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MİKROKLİMATİK DÜZENLEYİCİ OLARAK SU YÜZEYLERİ VE ARAZİ ÖRTÜSÜ: YAPAY ZEKÂ DESTEKLİ UZAKTAN ALGILAMA VERİLERİ İLE MEKÂNSAL BİR İNCELEME

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ÖZET

Küresel iklim değişikliği, dünya genelinde yüzey sıcaklıklarının artmasına ve yerel iklim sistemlerinde belirgin değişimlere neden olmaktadır. Artan atmosferik sıcaklıklar, arazi kullanım değişimleri ve su yüzeylerindeki farklılaşmalar, özellikle kara–su etkileşiminin yoğun olduğu alanlarda Arazi Yüzey Sıcaklığı (Land Surface Temperature, LST) üzerinde önemli etkiler oluşturmaktadır. Bu bağlamda su yüzeyleri ve çevresindeki arazi örtüsü desenleri, bölgesel mikroiklim koşullarının belirlenmesinde önemli rol oynamaktadır. Bu çalışma, Antalya İlindeki Alakır Baraj Gölü ve gölü çevreleyen 5 km yarıçaplı yakın çevresinde arazi örtüsü ile LST arasındaki mekânsal ilişkiyi değerlendirmeyi amaçlamaktadır. Analiz kapsamında, Landsat 8 uydu görüntüleri kullanılarak bölgeye ait arazi yüzey sıcaklığı haritası oluşturulmuştur. Aynı tarihe ait uydu verileri doğrultusunda, yapay zekâ destekli arazi örtüsü sınıfları ArcGIS Living Atlas üzerinden temin edilmiştir. Söz konusu veri seti, Esri ve Earth Observatory iş birliği ile Sentinel-2 görüntülerine dayalı olarak üretilmiş olup açık erişimlidir. Arazi örtüsü sınıfları ile LST verileri arasındaki ilişkiyi değerlendirmek amacıyla zonal istatistik analizi uygulanmıştır. Zonal istatistik analizi ile her bir arazi kullanım sınıfına karşılık gelen maksimum, minimum ve ortalama yüzey sıcaklığı değerleri belirlenmiştir. Elde edilen sonuçlar, bölgenin iklimsel özellikleri, bitki örtüsü dağılımı ve topoğrafik yapısı çerçevesinde yorumlanmıştır. Bulguların, su yüzeylerinin ve doğal arazi örtüsünün yüzey sıcaklığını düzenleyici etkisini ortaya koyarak bölgesel ölçekte planlama süreçlerine katkı sağlaması ve yerel yönetimler için karar destek niteliği taşıması beklenmektedir.

Anahtar kelimeler: Arazi örtüsü, Arazi Yüzey Sıcaklığı, Mekânsal istatistik, Alakır Baraj Gölü, Uzaktan algılama

WATER BODIES AND LAND COVER AS MICRO-CLIMATIC REGULATORS: A SPATIAL ANALYSIS USING AI-SUPPORTED REMOTE SENSING DATA

ABSTRACT

Global climate change has led to a widespread increase in surface temperatures and significant alterations in local climate systems. Rising atmospheric temperatures, land use changes, and variations in water bodies exert considerable influence on Land Surface Temperature (LST), particularly in areas characterized by intense land–water interactions. In this context, water bodies and surrounding land cover patterns play a critical role in shaping regional microclimatic conditions. This study aims to evaluate the spatial relationship between land cover and LST in and around Alakır Reservoir in Antalya Province, within a 5 km buffer zone. Within the scope of the analysis, a land surface temperature map was generated using Landsat 8 satellite imagery. Corresponding to the same date, artificial intelligence–based land cover classes were obtained from the ArcGIS Living Atlas platform. This dataset, developed through collaboration between Esri and Earth Observatory and derived from Sentinel-2 imagery, is openly accessible. To assess the relationship between land cover classes and LST values, zonal statistical analysis was applied, and surface temperature values corresponding to each land use category were determined. The results were interpreted in the context of the region's climatic characteristics, vegetation distribution, and topographic structure. The findings are expected to demonstrate the regulating effect of water bodies and natural land cover on surface temperature and to contribute to regional-scale planning processes, providing decision-support insights for local authorities.

