Green Routes and Urban Heat Island mitigation in the Municipality of Kalamata

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Abstract. Humanity faces a triple planetary crisis: climate change, biodiversity loss, and pollution, which threaten ecosystems and quality of life. Cities play a key role in tackling these challenges and achieving climate neutrality as hubs of housing, economy, and resource use.
Kalamata, a member of the EU's "100 Climate-Neutral and Smart Cities by 2030" Mission, leverages digital innovations for sustainability. Through smart solutions in energy, buildings, waste management, and transport, it aims to enhance resilience and reduce environmental risks.
This study aims to highlight, through Geographic Information Systems (GIS), green routes within the city's residential fabric that are suitable for cooler walks. Key factors considered and applied as criteria for reducing urban heat, are urban green spaces, which aid in air cooling through vegetation. In contrast, factors such as asphalt and concrete (which absorb heat), high buildings, and narrow streets (which trap heat by limiting airflow), along with human activities such as heating of the buildings and driving cars, contribute to increase urban temperatures.
Additionally, the study assesses accessibility to green spaces and presents comparative maps of land surface temperatures, highlighting ways to mitigate urban heat.

Keywords: Urban Heat Island, Green Routes, Climate Change, Kalamata, GIS, Satellite Remote Sensing

1 Introduction

Cities are on the frontline of the climate crisis, concentrating population, infrastructure, and exposure to extreme heat. The Urban Heat Island (UHI) effect—systematically higher urban than rural temperatures—intensifies heat stress, increases energy demand, and reduces environmental quality. Kalamata, as part of the EU Mission "100 Climate-Neutral and Smart Cities by 2030," provides a timely context to examine how geospatial analysis can inform place-based adaptation.

This paper uses satellite remote sensing and Geographic Information Systems (GIS) to (i) map land surface temperature (LST) and characterize intra-urban UHI patterns and (ii) translate these findings into a planning framework for climate-sensitive "green routes." We integrate thermal vulnerability with accessibility to greenery to delineate priority corridors that can reduce heat exposure and enhance everyday walkability. Our contribution is twofold: a reproducible workflow for LST/UHI mapping tailored to a Mediterranean city, and a design logic that links quantitative heat evidence to a continuous network of green infrastructure.

1.1 The Urban Heat Island Effect

The Urban Heat Island (UHI) effect describes the phenomenon whereby air temperatures in urban areas are higher than those in suburban and rural areas [1]. It is one of the most widely recognized consequences of human-induced climate modification and is primarily driven by urbanization. The growth of urban centers has intensified over recent decades, although societies have long been aware of bioclimatic design strategies to mitigate extreme heat in settlements [2]. Currently, about 73% of Europe's population resides in cities and urban areas, and this percentage is expected to rise to 80% by 2050, according to data from Eurostat, the official statistical office of European Union.

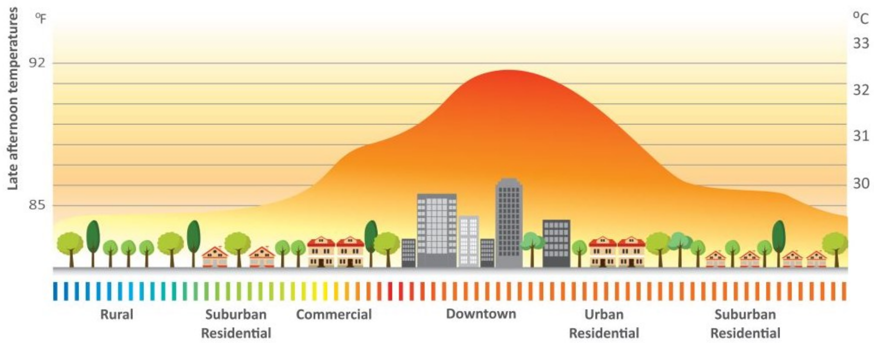

Fig.1. The Urban Heat Island Effect [3]

Vegetation plays a critical role in regulating urban temperatures. Compared to suburban and rural landscapes, which typically contain denser and more diverse vegetation, urban environments often lack sufficient greenery to moderate heat [4].

