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Land surface temperature and urban heat island analysis using remote sensing and GIS: A case study in Mersin, Türkiye

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Abstract

Global urbanization is rapidly increasing. This situation shifts land use/land cover (Lu/Lc) quickly. It also puts pressure on the land. Mersin, the study area, is also experiencing an increase in urbanization pressure. It is critical to assess the effects of urbanization on land. The calculation of remote sensing (RS) and geographic information system (GIS)-based Land surface temperature (LST) and urban heat island (UHI) aids in detecting impacts. LST and UHI maps were constructed for this purpose, and the most recent changes in the study area were monitored.

1. Introduction

Rapid and ongoing urbanization as a result of the world's expanding population is currently putting pressure on the land and causing the land use/land cover (Lu/Lc) to shift rapidly (Mishra et al., 2021). The fact that nearly 56% of the global population lives in cities, with the pace gradually increasing, demonstrates the strain [2]. The relationship between Lu/Lc and Land Surface Temperature (LST) and Urban Heat Island (UHI) is direct. LST and UHI can be used to calculate changes in Lu/Lc over time.

With sustainable urban management, places under urbanization pressure can grow in a planned and ecologically sound manner (Çoruhlu & Çelik, 2022; Coruhlu et al., 2021; Coruhlu and Toludan, 2019). This requires determining the Lu/Lc change caused by urbanization. LST and UHI based on remote sensing (RS) and Geographic Information Systems (GIS) are gaining attention as metrics to be used in assessing variations in Lu/Lc (Kusak & Kucukali, 2023; Rahman et al., 2022; Dewan et al., 2021; Doğan & Yakar, 2018).

The application was carried out in Mersin, which is located in the Mediterranean Region and has seen a growth in population in recent years. The current LST and UHI of the study area were computed using November 2023 Landsat 8-OLI satellite images. Thus, the consequences of urbanization pressure were attempted to be exposed in the study area.

2. Study Area

Mersin province is located in Turkey's southern region, between 36-37° North latitudes and 33-35° East longitudes (Figure 1). It has a land area of 15853 km^2 and a population of 1,916,432 (TÜİK, 2023).

3. Material and Method

Land surface temperature (LST) and urban heat island (UHI) were calculated in the study area, where the pressure on the land is growing due to urbanization, to examine the Lu/Lc change. A four-stage technique was used for this goal (Figure 2). Firstly, USGS EarthExplorer was used to retrieve Landsat 8-OLI images dated November 13-15, 2023 (USGS, 2023). Secondly, the LST calculation was performed. Radiance (Equation 1), Brightness Temperature (BT) (Equation 2), Normalized Difference Vegetation Index (NDVI) (Equation 3), and Land Surface Emissivity (LSE) (Equation 4) were estimated for this purpose. LST was eventually discovered (Equation 5). Finally, UHI (Equation 6) was estimated. Finally, it was generated LST and UHI.

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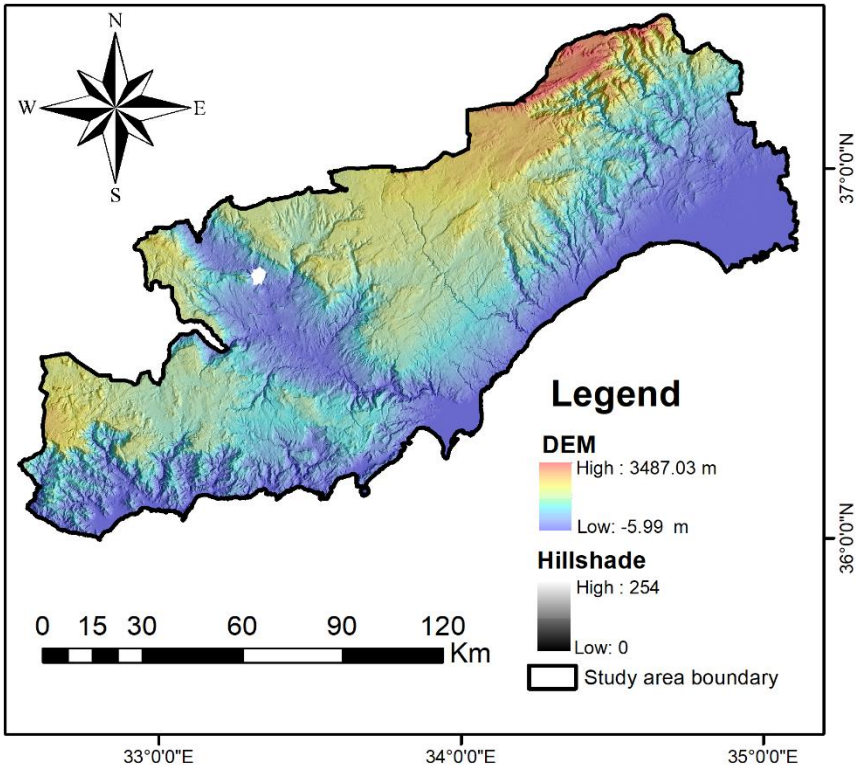