Keywords: Land cover, Land Surface Temperature, Spatial statistics, Alakır Reservoir, Remote sensing

1. INTRODUCTION

Global climate change is increasingly exerting pronounced effects, particularly on land surface temperature (LST) and microclimatic dynamics (Wang et al., 2022). Rising air temperatures, rapid urbanization processes, and transformations in land use are reshaping the role of natural surfaces in the energy balance (Barati et al., 2023). In this context, water surfaces play a crucial buffering role in regulating environmental temperatures due to their high heat capacity, evapotranspiration processes, and albedo characteristics (Cao et al., 2022). Moreover, the interaction between water bodies and the surrounding vegetation and land cover patterns emerges as a critical determinant in the formation and sustainability of regional microclimatic conditions (Wolch et al., 2014). Consequently, the detailed assessment of the microclimatic characteristics of water surfaces and their surroundings is of great importance for revealing

local climatic variations and understanding spatial patterns. Such analyses provide strategic contributions, particularly in terms of mitigating the urban heat island effect, evaluating ecosystem services, and grounding land-use planning on scientific principles (Wu and Zhang, 2019). Furthermore, data obtainable through methods such as remote sensing and geographic information systems enable the quantitative evaluation of the environmental regulatory capacity of water surfaces (Huang et al., 2018).

Advances in remote sensing technologies, particularly the high spatial and temporal resolution of Landsat and Sentinel satellite data, allow for detailed examination of the relationships between LST and land cover (Onačillová et al., 2022). In addition, artificial intelligence (AI)-based classification methods have shown significant improvements in recent years compared to traditional image processing techniques and have increasingly been preferred in land cover classification studies due to their potential to provide high accuracy (Southworth et al., 2024). Therefore, the use of AI-supported remote sensing data in investigating the microclimatic regulatory effects of land cover and water surfaces is gaining increasing importance in the literature (Kaloop et al., 2022; Fong et al., 2025).

The microclimatic regulatory effect of water surfaces is particularly pronounced around reservoir lakes and natural water bodies (Liu et al., 2025). Due to their high specific heat capacities, water bodies exhibit lower temperature fluctuations compared to surrounding terrestrial areas, directly influencing local climatic conditions (Xue et al., 2022; Piccolroaz et al., 2024). Moreover, the enhancement of atmospheric humidity through evaporation from water surfaces reduces thermal stress on surrounding vegetation, thereby strengthening ecosystem resilience (Qi et al., 2025). In this context, the water surfaces of reservoirs exert a significant regulatory effect on the local microclimate due to their strong energy storage properties (Cheng et al., 2022). These water bodies heat more slowly than terrestrial surfaces during the day and release stored heat more evenly at night. This thermal buffering characteristic reduces temperature fluctuations and contributes to local climate stability (Hoziy and Sushama, 2017; Deng et al., 2026). Furthermore, during the evaporation (latent heat flux) process, energy is transferred from the surface to the atmosphere, creating a cooling effect in the surroundings and increasing relative humidity (Martynov et al., 2012). Consequently, water bodies have been reported to reduce surface temperatures in urban and rural areas, improve thermal comfort, and mitigate heat stress, particularly during the summer (Wu et al., 2019; Cheng et al., 2022). Thus, reservoirs are considered not only hydraulic structures but also microclimatic elements with environmental regulatory capacity (Zhu et al., 2018).

Land cover patterns exert differential effects on LST. For instance, forested areas reduce surface temperatures through evapotranspiration and shading effects, whereas bare soils and artificial surfaces intensify the urban heat island effect (Nega and Balew, 2022; Tun et al., 2025). Therefore, examining the interactions between water surfaces and land cover at the spatial level is critical for understanding the local-scale impacts of climate change.