In urban areas, the phenomenon of heat absorption occurs mainly through asphalt materials and concrete, which are characterized by low albedo values and high thermal capacity. These surfaces absorb a substantial portion of incoming solar radiation during the day and release it slowly during the night, thereby intensifying the Urban Heat Island (UHI) effect [12]. Asphalt surfaces, for instance, can reach temperatures above 60 °C under strong solar exposure, while concrete, due to its thermal mass, retains and gradually emits heat long after sunset [10]. This thermal storage not only elevates nighttime temperatures but also reduces natural cooling processes in cities. In contrast, urban green spaces act as natural coolers by providing shade and facilitating evapotranspiration, which lowers both surface and air temperatures [5], [12]. Beyond thermal regulation, vegetation also filters pollutants, improves air quality, promotes biodiversity, and enhances residents' mental well-being, highlighting its multidimensional role in sustainable urban planning [6].

Other built-environment factors also contribute to UHI. High-rise buildings and narrow street canyons can trap heat and restrict airflow, while anthropogenic activities such as building heating and vehicle traffic release additional heat into the environment [7].

All the above factors contribute to the urban heat island effect, the intensity of which is defined as the difference between the urban temperature and the corresponding suburban or rural temperature. The phenomenon is most pronounced during the night when temperatures in urban areas can be up to 10°C higher than in rural areas. This is due to the retained heat in structures such as buildings and roads, which is released during the night [8].

In summary multiple drivers shape the UHI effect, particularly in dense urban fabrics.[9]. Vegetation mitigates these impacts by lowering cooling demand and improving air quality [10]. Urban green spaces also support biodiversity and mental well-being [11]. On the other hand, buildings and asphalt absorb heat, increasing urban temperatures [12]. Human activities such as heating buildings and driving also contribute to heat [13]. The cumulative outcome is a distinct thermal imbalance, with cities often experiencing higher and more persistent temperatures compared to their rural counterparts [14].

1.2 The Study Area

Kalamata is the largest city in terms of population in the Peloponnese Region and the second largest in the broader geographic division, after Patras. It is located in the southern Peloponnese, extending along the Messinian Gulf and lying at the foothills of Mount Taygetos. This specific topographic setting strongly influences the city's climate and local thermal environment. The mountain range to the east often restricts natural airflow, reducing the dispersion of warm air masses, while the proximity to the sea contributes to high levels of humidity and occasional temperature inversions. These conditions, combined with dense urban development and limited vegetated areas in certain neighborhoods, exacerbate the intensity of the Urban Heat Island (UHI) effect.

Moreover, the spatial relationship between the urban fabric, the coastal zone, and the surrounding natural landscape creates microclimatic variations across the city. Western neighborhoods closer to the industrial and commercial zones tend to accumulate higher surface temperatures, whereas eastern districts near the Taygetos foothills show relatively cooler conditions. Recognizing these geographical and climatic dynamics is essential for interpreting the observed thermal patterns and for designing effective green routes that enhance urban resilience against climate change.

Fig.2. The location of the Municipality and the city of Kalamata in the geographic division of the Peloponnese

The effects of climate change have become noticeable in Kalamata, with manifestations such as increased climate variability and temperature fluctuations. Since the year 2000, Kalamata has experienced a rise of 1°C in its average annual temperature. The 2010s were recorded as the hottest decade in the city since 1850. In addition to this overall temperature increase, certain urban areas are experiencing unusually high soil temperatures, reaching up to 41°C, indicating a severe local impact of the changing climate [15].

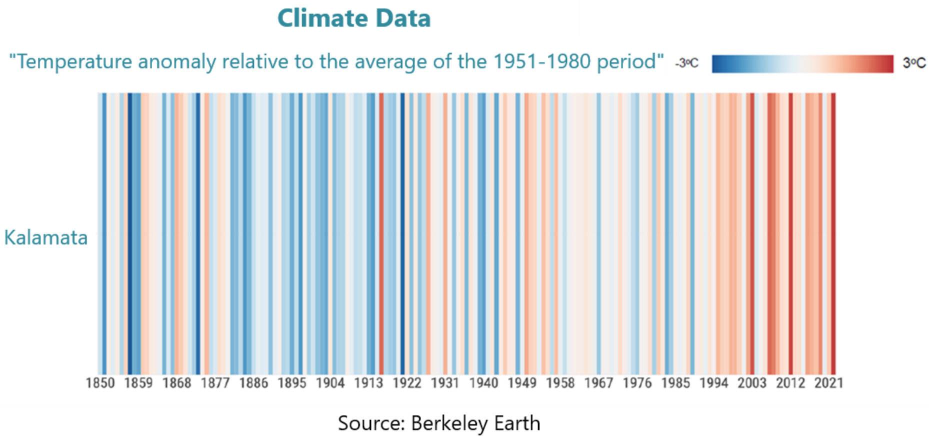

Fig.3. Temperature anomaly relative to the average of the 1951-1980 period for the city of Kalamata

