Konya Mühendislik Bilimleri Dergisi, c. 13, s. 3, 712-725, 2025
Konya Journal of Engineering Sciences, v. 13, n. 3, 712-725, 2025
ISSN: 2667-8055 (Electronic)
DOI: 10.36306/konjes.1552187

THE IMPACT OF URBAN GROWTH ON LAND SURFACE TEMPERATURE IN KONYA PROVINCE's SELÇUKLU DISTRICT

[1]Deniz KÖKLÜ, [2]Fatih İŞCAN, [3]Ceren YAGCI

[1,2] Konya Technical University, Engineering and Natural Sciences Faculty, Geomatics Engineering Department, Konya, TÜRKİYE
[3] Osmaniye Korkut Ata University, Engineering and Natural Sciences Faculty, Geomatics Engineering Department, Osmaniye, TÜRKİYE
[1]e208123001002@ktun.edu.tr, [2]fiscan@ktun.edu.tr, [3]cerenavciyagci@gmail.com

Highlights

- The study found that industrial regions and their immediate surroundings experienced the most severe temperature changes.
- It reveals its displacement with surfaces as well as their effect on quick temperature change.
- In surface temperature tests conducted separately for residential and industrial zones, a significant rise was noted in industrial areas. As a result, the temperature change in Selçuklu district between 1985 and 2015 was at most 12 degrees, with an average temperature difference of 4 degrees, whereas the temperature in the two determined industrial zones changed at most 15 degrees, with an average temperature change of 4 degrees.This leads us to the conclusion that industrial regions have a greater impact on temperature than residential areas.

***Corresponding Author:** Deniz KÖKLÜ, e208123001002@ktun.edu.tr

Konya Mühendislik Bilimleri Dergisi, c. 13, s. 3, 712-725, 2025
Konya Journal of Engineering Sciences, v. 13, n. 3, 712-725, 2025
ISSN: 2667-8055 (Electronic)
DOI: 10.36306/konjes.1552187

THE IMPACT OF URBAN GROWTH ON LAND SURFACE TEMPERATURE IN KONYA PROVINCE's SELÇUKLU DISTRICT

[1] Deniz KÖKLÜ, [2] Fatih İŞCAN, [3] Ceren YAGCI

[1, 2] *Konya Technical University, Engineering and Natural Sciences Faculty, Geomatics Engineering Department, Konya, TÜRKİYE*
[3] *Osmaniye Korkut Ata University, Engineering and Natural Sciences Faculty, Geomatics Engineering Department, Osmaniye, TÜRKİYE*
[1]e208123001002@ktun.edu.tr, [2]fiscan@ktun.edu.tr, [3]cerenyagci@osmaniye.edu.tr
(Received: 18.09.2024; Accepted in Revised Form: 10.06.2025)

ABSTRACT: The ecosystem and climate are significantly impacted by population increase and rapid, uncontrolled urbanization. Green, moisture-retaining natural environments become impermeable artificial surfaces as a result of urbanization, changes in land cover, and the rate of melting. These changes in land cover caused by humans have a big impact on the microclimate. The urban environment gets hotter due to the rise in artificial surfaces and the fall in greenery, particularly in regular areas. Heat islands are what these situations are known as. This study uses data from Landsat 5 TM and Landsat 8 OLI/TIRS Konya for the years 1985-2005-2015-2021 of the Selçuklu district, a highly developed province with a population and service sector resulting from industrial development between 1985 and 2015, as well as sensors and industrial zones. The impact of increase on Land Surface Temperature (LST) was explored. Land surface temperature tests conducted separately for residential and industrial zones, a significant rise was noted in industrial areas. Increased land surface temperatures caused by industrialization in the Selçuk region also impacted the villages nearby, resulting in an increase in land surface temperature in areas close to the industrial area. This leads us to the conclusion that industrial regions have a greater impact on temperature than residential areas.

Keywords: *Atmospheric Heat Islands, Land Surface Temperature, Landsat 5 TM and Landsat 8 OLI/TIRS Satellite Sensors*

1. INTRODUCTION

Cities, which are today's most important living locations, have a diverse range of natural and cultural features. Cities are living areas where environmental conditions and socioeconomic elements such as transportation, trade, industry, and tourism, all of which contribute to economic development, are interconnected.

Decision-makers aim to accelerate the expansion of urban sprawl and manage the land within the city bounds in order to better employ urban and environmental resources and create livable communities. Changes in urban settings, particularly with population expansion and migration from villages to cities, are attempted to be explained by the conditions of uncertainty, broken growth, broken change, and broken development. Although these procedures are frequently utilized in comparable contexts, the size of the fragments varies.

Urban development is a term that suggests that both the physical life of a city and the society in which it is located are improving economically, culturally, and socially. According to Başlik (2008), unique components of change contribute to the city's physical growth and differentiation.

The concept of urban expansion can explain not only the physical extension of urban space, but also its modification in response to environmental and socioeconomic conditions. The word sprawl was coined by American urban planner Earle Draper in 1937 (Nechyba and Walsh, 2004).

The ACA defines urban sprawl as the unplanned and uncontrolled spread of a city, namely the expansion of the low-density physical fabric of large urban centers towards agricultural areas under free

***Corresponding Author:** Deniz KÖKLÜ, e208123001002@ktun.edu.tr

market economy conditions (AÇA, 2006). In other words, urban sprawl refers to the intertwining of land use and functions that occurs as city borders expand from the city center to the periphery. (AÇA, 2006; Cheng, 2003).

The elements given by the EU Environment Agency in the report assessing the urbanization concerns of EU member and candidate countries are organized into seven beliefs (EEA, 2006): • Macroeconomic factors • Microeconomic considerations. • Demographic factors • Housing preferences. Urban problems • Transport • Planning Clarke et al. (1997), Cheng (2003), and Portugali (2006) describe a dynamic, non-linear, and complex urban structure that is dependent on physical, economic, and socio-economic factors and may be studied using complex system methodologies. Cities, as major drivers of sociocultural and economic progress, play an important role in sourcing resources in these sectors. This secret compartment condition, along with valuable potentials such as housing, work, and services, contains people's fragmented features. The most important difficulties of cities, which might be considered as many positives, especially in the twentieth century, can be characterized as water scarcity, insufficient infrastructure and transit alternatives, contaminated environment, and trash that cannot be collected and disposed of. Undoubtedly, these problems lead to the reformation of the living structure, the decrease of distinctions and the increase of every performance together with the emergence of environmental problems. Furthermore, it is evident that the causes of this disease come from unhealthy urbanization and population.