The aim of this study is to investigate the effects of water surfaces and land cover patterns on LST in Alakır Reservoir Lake and its surrounding areas in Antalya using AI-based remote sensing data. The innovative aspect of this study lies in the integration of up-to-date, open-access AI-supported land cover classes with Landsat 8 LST data within the framework of zonal statistical analysis. In this way, the effects of different land use classes on surface temperatures are presented comparatively. Within this scope, the study is significant for validating the microclimatic regulatory role of water surfaces using spatial statistics, demonstrating the application of AI-based remote sensing data in regional climate analyses, and generating decision-support information for local authorities and planning processes. Consequently, this research not only highlights the potential of remote sensing technologies in climate studies but also reveals the climate-regulating effects of water surfaces and natural land cover at a regional scale. The findings obtained in this context provide an important reference for sustainable land management and climate adaptation strategies.

2. MATERIAL AND METHODS

2.1. Study area

The study area is centered on Alakır Reservoir Lake, located within the Kumluca district of Antalya province in southern Türkiye, at coordinates 36°26'3.72"N and 30°14'39.01"E. The research scope has been defined as a circular buffer zone with a 5 km radius around the central point to represent the reservoir and its potential environmental interaction area (Fig. 1). This delimitation allows for a holistic assessment of the area within its hydrological and ecological impact framework.

Situated within the Mediterranean climate zone, the study area experiences hot and dry summers and mild, rainy winters. The average temperature in the hottest month, August, is approximately 32°C, while in the coldest month, January, it is around 15°C. Throughout the year, temperatures range between 4°C and 37°C. Precipitation is concentrated in the autumn and winter months, whereas the driest period occurs between June and September. Due to its proximity to the coast and the influence of extensive water bodies, the region exhibits a humid character. The wind regime varies seasonally, with higher speeds observed during winter

months. Significant elevation differences over short distances in the topography contribute to the diversification of local microclimatic conditions (Weatherspark, 2026).