Since April of 2022, Kalamata has been included in the network of cities "Mission for 100 Climate-Neutral and Smart Cities by 2030". These hundred cities from across Europe will act as innovation hubs and enable other cities in the future to follow their lead. The design includes a series of actions that will contribute to improving the energy efficiency of buildings, adopting sustainable urban regeneration practices, promoting the city's resilience, advancing sustainable mobility, generating energy from renewable sources, implementing circular economy principles and waste management, driving digital transformation, and fostering education and innovation.

A key goal in this process is to reduce the urban temperature, which involves mapping ground temperature variations across different city areas, comparing temperature extremes, and identifying locations for new green spaces to mitigate the Urban Heat Island effect and support climate neutrality. Reducing the temperature within the urban fabric is one of the primary objectives for the city's road towards climate neutrality. For this purpose, it is essential to map the ground temperature, considering the small fluctuations observed in various urban districts of the city.

2 Data and Methodology

2.1 Data

The data used for this study are Landsat TM 8-9 images. The algorithm for calculating the data was created using ARCGIS software [16]. The satellite images were retrieved from the website of the United States Geological Survey [17].

For estimating the brightness temperature values, Band 10 and Band 11 (Thermal infrared bands) were used, while for calculating the NDVI (Normalized Difference

Vegetation Index), Band 4 and Band 5 were used accordingly. Below is the methodology used, analyzing the typology [18], [19].

2.2 Methodology

The paper employs satellite remote sensing and GIS-based spatial analysis to map and analyze the UHI effect. It involves the creation of surface temperature maps for Kalamata to illustrate urban heat distribution and identify green corridors that help reduce UHI effects. It includes a comparative evaluation of current green spaces versus projected green spaces by 2030, aiming to assess the potential for urban cooling.

The methodology applied in this study follows well-established approaches that have been widely used in the literature for the estimation of Land Surface Temperature (LST) and the Urban Heat Island (UHI) index. The procedure has been tested in several urban contexts and provides a robust framework for analyzing thermal patterns through satellite remote sensing and GIS [18],[19]. In this study, the methodology was adapted and applied to the case of Kalamata in order to map temperature variations and identify areas suitable for the design of green routes.

The methodology for creating the Surface Temperature Map involves several steps. First, Digital Numbers (DN) from satellite imagery are converted into Top of Atmosphere (TOA) spectral radiance using specific rescaling factors for each band. Then, the TOA radiance is converted into at-satellite brightness temperature with thermal conversion constants. Next, the Normalized Difference Vegetation Index (NDVI) is calculated using bands 4 and 5, which helps assess vegetation coverage. Based on NDVI values, the proportion of vegetation (PV) is calculated, representing the vegetation cover percentage. Land Surface Emissivity (LSE) is determined from the vegetation fraction, and the Land Surface Temperature (LST) is computed using brightness temperature and LSE. Finally, the Urban Heat Island (UHI) index is calculated using the mean and standard deviation of the LST raster, enabling the analysis of thermal patterns and the identification of urban heat islands. These steps collectively allow for a comprehensive analysis of surface temperature and vegetation coverage in a GIS environment. More analytically, the following steps are followed for the creation of the Surface Temperature Map:

i) Converting Digital Numbers (DN) to Top of Atmospheric Spectral Radiance (TOA)

$$L\lambda = ML * QCal + AL \tag{1}$$

Where:
*$L\lambda$ = TOA spectral radiance (Watts/m2*srad*μm))*
M_L = Band-specific multiplicative rescaling factor from the metadata (RADIANCE_MULT_BAND_x, where x is the band number)
A_L = Band-specific additive rescaling factor from the metadata (RADIANCE_ADD_BAND_x, where x is the band number)
Q_{cal} = Quantized and calibrated standard product pixel values (DN)