Figure 1. Study area

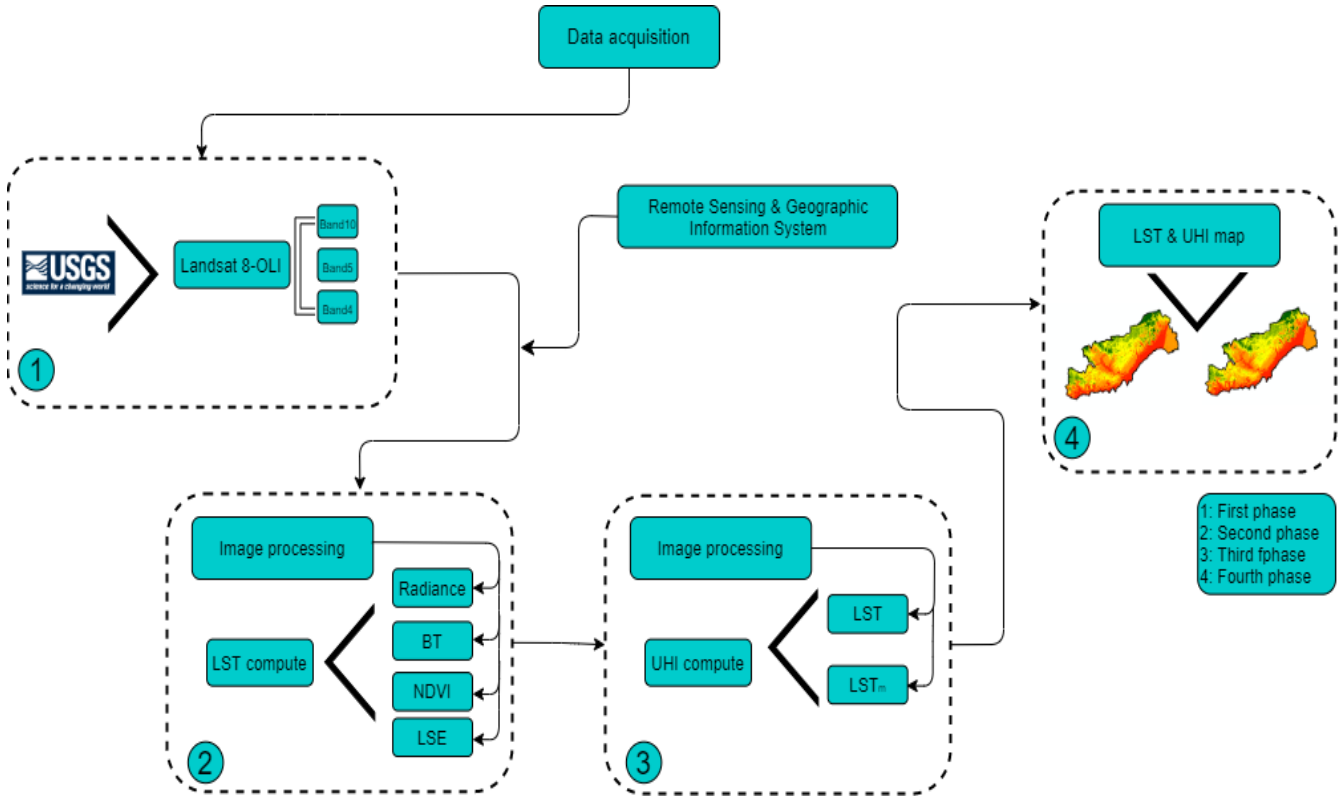


Figure 1. Flowchart of methodogy

$$L_\lambda = M_L * Q_{cal} + A_L - Q_i \quad (1)$$

Where L_λ is top of atmosphere spectral radiance (TOA), Q_{cal} is quantized and calibrated standard product pixel values, M_L is radiance multiplicative band number, A_L is radiance band ve Q_i is correction value for band 10 (0.29).