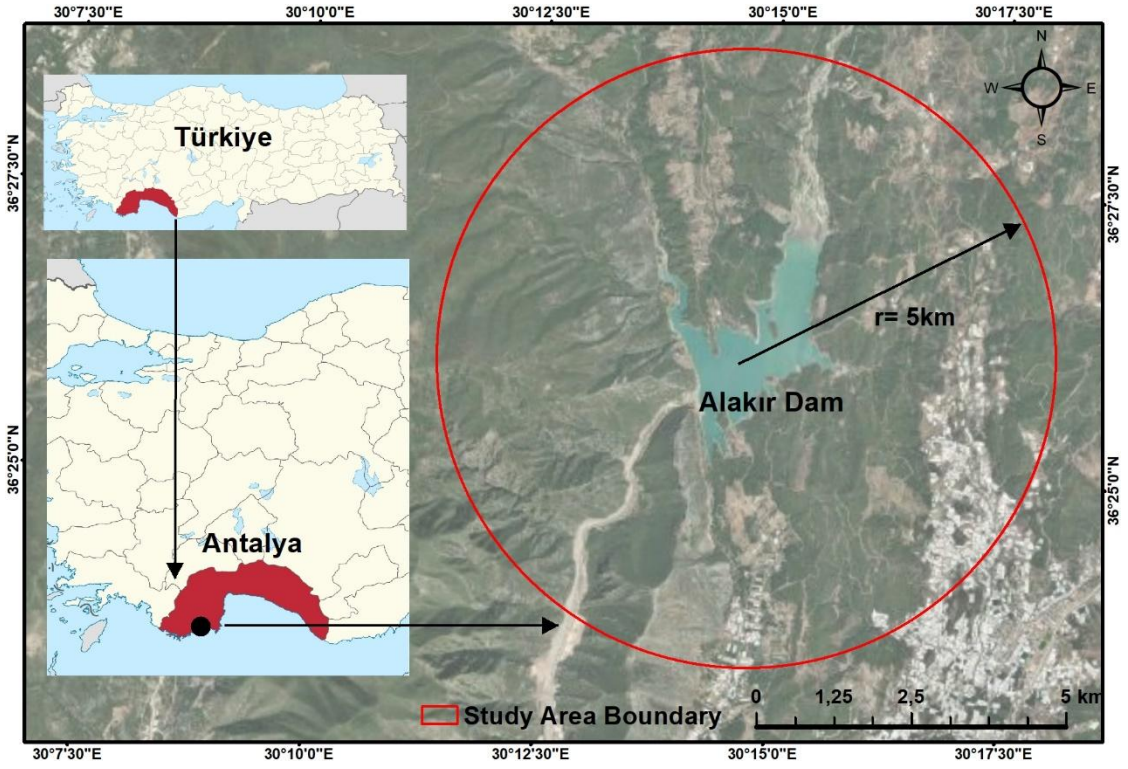


Fig. 1. Study area location

The reservoir and its surroundings constitute an important hydrological system, both for water resource management and local ecosystems. Natural maquis and forest cover dominate the areas around the lake, with agricultural lands and rural settlements occurring sporadically. The topography is generally mountainous and rugged, resulting in spatial variability of microclimatic conditions (Atalay et al., 2014). In addition to its functions in regional water supply, irrigation, and flood control, Alakır Reservoir Lake is a significant environmental feature that influences local temperature and humidity regimes due to the presence of its water surface.

2.2. Data sets

The LULC data used in this study were obtained from the AI-supported classified dataset freely available via ArcGIS Living Atlas (https://livingatlas.arcgis.com/landcoverexplorer/). The 2024 dataset is derived from multi-source remote sensing imagery and provides land cover information classified using machine learning algorithms (Karra et al., 2021). The dataset spatially represents the primary land cover categories in the study area, water, trees, flooded vegetation, crops, built area, bare ground, snow/ice, clouds, and rangelands, with high accuracy. This AI-supported approach was preferred over traditional classification methods due to its

consistency, currency, accessibility, and cost-free availability, thereby providing a reliable spatial basis for evaluating the microclimatic effects of surface characteristics in the analyses. LST dataset was also freely obtained from USGS Earth Explorer (https://earthexplorer.usgs.gov/). Landsat 8 thermal infrared sensor (TIRS) bands were used to calculate LST. For this study, cloud-free imagery from July 2024, representing the summer season, was selected. Thermal band data were converted to radiance values and then subjected to appropriate atmospheric corrections to derive surface temperature. The selection of July is important for observing pronounced thermal differences among water surfaces, vegetation, and other land use types under high temperature conditions. This enabled a detailed spatial analysis of the relationships between land cover distribution and surface temperature.

2.3. Methodology

In this study, a remote sensing-based spatial analysis approach was employed to assess the relationship between land cover and surface temperature. In the first stage, the AI-supported LULC dataset for 2024 was clipped to the boundaries of the study area. This subset procedure ensured that only pixels corresponding to the research site were included in the analysis. Subsequently, the land cover classes were reclassified, and spatial distribution maps were generated for each class, providing both numerical and mapped representations of the land cover composition within the study area.

In the second stage, Landsat 8 Thermal Infrared Sensor (TIRS) bands from July 2024 were used to determine LST. The thermal band data were first converted from digital number (DN) values to radiance, followed by atmospheric corrections using sensor calibration coefficients. Pixel-based LST was then calculated using appropriate transformation algorithms (Selim et al., 2023), and the results were reconstructed in raster format. The resulting surface temperature map revealed the spatial distribution of temperatures across the study area.

In the final stage, the LULC raster and LST raster datasets were spatially overlaid. Zonal statistics analysis was applied to calculate surface temperature values for each land cover class. This method produced statistical measures, including mean, minimum, and maximum LST values corresponding to different land use types. The obtained results were evaluated in the context of microclimatic interactions, with particular emphasis on comparative thermal differences among water surfaces, vegetation, and artificial surfaces. This integrated spatial analysis approach quantitatively revealed the influence of water surfaces and land cover patterns on surface temperature, providing a scientific basis for assessing microclimatic dynamics.

3. RESULTS AND DISCUSSION

In this study, which aims to assess the interactions between Alakır Reservoir Lake in Antalya and the surrounding land cover patterns, as well as to investigate the lake's thermal effects, the AI-supported land cover classes of the study area were first identified. The lake surface covers approximately 311 ha, accounting for 3.52% of the total study area. The remaining land cover classes, in terms of area, are distributed as follows: trees 65.44%, rangeland 22.13%, built area 7.28%, bare ground 1.24%, and crops 0.40% (Fig. 2).

