

Today, increase in the land surface temperature and the formation of heat islands in the metropolis areas has become one of the environmental problems. The aim of this research is spatial- temporal analysis of urban heat- island, vegetation, landuse and to identify the critical environmental zones of Shiraz urban thermal islands. For that purpose, the first 8 images were downloaded from landsat satellite including sensors of TM (Landsat 5), ETM+(Landsat 7) and TIRS/OLI (Landsat 8) for the warm period of the year during 1986 - 2015. Then, the required pre-processing schemes, land surface temperature (LST) and normalized difference vegetation index (NDVI) and landuse patterns for monitoring of the landuse changes in Shiraz were calculated. Then, the environmental criticality index (ECI) was used to identify and analysis of the sensitive regions. The results illustrated that barren lands surrounding the city in continuous and dense have the largest urban thermal islands and forming very hot temperature limits. These thermal centers in urban settlements correspond to the boundaries of the urban decay and dense context areas. At the same time, analyzing the land surface temperature maps in Shiraz indicate the coordination between the lowest class of temperature and vegetation landuse. The landuse maps also show the reduction of barren lands, vegetation and increasing the urban landuse. Thus, about 10.1 km2 of barren lands and 19.7 km2 of vegetation have been converted to urban landuse. This indicates that the decrease in vegetation cover(%36) was the most important factor in development of the heat islands in Shiraz. The highest environmental sensitivity (Crtical region, 29.7 Km2, 14.2% of studied region) is observed around the city due to existence of barren lands and in to the city around the industrial centers, around the international airport, passenger terminal(Karandish), around the metro stations, the highways and streets of heavily congested areas and urban decay context areas. Hence, the development of green roof vegetation and tailored to the indigenous climate is proposed as solution to mitigate urban thermal island and dealing with environmental crisis.

Introduction

One of the unwanted and negative effects of urban development is the increase in temperature of the urban environment. Urban heat islands have a negative effect on the air quality of urban areas, and the adverse effects on the

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surrounding lands, microclimate (rainfall, temperature, and wind flow), pollution and consumption of water resources. Since the main reason for the formation of the urban heat island is the use of land and land use change, this change will accelerate the expansion and development of the urban heat island through measures such as vegetation removal, land use change along the river and the sea, new constructions as well as concrete structures in the horizontal direction, asphalting streets and alleys, industrial and domestic activities (Xiao and Crane, 2006). The occurrence of the urban heat island is more intense in summer with a clear sky and no wind. Remote sensing images are a useful tool for analyzing the structure of urban heat islands due to extensive coverage, timeliness, and high precision. In fact, the lack of access to spatial data on the one hand, and the large variety of land use and land cover in urban zones, on the other hand, has led to the use of remote sensing technology in identifying and analyzing the urban heat islands.

Materials and methods

In this research, at first 8 images of the warm seasons of the year from 1986-2015 were extracted from Landsat satellite including Landsat 5 (TM), Landsat 7 (ETM+), Landsat 8 (OLI/TIRS) sensors. After the necessary pre-processing, land surface temperature (LST), and normalized difference vegetation index (NDVI) land use patterns were calculated for monitoring the land use changes in Shiraz. In the following, sensitive urban areas were identified and analyzed using environmental criticality index (ECI).

Results and Discussion

The results showed that the arid lands around the city have the highest temperature and form very hot temperature areas. These thermal centers are adapted to the urban old textures. At the same time, the analysis of land surface temperature maps in Shiraz indicates the coordination between the lowest temperatures with vegetation use. Land use maps also show a decrease in the area of arid lands and vegetation and increase urban use. Therefore, about 10.01 km^2 of arid land and 19.7 km^2 of vegetation has become urban use. This indicates that the main factor in the expansion of the heat islands was the reduction of vegetation. The highest environmental sensitivity is often observed around the city, due to the presence of arid lands. It is also observed within the city, around industrial centers, the international airport, the passenger terminal (Karandish), around metro stations, highways, and high traffic streets and places with old texture.

Conclusion

The urban heat islands in Shiraz have been dispersed continuously, densely, and in the strip form or canonical form in the city. Generally, in the city of Shiraz, four main classes of temperatures were identified during the study period, with a temperature range of at least 21 °C in different locations. In the time period studied, the largest and the smallest area was related to the third

temperature class (warm areas) and the first temperature class (cold areas), respectively. According to the findings of this study, thermal loops are consistent with traffic nodes and urban contaminated zones. Also, the establishment of industries in the urban environment has led to the formation of temperature zones with double heating in comparison with the perimeter points. This is confirmed by findings from Ahmadi et al. (2012). The temporal analysis of heat islands in the time period of the study also showed that over time, the expanse of very hot areas around the city has been reduced due to the conversion of arid lands to new urban areas and the construction of new towns with new construction. But along with this shortcoming, the area of the third class of temperature has been increased. The evaluation of land use in Shiraz during the study period also showed that the development of urban areas led to a decrease in arid lands. The vegetation of Shiraz city has also been significantly reduced due to changes in the use of agricultural lands around the urban and residential areas. In general, the expansion of the city in the arid and sometimes agricultural lands and the reduction of urban green space and at the same time the increase of urban traffic resulting from the development of the city has been a major factor in increasing the land surface temperature and the expansion of the urban heat islands in Shiraz. The results of the Environmental Criticality Index (ECI) showed that the highest environmental sensitivity is often observed around the city, due to the presence of arid lands. It is also observed within the city, around industrial centers, the international airport, the passenger terminal (Karandish), around metro stations, highways, and high traffic streets and places with old texture. The absence or severe deficiency of vegetation and the presence of severe heat islands have led to an increase in critical environmental conditions in these zones. Therefore, the development of green roofs and the use of vegetation adapted to the local climate is suggested as a way to modify the urban heat island and to confront the critical environmental situation.

Keywords: Urban thermal islands, Land surface temperature (LST), Normalized difference vegetation index (NDVI), Landuse, Environmental criticality index (ECI), Shiraz.

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