According to the European Environment Agency (EEA), cities will account for 80% of profits in Europe by 2020 (EEA, 2006). Parallel to the rapid rise of the global order, the effects of humans on nature are also expanding. For example, greater growth was caused by the establishment of new agricultural regions, which covered agricultural areas, as well as the separation of forests. Human impacts on nature cause these changes, and problems such as climate change persist on a global scale. Numerous studies show that both human-induced and natural-induced land cover changes significantly impact climate (Çelik, 2019).

Land use and land cover (LULC) sensing and mapping have applications in a variety of areas, including urban planning, climate change, and environmental monitoring. Land use changes, such as the conversion of vegetation/agricultural lands into impermeable surfaces (Yaghobzadeh and Akbarpour, 2011; Ogashawara and Brum Bastos, 2012), lead to a rise in land surface temperatures. These changes have been shown to affect the energy exchange between the terrestrial surface and the atmosphere, as well as solar radiation, land surface temperature (Mallick et al., 2008), evaporation rates, heat transmission to the ground, heat storage, wind turbulence, and near-surface atmospheric conditions over cities (Chen et al., 2006), among other environmental factors. It is recognized to have an important part in the process (Pal and Akoma 2009). Hence, the increase of urban areas and land.As a result, the average air temperature in a city rises as it grows. Thus, urban heat islands are generated. The concept of an urban 'heat island' has been around since 1820, when Luke Howard found it in London by comparing two rows of air temperature T data inside and outside the city. In fact, practically every metropolis, including tiny villages, develops its own 'heat island' (Adamenko, 1975; Böer, 1964; Kratzer, 1956; Landsberg, 1981; Oke, 1978). The establishment of an urban heat island (UHI) is a well-studied ecological consequence of rapid urbanization.

The creation of an urban heat island (UHI) is a extensively researched ecological effect of rapid urban growth. UHI refers to the rise in air and land surface temperatures within urban areas compared to adjacent suburban or rural regions (Voogt and Oke, 2003). The main drivers of UHI effects include diminished vegetation and the consequent reduction in evaporative cooling, low albedo surfaces with high thermal energy absorption, heat-retaining urban canyon structures, and elevated anthropogenic heat emissions from sources such as generators and vehicles (Debbage and Shepherd, 2015; Oke, 1982; Stone, Hess, and Frumkin, 2010; Zhou, Rybski, and Kropp, 2017). Additionally, urban form—encompassing physical layouts, patterns, and building structures—is closely related to the thermal conditions in urban environments (Debbage and Shepherd, 2015; Schwarz and Manceur, 2015; Zhou et al., 2017). (Table 1)

Table 1. Literature Review

WORKING INFORMATION	DATA
Citygml. Interoperable Semantic 3d City Models Gröger Gerhard, Plümer Luz(2012)	**DATA** Lod0 Lod1 Lod2 Lod3 **METHOD** Triangulation Method (A METHOD for Integrating 2d/2.5d Properties)
An Evaluation Of Ifc-Citygml Unidirectional Conversion El-Mekawy Mohamed, Östman Anders, And Hijazi Ihab(2012)	**DATA** Spatial Project Structure (Defining the Site,Building, Building Floor And Space), Element Structure Element, Decking Element, Distribution Element and Transport Element, Grid (Placing Restrictions For Elements), Connection Point (Defining the Connection Between Elements) **METHOD** Building Information Models (Bim) GIS
The Urban Heat İsland Effect İn A Small Mediterranean City Of High Summer Temperatures And Energy Demands Vardoulakis, E., Karamanis, D., Fotiadi, A. And Mihalakakou, G(2013)	**DATA** Urban Structure And Climate Data,Narrow Streets And Medium-Sized Buildings (4-6 Floors). Meteorological DATAler **METHOD** Post Hoc Tests
Urban ‘Heat İsland’ İn Moscow Urban Climate Lokoshchenko, M.A (2014)	**DATA** Air Temperature, Soil Temperature, Snow Cover Depth, Frost Dates **METHOD** Daily Weekly Metorological Dataler
Determination of the Urban Heat Island Effect Related to Urban Geometry the Example of Konya Canan, F. (2017)	**DATA** The Sky Vision Factor **METHOD** Svf With Townscope Iii Software The (Sky Opening) Values have been Calculated.
Urbanization effect on trends of extreme temperature indices in Turkey Aykır, D (2017)	**DATA** Daily Maximum, Minimum And Precipitation Data Summer Days, Tropical Nights, Temperature of Hot Nights, Temperature Width Index **METHOD** Rclimdex Program And Mann-Kendall Trend Analysis
The Urban Growth Effects Over The Local Climate Change İn The Case Of Bursa Morodi, M., Tamer, N. (2017)	**DATA** Climate Parameters Satellite Images **METHOD** Remote Sensing (UA)
Evaluation of Urban Micro-Climate in Cold Climate Cities: The Case of Urban Transformation Area in Erzurum Yavaş, M., & Yılmaz, S. (2019)	**DATA** Vegetation Floor Surface Characteristics Meteorological Data Soil Structure **METHOD** Envı-Met Model