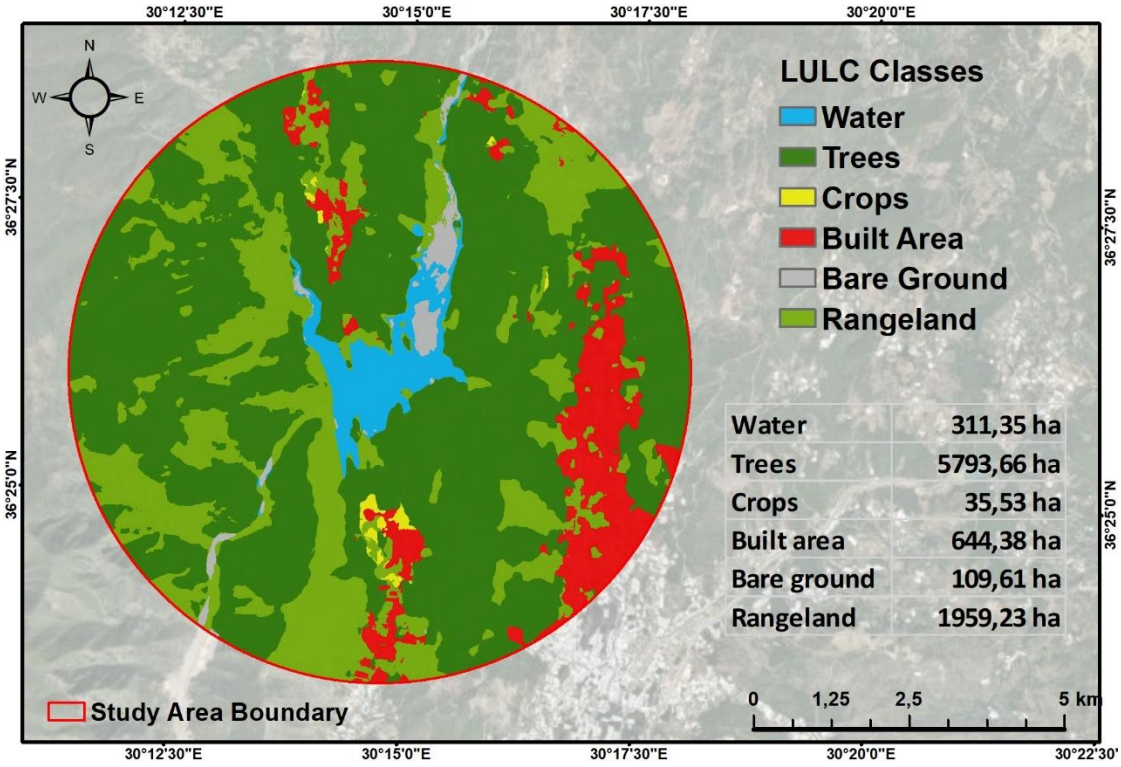


Fig. 2. LULC classes of Alakır Reservoir Lake and its surrounding area

The most dominant land cover around Alakır Reservoir Lake is observed to be trees. Forested areas cover 5,793.66 ha, representing the majority of the total area and forming a broad belt surrounding the lake. This is followed by rangeland areas, which occupy 1,959.23 ha. These two classes indicate that a large portion of the study area consists of natural and semi-natural vegetation. The built area class has a more limited distribution, covering 644.38 ha, and is primarily concentrated in the eastern and southeastern sections of the lake. Although Alakır Reservoir Lake occupies a smaller area compared to the surrounding land cover, it plays a significant role in terms of thermal influence. Bare ground is limited to 109.61 ha and occurs in a fragmented pattern, while crops constitute the smallest land cover class at 35.53 ha, appearing only in localized areas around the lake.