ii) Conversion of TOA to At-Satellite Brightness Temperature

$$BT = K2 / \ln (K1 / L\lambda + 1) - 273.15 \quad (2)$$

Where:
BT = Top of atmosphere brightness temperature (°C)
*Lλ = TOA spectral radiance (Watts/m2*srad*μm)*
K1 = Band-specific thermal conversion constant from the metadata (constants that are referenced in the accompanying TXT file of each satellite image. For this reason, we refer to the accompanying file every time, as each satellite image may have different values)
K2 = Band-specific thermal conversion constant from the metadata (Constants that are referenced in the accompanying TXT file of each satellite image. For this reason, we refer to the accompanying file every time, as each satellite image may have different values)

iii) Calculating NDVI. The calculation of the Normalized Difference Vegetation Index (NDVI) is crucial because in the next step, the proportion of vegetation (PV) will need to be calculated. For this reason, we will use bands 4 and 5 of the satellite image

$$NDVI = (NIR_{band5} - RED_{band4}) / (NIR_{band5} + RED_{band4}) \quad (3)$$

Where:
NIR = Near Indfrared Band (band5)
RED = Red Band (band4)

iv) Calculating the Proportion of Vegetation. The vegetation ratio is defined as the percentage of vegetation cover on the ground in a vertical projection. The percentage of vegetation is closely related to the NDVI values for both vegetation and soil.

$$Pv = [(NDVI - NDVI_{min}) / (NDVI_{max} + NDVI_{min})]^2 \quad (4)$$

Where:
Pv = Proportion of vegetation or Vegetation Fraction
$NDVI_{min}$= Minimum DN Values from NDVI Image
$NDVI_{max}$= Maximum DN Values from NDVI Image

v) Calculating Land Surface Emissivity (LSE)

$$E = 0.004 * PV + 0.986 \quad (5)$$

Where:
Pv = Proportion of vegetation or Vegetation Fraction
E = Land Surface Emissivity

vi) Calculating Land Surface Temperature. LST (Land Surface Temperature) affects the distribution of energy between the soil and photosynthetic chlorophyll and determines the temperature of the surface air. It also influences the thermal environment locally within an area [20].

$$LST = BT / [1 + W * (BT / C2) * Ln(E)] \quad (6)$$

Where:
BT = Top of atmosphere brightness temperature (°C)
E = Land Surface Emissivity
*C2 = h * e/s = 1.4388 *10-2 mk = 14388 mk*
h = Planck's constant (6.626 × 10−34 J s)
e = velocity of light (2.998 × 108 m/s)
s = Boltzmann constant (1.38 × 10−23 J/K)
W = Wavelength of emitted radiance (values of W in Band10 = 10.8, values for Band11 = 12)

The final step was to calculate the Urban Heat Island (UHI) effect index in GIS environment. The mean value and the standard deviation value are displayed in the properties tab for each generated LST raster file, as created in the previous stage.

$$UHI_{index} = LST - LSTm/LSTsd \quad (7)$$

Where:
LSTm= The mean value of LST from the generated RASTER file
LSTsd = The standard deviation of LST from the generated RASTER file

3 Results

The first map produced concerns the Land Surface Temperature (LST) for the city of Kalamata. LST, using Geographic Information Systems (GIS), refers to the temperature of the Earth's surface as measured by satellite remote sensing data indicates the actual surface temperature, unlike air temperature, which is influenced by atmospheric conditions [21]. So, LST represents the temperature of the actual surface (such as soil, vegetation, or buildings) and is derived from infrared radiation data, which is collected by satellite image sensors like Landsat, MODIS, or ASTER [22]. These sensors measure the amount of thermal radiation emitted from the surface. This data is then used to calculate the surface temperature, providing valuable insights into local thermal conditions [23].