Evaluation of Urban Microclimate Modeling Tools Kızılca, B., (2021)	**DATA** Type Compatibility,Cad/Gis Connection,Accuracy,Charge,Pmv Index,Pet,Utci (Universal,Thermal,Climate Index),Set (Standard,EffectivesTemperature) Pet UtciPmv,Pet,Mrt, Relative Humidity, Temperature ,Wind Speed/Direction ,Radiation,Thermal Comfort,Sky Visibility,Air Quality Factor (Svf) **METHOD** Evaluation and comparison method
Urban Heat Island Study Of Cıtıes Wıth 500.000 Populatıon And Over In Turkey Yasdıman.K,. (2021)	**DATA** Meteorological Station Data **METHOD** Homogeneity Test: Kruskal-Wallis Test Mann-Kendall Ordinal Relationship Coefficient Sen's Trend Slope Method Trend Analysis
Investigating Urban Heat Island Effects On University Campuses Where Located İn Eskişehir City Center With Landsat-8 Data Güneş, C., Pekkan, E., & Muammer, T. Ü. N. (2021)	**DATA** Vegetation, Green And Wooded Areas, Baki Temperature Satellite Image **METHOD** Remote Sensing (UA)
Study of urban heat island effect in Hangzhou metropolitan area based on SW-TES algorithm and image dichotomous model.. Shang, K., Xu, L., Liu, X., Yin, Z., Liu, Z., Li, X., ... & Zheng, W. (2023).	**DATA** LULC map Aqua satellite remote sensing image(MODIS) Administrative map CRU TS **METHOD** SWTES method the LST inversion of the algorithm
Influences of urban spatial factors on surface urban heat island effect and its spatial heterogeneity Xu, D., Wang, Y., Zhou, D., Wang, Y., Zhang, Q., & Yang, Y. (2024).	**DATA** DEM Landsat 8 image Land classification raster image **METHOD** The block-scale UHI intensit the RF model MGWR model

In the literature, there are studies on the urban heat island (UHI) effect conducted in various cities and under different climate conditions. The UHI effect, which describes the phenomenon where urban areas experience higher temperatures than their rural surroundings due to human activities, has been widely studied using diverse datasets and methods.

Several studies have explored the relationship between urbanization and local climate changes. For instance, Nasrallah, Brazel, and Balling Jr. (1990) analyzed annual maximum and minimum temperature averages through regression analysis to examine UHI effects in Kuwait City.

Other studies have focused on more specific aspects of UHI, such as the impact of urban climate on energy consumption (Santamouris et al., 2001), or the difference in land surface temperatures between urban and rural areas (Peterson, 2003). These studies highlight the significant role of urbanization in altering local climate patterns, with far-reaching implications for energy use and public health.

Advanced modeling techniques have also been employed to simulate and analyze UHI effects. For example, Chen, Yang, and Zhu (2014) used the Weather Research and Forecasting (WRF) model to simulate UHI in Hangzhou, China. Similarly, Mihalakakou et al. (2004) applied artificial neural networks to model UHI phenomena in Mediterranean climates.

Remote sensing has become a crucial tool in UHI research, with studies like those by Cai, Du, and Xue (2011) using satellite data to monitor UHI effects in Beijing. These methods allow for high-resolution observations of temperature distribution and other climatic factors, providing valuable data for urban planning and climate adaptation strategies.

Overall, the literature demonstrates the significant impact of urbanization on local climate, particularly through the UHI effect. The findings underscore the importance of integrating climate considerations into urban planning to mitigate the adverse effects of UHI on energy consumption, air quality, and overall ecological balance.

Modeling studies are increasingly being used to examine the effects of urbanization on weather and climate, as well as the mechanisms that shape the spatial and temporal patterns of urban heat islands on a broad scale. These studies concentrate on the variation of surface ground temperatures in urban, industrial, and commercial environments. When the data are analyzed, it is clear that industrial regions have a substantial impact on temperature increases associated with urbanization.

In this study, in addition to site selection and earlier research in the literature, an attempt was made to establish a richer and different perspective on Land surface temperature tests conducted separately for residential and industrial zones.

In prospective studies, collaborative research including city and regional planners, architects, civil engineers, decision-makers should be conducted. This collaboration will enable the GIS-based research to be conducted with greater precision and scientific rigor.

Therefore, to emphasize the importance of industrial areas in urban planning, this study focuses on the impact of urban growth on land surface temperature in the industrial areas of Konya province for the years 1985, 2005, 2015, and 2021.

2. MATERYAL VE METHOD

2.1. Introduction of the Study Area

Selçuklu district, with a population of 475,000, is greater than 63 provinces and Turkey's 17th largest district. The district border covers 70376 hectares, with an additional 78045 hectares in nearby areas. The zoning area is 13,700 hectares, including 66 neighborhoods. Selçuklu, Konya's most populous and developed central district, exemplifies the city's development and growth in all aspects. Selçuk is located in the north of Konya, near Sarayönü, Kadınhanı, Derbent, Beyşehir, Meram, and Karatay districts (see Figure 1). Furthermore, Selçuklu district is a highly developed center district for Konya province, with its population and service sector resulting from industrial development.

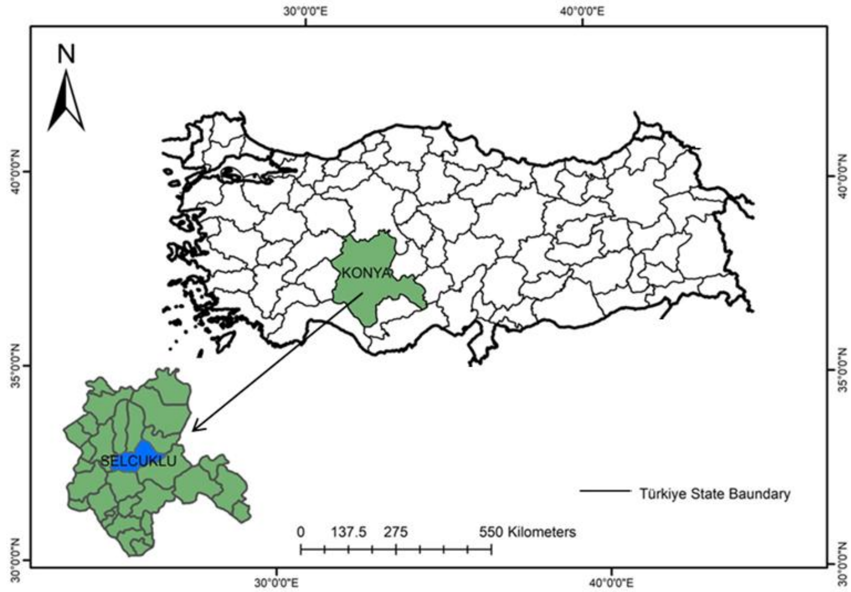

Figure 1. Study Area

2.2. Method

Landsat-5 TM/ 8 OLI satellite photos were utilized as baseline data to evaluate the effects of temperature change in the district. Table 2 shows the satellites utilized to make LST maps as well as the picture shooting dates.