$$BT = K_2/ln\,(K_1/L_\lambda + 1) - 273.15 \quad (2)$$

Where represents BT TOA brightness temperature, K_1 constant band, and K_2 constant band.

$$NDVI = (NIR\ - RED)/(NIR + RED) \quad (3)$$

Where NIR is near infrared band (Band5), and RED is red (Band4).

$$P_V = (NDVI - NDVI_{min}) / (NDVI_{max} - NDVI_{min})^2$$
$$LSE = 0.004 * P_V + 0.986 \quad (4)$$

Where LSE presents land surface emissivity, P_V symbolize the proportion of vegetation.

$$LST = (BT/1 + 0.00115 * BT/1.4388) * ln\,(LSE) \quad (5)$$

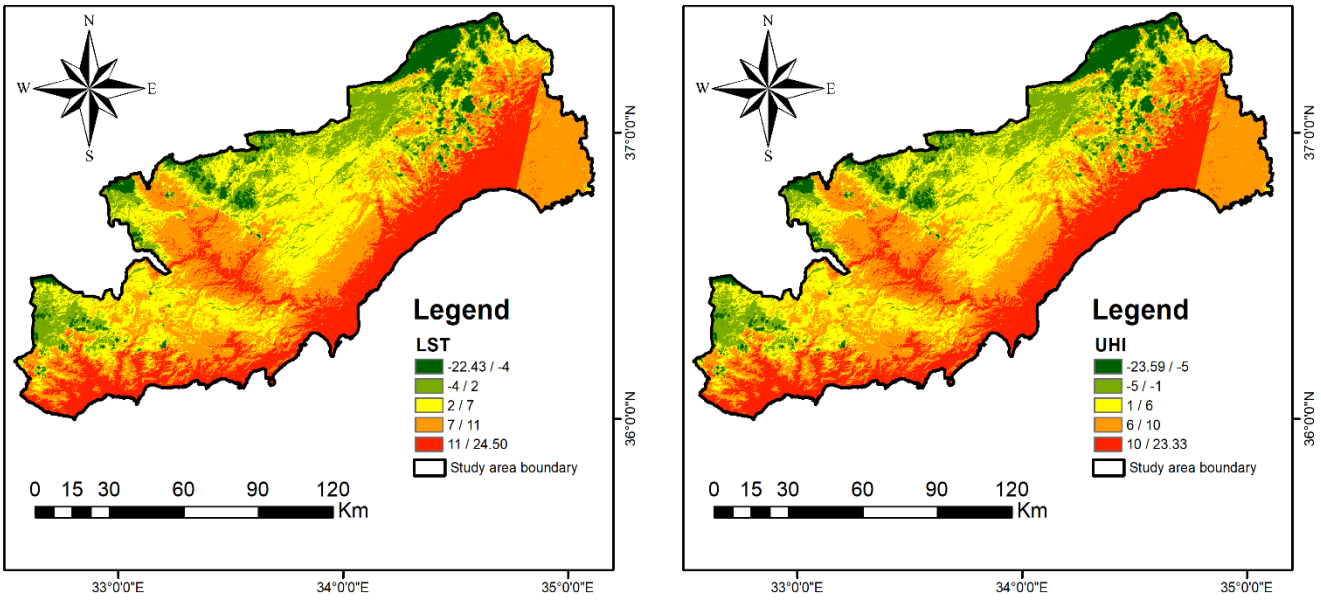
Where LST is land surface temperature.

$$UHI = (LST - LST_m)/SD \quad (6)$$

Where UHI is urban heat island, LST_m is the mean temperature of the land surface temperature in the study area, and SD is standard deviation of temperature.

4. Results

LST and UHI were calculated and maps were created as part of a study that determined the effects caused by urbanization and land construction. Initially, LST was calculated and a map of it was created using Equations 1-5 (Figure 3a). Following that, UHI was calculated using Equation 6, and a map of it was constructed (Figure 3b).



(a) (b)

Figure 3. (a) LST, (b) UHI

5. Conclusion

Following the growth in urbanization in Mersin, the study's area, considerable changes have occurred in Lu/Lc. The consequences of urbanization concentrated in the city center can be reached using both the LST and UHI maps. In this context, it would not be incorrect to say that the maps developed are consistent. The study is expected to help decision-makers understand the importance of sustainable land management and use.

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