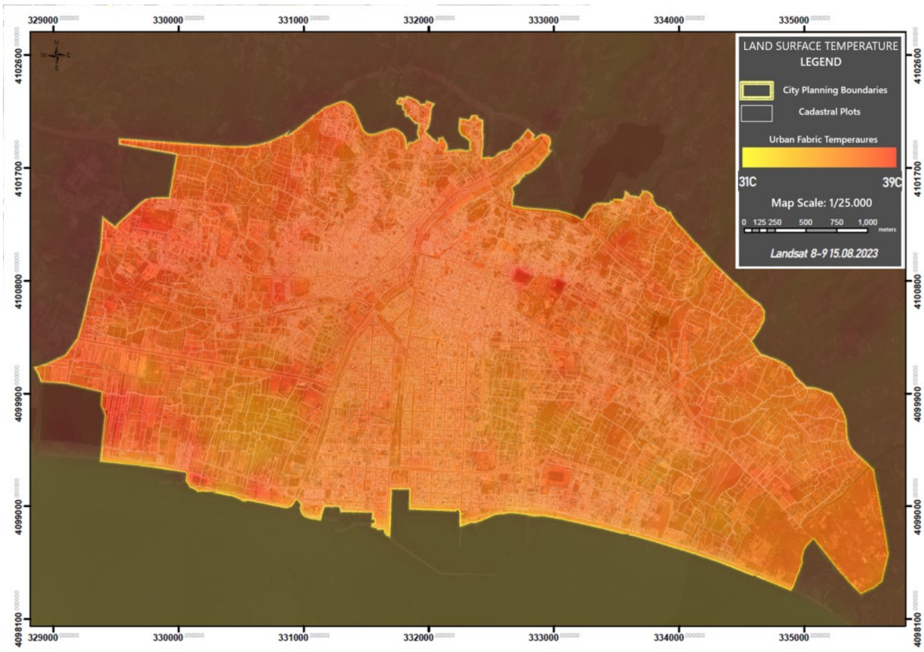

Fig.4. Mapping LST in the city of Kalamata based on the Landsat satellite image (15-8-2023)

Land Surface Temperature (LST) serves as a vital tool for understanding surface temperatures on both local and global scales, offering essential data for urban planning, environmental management, and climate change monitoring. Following this, a map illustrating the Urban Heat Island (UHI) effect was developed, highlighting temperature variations within the urban areas.

The analysis of Landsat imagery (15 August 2023) revealed that land surface temperatures (LST) across Kalamata ranged from 27 °C to 41 °C, with an average of 34.2 °C. The highest values were concentrated in the western districts, characterized by dense built-up areas and limited vegetation, whereas cooler conditions (below 30 °C) were observed near the Taygetos foothills. The calculated Urban Heat Island (UHI) intensity, defined as the difference between urban and peri-urban LST, ranged between 4–7 °C during daytime, while at night the intensity reached up to 9 °C. These findings confirm the spatial heterogeneity of thermal stress within the urban fabric.

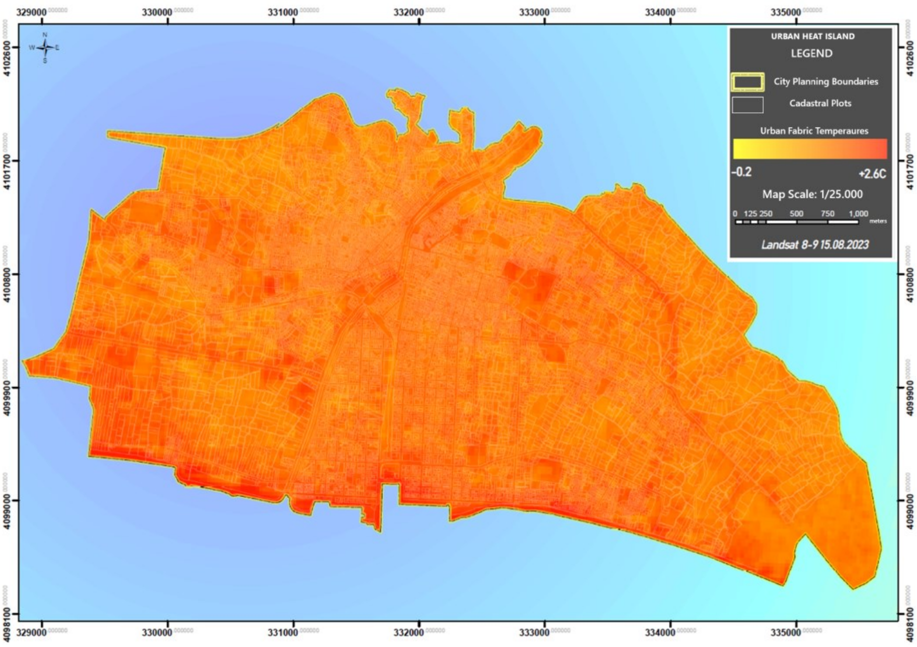

Fig.5. Urban Heat Island Map for the city of Kalamata

By consistently using and analyzing data over an extended period, the mapping will provide increasingly reliable information. Additionally, through mapping existing green spaces, it will be possible to analyze and compare temperature variations within the urban area, in relation to the 2030 goal of more than doubling the city's green spaces. This will help significantly reduce the temperatures caused by the Urban Heat Island effect.