Table 2. Satellites LST maps and image dates

DATA SETS:	DATE:
Landsat-5 TM	25.08.1985
Landsat-5 TM	03.07.2005
Landsat-8 OLI	15.07.2015
Landsat-8 OLI	31.07.2021

2.2.1. Production of land Surface Temperature Maps

To obtain LST using Landsat-5 TM (thermal band) data, sensor pixel values freedom-1 and spectral radian values were obtained (Chander and Groeneveld, 2009). $L\lambda$ = $Lmax\lambda - Lmin\lambda$ $Qcalmax{-}Qcalmin$ × (Qc) $al - Qcalmin)$ + $Lmin\lambda$ (1) Here; $L\lambda$ is the spectral radian value in the sensor, Qcal is the digital pixel value, Qcalmax and Qcal are the maximum and minimum digital pixel values, and Lmax and Lmin are the spectral reflection value scaled according to Qcalmax and Qcalmin. The sensor pixel values for Landsat-8 OLI (band 10) with the following freedoms are displayed as spectral radian values. $L\lambda$ = Ml × Qcal + Al (2) Barsi et al. (2014) define $L\lambda$ as the sensor's spectrum radiance value, ML as the band-specific scaling multiplier factor, and Qcal as the digital pixel value.

Equation-3 calculates sensor brightness temperature based on spectral reflectance data from the satellite's thermal band (Chander and Markham, 2003; Orhan et al., 2014).

Tb = $K2$ ln $((K1/L\lambda)$ + 1) (3)

Avdan and Jovanovska (2016) define Tb as the sensor brightness temperature, $L\lambda$ as the spectral radiance, and K1, K2 as the Landsat-5 and Landsat-8 thermal conversion constants, respectively.

Surface emissivity correction, which includes sensor temperature, yields LST, which is not a representation of real surfaces (equation 4).

Ts = Tb 1 + $(\lambda \times Tb\ h * c\ b)$ ln $\varepsilon\lambda$ (4)

Here; For LST calculation, λ is the incident thermal band wavelength (11.45 μm for Landsat 4,5,7 / 10.895 μm for Landsat-8 band 10), h is Planck's constant (6.626*10−34Js), b is Boltzmann's constant (1.38*10−23J/K), c is the speed of light (2.998*108m/s), and $\varepsilon\lambda$ is the emissivity value corresponding to the pixel. To finish the LST maps in degrees Celsius, the LST data were set to absolute zero. Broadcasting is defined as the ratio of total beam energy incident on an item to absorbed beam energy.

According to Şekertekin and Marangoz (2019), increased emissivity is associated with blacker and more matte objects, while decreasing emissivity with increasing density.

To estimate the LST, we need to know the ground surface emissivity-YYY (ε). Sobrino et al. (2004) determine publication value using the following freedoms.

$\varepsilon\lambda = \varepsilon v\lambda Pv + \varepsilon s\lambda(1 - Pv) + C\lambda$ (5) Sobrino, Caselles, and Becker (1990) define εv and εs as plant and soil dispersal qualities, Pv as plant pattern distribution, and Cλ as average land roughness.

The ground surface emissivity was determined using the NDVI threshold approach (Sobrino and Raissouni 2000). Ground surface emissivity was measured using NDVI for three different terrain types (rock and soil, vegetation, and a combination of the two). The vegetation cover ratio is calculated using the following formulae.

$Pv = [NDVI - NDVImin\ NDVImax - NDVImin]$ 2 (6) $\boldsymbol{NPVU} = \boldsymbol{NUR} - R\boldsymbol{QP}\ \boldsymbol{NUR} + R\boldsymbol{QP}$ (7) YYY for Landsat-5 TM. If the NDVI value is less than 0.2, the surface represents rock and soil, and the emissivity value of 0.97 is used; if the NDVI value is between 0.2 and 0.5, the surface represents a combination of rocks and vegetation, and equation 8 is used.$\varepsilon\ TM6 = 0.986 + 0.004\ P\ v$ (8) If the NDVI score is greater than 0.5, the surface is vegetated, and the diffusivity value of 0.97 is recommended (Sobrino et al. 2004, 2008).

LST for Landsat-8 TM, Wang et al. In 2015, it was advised to utilize the following values: water (0.991), building (0.962), soil (0.966), and plant (0.973). To determine NDVI values between 0.2 and 0.5, use a diffusivity value of 0.966 for soil and 0.973 for vegetation, based on the NDVI threshold values indicated above (equation 5).

3. RESEARCH RESULTS

In this study, we initially attempted to estimate the urban growth of Konya province's Selçuklu district from 1985 to 2005-2015 and 2021 (Figure 2).

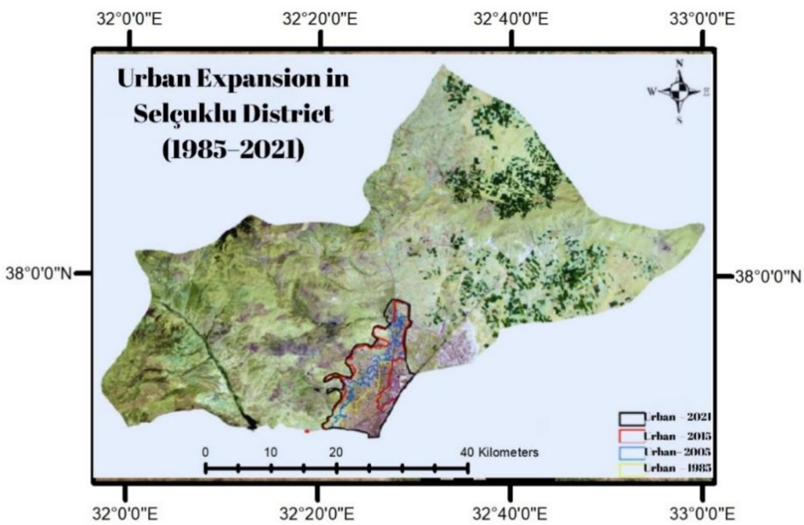

Figure 2. Urban Expansion for the Years 1985-2005-2015 and 2021

In the second stage, multi-temporal LST maps of the Selçuklu district coDATAng the years 1985-2005-2015-2021 were produced using Landsat-5 TM and Landsat-8 OLI satellite images (Figure 3).