From a thermal perspective, the extensive coverage of forests and rangelands is expected to contribute to the stabilization of surface temperatures around the lake, generating a cooling microclimatic effect. In contrast, built-up areas and bare soils, characterized by low vegetation cover and high surface heating, tend to produce higher surface temperatures. The reservoir itself, due to its high heat capacity, is expected to maintain lower temperatures than the surrounding land during the day, exerting a thermal regulatory effect, particularly in its immediate vicinity. In line with these expectations, the LST map derived from Landsat 8 imagery for July 2024 is presented in Figure 3.

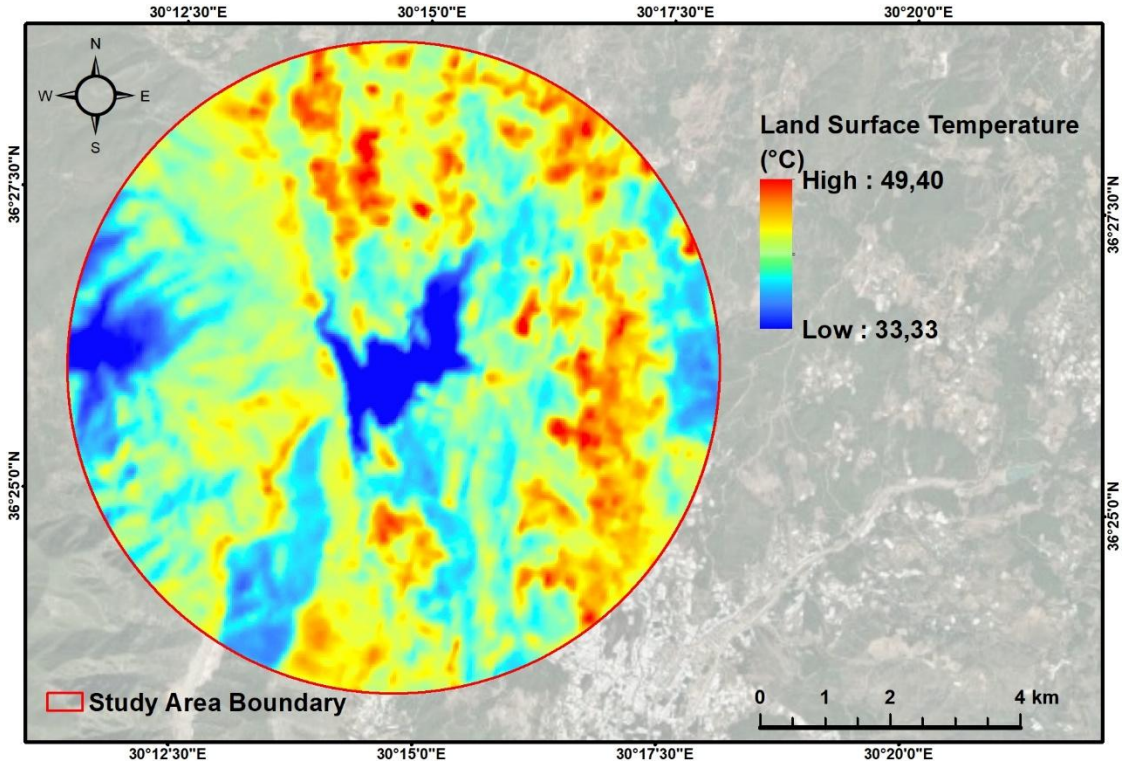


Fig. 3. LST maps of Alakır Reservoir Lake and its surrounding area

LST map for Alakır Reservoir Lake and its surrounding area clearly illustrates the lake's microclimatic regulatory effect. According to the map, surface temperatures in the study area range from 33.33°C to 49.40°C. The lowest temperatures (33–36°C) are observed over the lake surface and adjacent areas (dark blue tones). Moderate temperatures (36–42°C) occur in the transitional zones surrounding the lake (green–light yellow tones), while the highest temperatures (42–49°C) are concentrated in areas farther from the lake, particularly in the southern, eastern and southeast sections (orange–red tones). This distribution indicates that surface temperature is associated with water presence, topography, and land cover.