Fig.6. This illustrates the current recorded green spaces in Kalamata, shown in green on the upper image, alongside the predicted expansion of green spaces by 2030, shown on the bottom image. The comparison highlights the planned increase in green areas to help reduce urban heat and improve environmental quality

4 Discussion and Proposal of Green Routes

4.1 Discussion

The analysis of Land Surface Temperature (LST) and Urban Heat Island (UHI) patterns in Kalamata reveals pronounced intra-urban disparities. Figure 6a illustrates the current fragmented distribution of green spaces, while Figure 6b shows the projected expansion of greenery by 2030. This comparison highlights the uneven coverage of vegetation across the city, with the most intense hot spots located in the western districts.

These western neighborhoods are characterized by higher commercial and industrial activity, where impervious surfaces such as asphalt and concrete absorb and retain heat.

Similar findings have been documented in other cities, confirming the role of surface materials in exacerbating UHI effects [10]. Another important factor is the age and typology of the building stock. Much of the western urban fabric predates the 1986 earthquake and is composed of older structures that lack modern bioclimatic design features. These buildings store more heat, reduce natural ventilation, and thus intensify local UHI effects, as shown in comparable Mediterranean contexts [7].

By contrast, the eastern neighborhoods benefit from proximity to Mount Taygetos. The mountain topography promotes natural airflow and ventilation, while lower building density and partial shading from terrain reduce thermal stress. Such geographical influences illustrate how topography, urban morphology, and land use jointly determine local microclimates ([9].

Overall, the spatial analysis confirms that UHI intensity in Kalamata is not uniformly distributed but is strongly linked to land use, architectural history, and topographical constraints. This underlines the importance of integrating both environmental and socio-spatial dimensions in urban planning. In this context, the identification of hot spots is not only diagnostic but also prescriptive, as it indicates priority zones for targeted interventions.

The presence of such significant intra-urban differences, with nighttime UHI intensities approaching 9 °C, highlights the vulnerability of the western neighborhoods as critical thermal hot spots. Similar studies in Mediterranean cities have demonstrated that targeted green infrastructure interventions (e.g., tree planting, permeable pavements) can reduce local surface temperatures by 2–4 °C, thereby mitigating these disparities. This quantitative evidence strengthens the case for prioritizing the western districts in climate-sensitive planning.

4.2 Proposal of Green Routes

To address these disparities, the study proposes the development of green routes as a multifunctional strategy that combines climate adaptation, mobility, and ecological connectivity. The concept entails integrating existing and planned green areas into a continuous network, ensuring that every resident can access shaded environments within a 15-minute walk. This vision aligns with the principles of equitable urbanism and the EU's "100 Climate-Neutral and Smart Cities by 2030" initiative.

The design of green routes is based on three main criteria:

1. Thermal vulnerability – priority is given to areas with the most intense hot spots
2. Accessibility and connectivity – routes should link neighborhoods, public spaces, and mobility hubs
3. Compatibility with urban morphology – interventions must adapt to narrow streets, dense built environments, and heritage constraints

A variety of green infrastructure measures can be integrated: tree-lined boulevards for shade and evapotranspiration, pocket parks and climbing plants in narrow streets, permeable and cool pavements to reduce surface heat absorption, and green roofs or vertical gardens to extend greenery into the built environment [5]. Evidence from other cities shows that such interventions can lower ambient temperatures, improve air quality, and enhance biodiversity [11]. Ultimately, these routes aim to ensure that residents can move through the city more comfortably and safely during hot summer days, reducing exposure to extreme temperatures while also enhancing the overall urban experience [24].

Special emphasis should be placed on the western districts of Kalamata, where the convergence of economic activity, outdated building stock, and lack of vegetation creates critical thermal vulnerability. In these areas, green routes must not be conceived merely as recreational amenities but as structural interventions that integrate with energy retrofitting programs, stormwater management, and public space regeneration. Such multifunctional strategies can simultaneously advance climate mitigation, social well-being, and resilience.