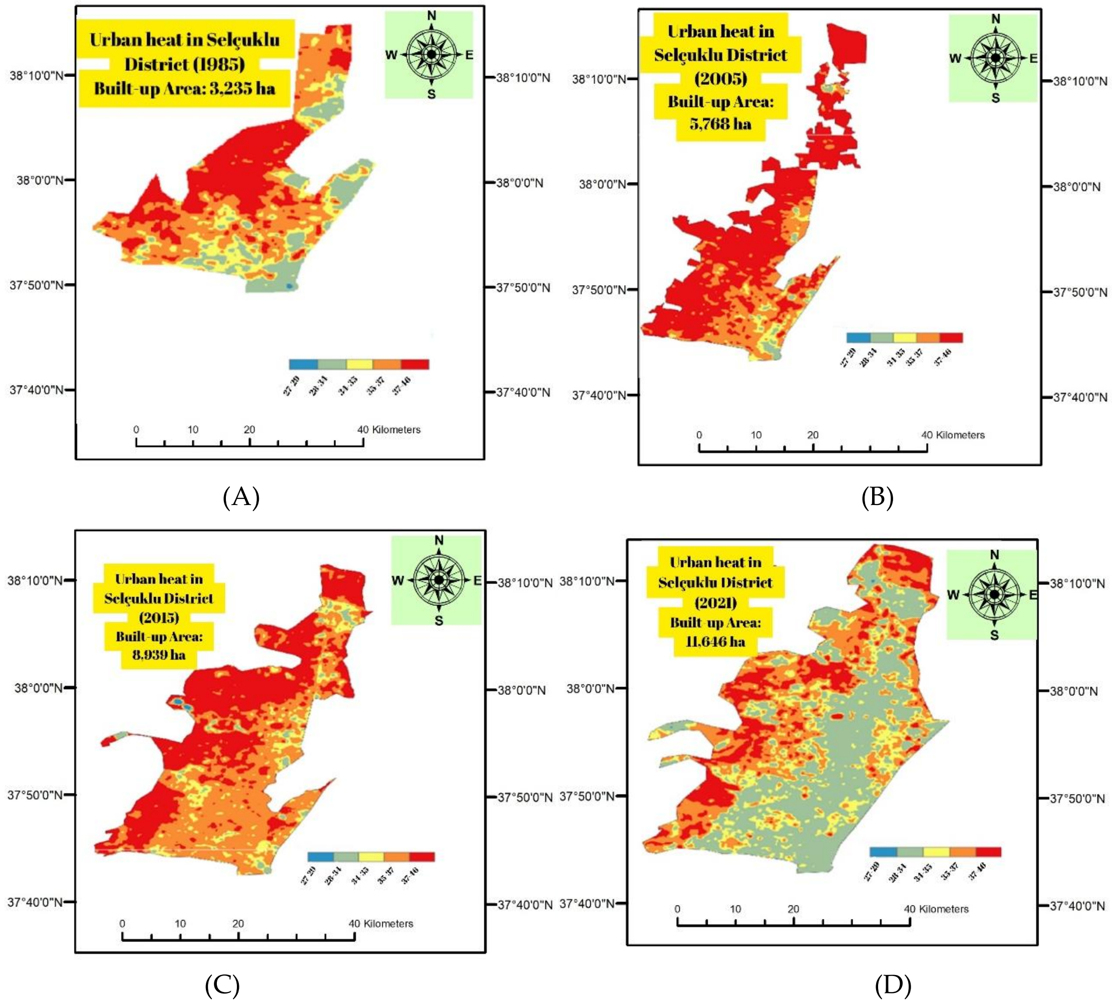

Figure 3. Konya / Selçuklu Urban Area – LST Maps (A) 1985, (B) 2005, (C) 2015 (D) 2021

The study and maps revealed that the land surface temperature in residential areas increased by a maximum of 12 degrees between 1985 and 2015, with an average temperature change of 4 degrees. (Figure 4).

The study also looked into the influence of increase in urban residential areas on ground temperature, as well as the effect of industrial zones on ground temperatures (Figure 5). The most extreme temperature changes occur in industrial areas and their immediate surroundings. As a result, it was discovered that the temperature of the two industrial zones identified in Selçuklu district (Figure 6 and Figure 7) varied by a maximum of 15 degrees between 1985 and 2015, with an average shift of 4 degrees.