The microclimatic regulatory effect of Alakır Reservoir Lake is attributed to its slower absorption of solar energy, reduction of diurnal temperature fluctuations, and evaporative

cooling through evaporation (Wu and Zhang, 2019). In addition, surface temperature data for other land use types are presented in Table 1. LST statistics calculated for different land use types around Alakır Reservoir Lake clearly demonstrate the distinct thermal characteristics of various land cover classes. According to the table, the lowest mean surface temperature is observed over water surfaces (36.46°C), whereas the highest mean temperatures are concentrated in agricultural areas (45.04°C) and built-up areas (44.47°C). Water surfaces stand out as the land use class with the lowest mean temperature, with a minimum of 33.67°C and a maximum of 46.84°C. Furthermore, the relatively low standard deviation (2.60) of water surfaces indicates limited temperature variation, highlighting their role in moderating diurnal temperature fluctuations. Therefore, the lake and its surrounding areas function as a microclimatically regulating core within the study area.

Table 1. Temperature Statistics for Land Cover Classes

	MIN	MAX	MEAN	STD
Water	33,67	46,84	36,46	2,60
Trees	33,33	47,30	40,89	1,96
Crops	41,17	47,66	45,04	1,43
Built Area	40,00	48,29	44,47	1,33
Bare Ground	34,06	46,37	40,59	4,20
Rangeland	35,51	49,40	43,42	1,95

Trees, exhibit the second-lowest mean temperature after water surfaces, at 40.89°C. The low standard deviation in these areas (1.96) indicates that temperatures are more uniformly distributed. Dense vegetation, shading, and evapotranspiration processes contribute to reducing surface temperatures, endowing these areas with cooling microclimatic properties (Su et al., 2022). This emphasizes the important role of forests in local climate regulation. Rangelands, with a mean temperature of 43.42°C, fall into the medium–high temperature category. Due to the sparse vegetation cover, shading and evapotranspiration effects are limited, leading to higher surface temperatures (Hossain et al., 2025). Nevertheless, rangeland temperatures remain lower than those of built-up and agricultural areas, indicating their transitional zone characteristics. Crops areas (45.04°C) and built-up areas (44.47°C) are the land use classes with the highest mean surface temperatures. In crops areas, seasonal variations in vegetation and exposed soils following harvest contribute to increased surface temperatures (Weng et al., 2004). In built areas, the high heat storage capacity of concrete, asphalt, and other artificial surfaces results in elevated temperatures (Santamouris, 2015), demonstrating a localized urban heat island effect in these parts of the study area. Bare ground, with a mean temperature of

40.59°C, is notable for having the highest standard deviation (4.20) among land use classes, indicating a highly heterogeneous thermal structure. This variability is influenced by topography, surface moisture, and soil properties, which cause bare soils to exhibit different temperature values across the landscape (Zhuo et al., 2017).

Overall, a clear relationship is observed between land use types and surface temperatures. Water bodies and dense vegetation are associated with lower temperatures, whereas built-up areas, agricultural lands, and sparsely vegetated regions exhibit higher temperatures. These findings highlight the microclimatic regulatory role of the reservoir and natural vegetation in the study area, significantly influencing the spatial distribution of surface temperatures.

4. CONCLUSION

In this study, the spatial distribution of land surface temperatures (LST) and their relationship with land use/land cover (LULC) around Alakır Reservoir Lake were analyzed using remote sensing and geographic information systems (GIS) methods. The findings indicate that land use types play a decisive role in the spatial differentiation of surface temperatures. Surface temperatures in the study area were found to range between 33.33°C and 49.40°C, with the lowest temperatures observed in water bodies and densely vegetated areas, and the highest temperatures concentrated in agricultural lands, built-up areas, and sparsely vegetated regions. This highlights the significant role of water surfaces and natural vegetation in regulating local climatic conditions.

In conclusion, it has been determined that land use types and surface temperatures are in interaction within the study area. Water bodies and dense vegetation exert a cooling effect on surface temperatures, whereas built-up areas and bare soils contribute to temperature increases. These findings underscore the importance of preserving water surfaces and natural vegetation for sustainable land-use planning and climate change adaptation strategies. Furthermore, future studies incorporating different seasonal periods and higher spatial resolution data could provide more detailed insights into microclimatic effects.

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