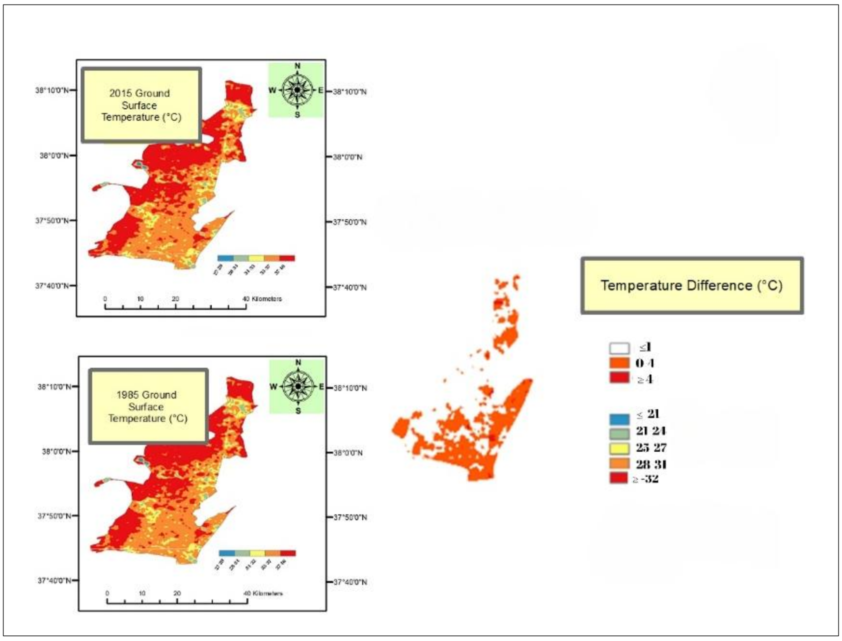

Figure 4. 1985-2015 Temperature Change Map

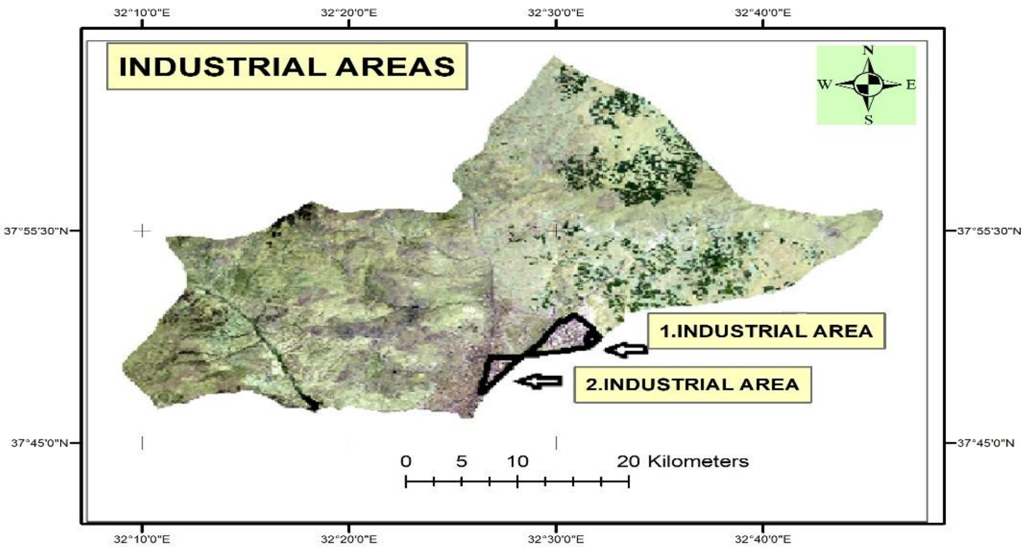

Figure 5. Industrial Areas

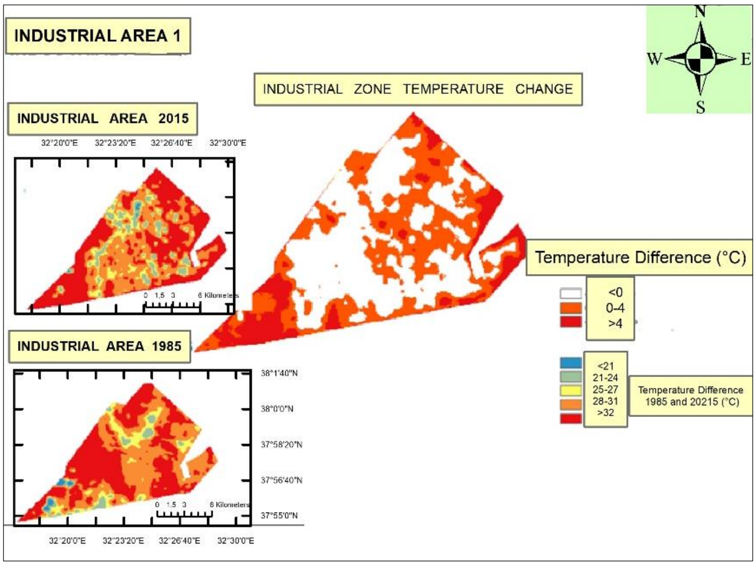

Figure 6. Industrial Zone 1 and Land Surface Temperature

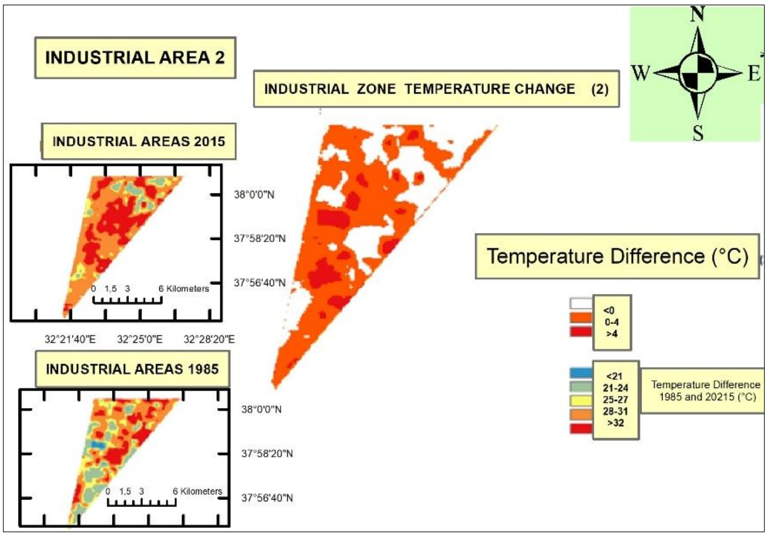

Figure 7. Industrial Zone 2 and Land Surface Temperature

4. RESULTS AND DISCUSSION

Urban heat islands refer to the phenomenon where temperatures in cities, both in the atmosphere and on surfaces, are notably higher compared to their rural or non-urban surroundings (Voogt, 2005). The process of urbanization leads to the formation of heat islands, where structures like buildings, roads, and asphalt absorb heat throughout the day and release it slowly in the evening, causing urban areas to be warmer than their neighboring areas. Artificial heat from industrial activities, along with heat from air conditioning in commercial and residential buildings, further contributes to elevated air and land surface temperatures in cities. These heat islands affect the urban climate, energy use, and overall livability of cities. Increased temperatures raise the demand for cooling energy and accelerate urban pollution. To mitigate these temperature increases, incorporating elements such as trees, shaded areas, and permeable surfaces into urban environments (Akbari et al., 1992), along with factors like low solar radiation, low wind speed, and low cloud cover, and maintaining dense vegetation are recommended. Research by Nichol (1994) and others has explored whether effective building management can help reduce temperature and humidity variations between urban and rural areas.

Decision-makers aim to accelerate the expansion of urban sprawl and manage the land within the city bounds in order to better employ urban and environmental resources and create livable communities. The changes in the shape of the city, particularly those caused by population expansion and migration from villages to cities, have been attempted to be described by unique growth, changing change, and shifting development conditions.

It has been observed that the swell, low temperature, and intermediate temperatures in Konya have not been as high as projected since 1980. The Selçuklu district of Konya province, which became a metropolitan city in 1989, experienced a significant increase in LST values from 1985 to 2015, with 2015 having the highest temperatures compared to previous years.

Selçuk University, which is located in the city's north, has prompted growth in that area. Furthermore, in the Selçuklu area, around the University campus, growing neighborhoods have emerged, and it has been concluded that the city has grown to the north with the tram line. The airport, Konya industrial zone, and Selçuk University campus, which began construction outside the city, have all contributed to rapid urban growth in the urban fabric. The contrary features of the thermal study results suggest that land surface temperatures in 2021 are lower than in 2015 and are not accessible in accordance with the extremely high temperature. The explanation for this disparity is where it is. The primary reason is because weather conditions differed between the dates when satellite data were collected. Land surface temperature measurements varied due to differences in air temperatures during satellite record-taking dates. The humidity inside the machine influences the change of cells. is one of the scenarios for remote sensing. A second factor is that a hard winter in 2021 left the ground surfaces as they fell.

The study found that industrial regions and their immediate surroundings experienced the most severe temperature changes. This region's green spaces are entirely composed of concrete and asphalt, among other materials. It reveals its displacement with surfaces as well as their effect on quick temperature change. As a result, the temperature change in Selçuklu district between 1985 and 2015 was at most 12 degrees, with an average temperature difference of 4 degrees, whereas the temperature in the two determined industrial zones changed at most 15 degrees, with an average temperature change of 4 degrees.

As a result, in land surface temperature tests conducted separately for residential and industrial zones, a significant rise was noted in industrial areas. Increased land surface temperatures caused by industrialization in the Selçuk region also impacted the villages nearby, resulting in an increase in land surface temperature in areas close to the industrial area. This leads us to the conclusion that industrial regions have a greater impact on temperature than residential areas.

Declaration of Ethical Standards

The authors declare that the study complies with all applicable laws and regulations and meets ethical standards.

Credit Authorship Contribution Statement

Deniz KÖKLÜ: Methodology, Conceptualization, Resources, Investigation, Writing.
Fatih İŞCAN: Review & editing, Supervision.
Ceren YAĞCI: Methodology, Conceptualization, Resources, Investigation, Writing -review

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

This study was carried out in the scope of the doctoral thesis of Author1. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

[1] European Environment Agency, Urban Sprawl in Europe: The Ignored Challenge, EEA Report No. 10/2006, Copenhagen, Denmark, 2006.

[2] V. N. Adamenko, Climate of Big Cities (review), Obninsk, Russia: All-Union Research Institute of Hydrometeorological Information – World Data Center, 1975.

[3] H. Akbari and H. Taha, "The impact of trees and white surfaces on residential heating and cooling energy use in four Canadian cities," Energy, vol. 17, no. 2, pp. 141–149, 1992.

[4] D. Aykır, "The effect of urbanization on the trends of extreme temperature indices in Turkey," Turkish Geographical Review, no. 69, pp. 47–57, 2017.

[5] S. Başlık, Modeling of Dynamic Urban Growth Using Logistic Regression and Cellular Automata (Istanbul and Lisbon), 2008.

[6] W. Böer, Technische Meteorologie, Leipzig, Germany: B.G. Teubner Verlagsgesellschaft, 1964.

[7] G. Y. Cai, M. Y. Du, and Y. Xue, "Monitoring of urban heat island effect in Beijing combining ASTER and TM data," International Journal of Remote Sensing, vol. 32, no. 5, pp. 1213–1232, 2011, doi: 10.1080/01431160903469079.

[8] F. Canan, "Determination of the urban heat island effect related to urban geometry: The example of Konya," Journal of the Faculty of Engineering and Architecture of Cukurova University, vol. 32, no. 3, pp. 69–80, 2017.

[9] X. L. Chen, H. M. Zhao, P. X. Li, and Z. Y. Yin, "Remote sensing image-based analysis of the relationship between urban heat island and land use/cover changes," Remote Sensing of Environment, vol. 104, no. 2, pp. 133–146, 2006.

[10] F. Chen, X. Yang, and W. Zhu, "WRF simulations of urban heat island under hot-weather synoptic conditions: The case study of Hangzhou City, China," Atmospheric Research, vol. 138, pp. 364–377, 2014.

[11] J. Cheng, Modelling Spatial and Temporal Urban Growth, Utrecht, The Netherlands: Utrecht University, 2003.

[12] K. C. Clarke, S. Hoppen, and L. Gaydos, "A self-modifying cellular automaton model of historical urbanization in the San Francisco Bay Area," Environment and Planning B: Planning and Design, vol. 24, pp. 247–261, 1997.

[13] D. B. Clarke, Ed., The Cinematic City, Hove, UK: Psychology Press, 1997.

[14] B. Çelik, Investigation of the Temporal and Spatial Effects of Land Cover Changes on Urban Heat Islands, Ph.D. dissertation, Dept. of Geomatics Engineering, Istanbul Technical University, Istanbul, Turkey, 2019.

[15] N. Debbage and J. M. Shepherd, "The urban heat island effect and city contiguity," Computers, Environment and Urban Systems, vol. 54, pp. 181–194, 2015.

[16] M. El-Mekawy, A. Östman, and I. Hijazi, "A unified building model for 3D urban GIS," ISPRS International Journal of Geo-Information, vol. 1, no. 2, pp. 120–145, 2012.

[17] G. Gröger and L. Plümer, "CityGML – Interoperable semantic 3D city models," ISPRS Journal of Photogrammetry and Remote Sensing, vol. 71, pp. 12–33, 2012.

[18] C. Güneş, E. Pekkan, and T. Ü. N. Muammer, "Investigation of the urban heat island effects in university campuses located in the city center of Eskişehir using Landsat-8 satellite images," National Journal of Environmental Sciences Research, vol. 4, no. 1, pp. 22–32, 2021.
[19] T. R. Karl, H. F. Diaz, and G. Kukla, "Urbanization: Its detection and effect in the United States climate record," Journal of Climate, vol. 1, no. 11, pp. 1099–1123, 1988.
[20] B. Kızılca, "Evaluation of urban microclimate modeling tools," Turkish Journal of Land Management, vol. 3, no. 2, pp. 79–86, 2021.
[21] P. A. Kratzer, The Urban Climate (Das Stadtklima), Braunschweig, Germany, 1956; H. E. Landsberg, The Urban Climate, New York, NY, USA: Academic Press, 1981.
[22] M. A. Lokoshchenko, "Urban 'heat island' in Moscow," Urban Climate, vol. 10, pp. 550–562, 2014.
[23] J. Mallıck, Y. Kant, and B. D. Bharath, "Estimation of land surface temperature over Delhi using Landsat-ETM+," Journal of the Indian Geophysical Union, vol. 12, no. 3, pp. 131–140, 2008.
[24] G. Mihalakakou, M. Santamouris, N. Papanikolaou, C. Cartalis, and A. Tsangrassoulis, "Simulation of the urban heat island phenomenon in Mediterranean climates," Pure and Applied Geophysics, vol. 161, pp. 429–451, 2004.
[25] M. Morodi and N. G. Tamer, "The urban growth effects over the local climate change in the case of Bursa," Planning, vol. 27, no. 1, pp. 26–37, 2017.
[26] H. A. Nasrallah, A. J. Brazel, and R. C. Balling, "Analysis of the Kuwait City urban heat island," International Journal of Climatology, vol. 10, no. 4, pp. 401–405, 1990.
[27] T. J. Nechyba and R. P. Walsh, "Urban sprawl," The Journal of Economic Perspectives, vol. 18, no. 4, pp. 177–200, 2004.
[28] K. L. Nichol, et al., "The efficacy and cost effectiveness of vaccination against influenza among elderly persons living in the community," New England Journal of Medicine, vol. 331, no. 12, pp. 778–784, 1994.
[29] I. Ogashawara and V. S. B. Bastos, "A quantitative approach for analyzing the relationship between urban heat islands and land cover," Remote Sensing, vol. 4, no. 11, pp. 3596–3618, 2012.
[30] T. R. Oke, Boundary Layer Climates, London, UK: Routledge, 1978.
[31] T. R. Oke, "The energetic basis of the urban heat island," Quarterly Journal of the Royal Meteorological Society, vol. 108, no. 455, pp. 1–24, 1982.
[32] S. Pal and O. C. Akoma, "Water scarcity in wetland area within Kandi block of West Bengal: A hydro-ecological assessment," Ethiopian Journal of Environmental Studies and Management, vol. 2, no. 3, pp. 1–12, 2009.
[33] T. C. Peterson, "Assessment of urban versus rural in situ surface temperatures in the contiguous United States: No difference found," Journal of Climate, vol. 16, no. 18, pp. 2941–2959, 2003.
[34] J. Portugali, Complex Artificial Environments: Simulation, Cognition and VR in the Study and Planning of Cities, Heidelberg, Germany: Springer, 2006.
[35] M. Santamouris, N. Papanikolaou, I. Livada, I. Koronakis, C. Georgakis, A. Argiriou, and D. N. Assimakopoulos, "On the impact of urban climate on the energy consumption of buildings," Solar Energy, vol. 70, no. 3, pp. 201–216, 2001.
[36] N. Schwarz and A. M. Manceur, "Analyzing the influence of urban forms on surface urban heat islands in Europe," Journal of Urban Planning and Development, vol. 141, no. 3, p. A4014003, 2015.
[37] K. Shang, L. Xu, X. Liu, Z. Yin, Z. Liu, X. Li, et al., "Study of urban heat island effect in Hangzhou metropolitan area based on SW-TES algorithm and image dichotomous model," Sage Open, vol. 13, no. 4, 2023, Art. no. 21582440231208851.
[38] B. Stone, J. J. Hess, and H. Frumkin, "Urban form and extreme heat events: Are sprawling cities more vulnerable to climate change than compact cities?," Environmental Health Perspectives, vol. 118, no. 10, pp. 1425–1428, 2010.
[39] E. Vardoulakis, D. Karamanis, A. Fotiadi, and G. Mihalakakou, "The urban heat island effect in a small Mediterranean city of high summer temperatures and cooling energy demands," Solar Energy, vol. 94, pp. 128–144, 2013.

[40] J. Vooght, "How researchers measure urban heat islands," U.S. Environmental Protection Agency, 2015. [Online]. Available: http://www.epa.gov/heatislands/resources/pdf/EPA_How_to_measure_a_UHI.pdf
[41] J. A. Voogt and T. R. Oke, "Thermal remote sensing of urban climates," Remote Sensing of Environment, vol. 86, no. 3, pp. 370–384, 2003.
[42] D. Xu, Y. Wang, D. Zhou, Y. Wang, Q. Zhang, and Y. Yang, "Influences of urban spatial factors on surface urban heat island effect and its spatial heterogeneity: A case study of Xi'an," Building and Environment, vol. 248, p. 111072, 2024.
[43] M. Yaghobzadeh and A. Akbarpour, "The effect of satellite image classification algorithm based on curve number runoff and maximum flood discharge using GIS and RS," Geography and Development, vol. 9, no. 22, pp. 5–22, 2011.
[44] K. Yasdıman, Urban Heat Island Studies in Turkish Cities with a Population of 500,000 and Above, Ph.D. dissertation, Dept. of Geography, Istanbul University, Istanbul, Turkey.
[45] M. Yavaş and S. Yılmaz, "Evaluation of urban microclimate in a cold climate zone: The case of Erzurum urban transformation area," Artium, vol. 7, no. 2, pp. 103–114, 2021.
[46] B. Zhou, D. Rybski, and J. P. Kropp, "The role of city size and urban form in the surface urban heat island," Scientific Reports, vol. 7, no. 1, p. 4791, 2017.