Beyond the environmental and technical dimensions, the integration of social perspectives is essential. Green routes are not merely ecological corridors but also everyday public spaces that enhance walkability, safety, and social cohesion. International experiences, such as in Barcelona and Copenhagen, show that combining thermal mapping with resident surveys or participatory workshops results in more widely accepted and effective interventions. In Kalamata, involving citizens through participatory planning or citizen science initiatives could provide valuable insights into preferred routes, perceived comfort levels, and community priorities. Such engagement would ensure that green routes respond to both climatic challenges and social needs.

Ultimately, green routes in Kalamata provide a replicable model of climate-sensitive urban design, capable of reducing intra-urban thermal inequalities while also encouraging sustainable mobility and ecological continuity.

5 Conclusions

This study provides new evidence on the Urban Heat Island (UHI) effect in the city of Kalamata by employing Geographic Information Systems (GIS) and satellite remote sensing techniques. The results reveal clear spatial inequalities in land surface temperatures (LST), demonstrating that the western districts are disproportionately affected by heat stress due to a combination of land-use patterns, outdated building stock, and limited vegetation, while the eastern areas benefit from topographical ventilation and lower urban density. These findings reinforce the argument that UHI is not a uniform phenomenon but is shaped by the interplay between socio-economic activities, architectural practices, and geographical features.

Additionally, by mapping the existing green spaces throughout different urban neigh-borhoods, the city can identify areas that have insufficient green coverage and are therefore more vulnerable to high temperatures. These neighborhoods should be pri-oritized for the development of new green spaces. This approach is not new; historically, ancient societies have long recognized the importance of integrating green spaces within urban environments to mitigate heat, enhance living conditions, and provide communal gathering areas — examples of such practices can be traced back to ancient Greek agoras, Roman gardens, and Persian paradise gardens [25]. It is essential to ensure that green spaces are evenly distributed across the city to avoid creating areas with limited access to cooling and recreational spaces.

The integration of these results into urban planning highlights the necessity of adopting green infrastructure strategies that extend beyond isolated parks or small-scale plantings. The proposed network of green routes emerges as a coherent framework capable of connecting fragmented green areas, ensuring equitable access to cooling, and enhancing ecological connectivity across the city. Such interventions should be understood not merely as environmental measures, but as cross-cutting solutions that address public health, social inclusion, energy efficiency, and biodiversity simultaneously.

In the context of climate change and rising heat extremes, the role of municipalities becomes increasingly decisive. For Kalamata, green routes represent both a local adaptation strategy and a contribution to the broader European objective of climate neutrality. By targeting the most vulnerable districts and integrating green corridors into existing urban morphology, the city can reduce thermal inequalities, promote sustainable mobility, and enhance overall resilience. Importantly, this approach aligns with the EU's Mission for 100 Climate-Neutral and Smart Cities by 2030, positioning Kalamata as a frontrunner in climate-sensitive urban design.

Nevertheless, the successful implementation of green routes requires systematic planning and governance. Future steps should involve:

- conducting detailed microclimatic and social impact assessments
- developing participatory planning processes to ensure community acceptance
- integrating building retrofitting and energy efficiency programs with green route development
- securing financial mechanisms and EU funding instruments to support long-term maintenance

Equally important is the systematic engagement of local residents in the planning process. Participatory approaches can secure community acceptance and ensure that green routes are not only environmentally efficient but also socially inclusive and resilient.

At the same time, continuous monitoring and evaluation through remote sensing, in-situ measurements, and citizen science will be necessary to track progress and optimize interventions. Expanding interdisciplinary collaborations between urban planners, climatologists, ecologists, and local communities will also strengthen the adaptive capacity of the city.

Finally, the findings of this research offer insights beyond Kalamata. Many Mediterranean cities share similar conditions—dense urban cores, limited vegetation, and topographical constraints—that make them particularly vulnerable to UHI effects. The methodological framework presented here, combining GIS-based mapping, spatial analysis of LST, and the design of green routes, can serve as a transferable model for other urban areas. By adopting such integrated strategies, cities can move closer to achieving climate neutrality, improving livability, and securing resilience for future generations.

References

1. Kyriakopoulos, P. (2022). "Study of the Urban Heat Island Phenomenon in the City of Kalamata – Impact on the Energy Performance of Buildings," Doctoral Dissertation, Department of Mechanical and Aeronautical Engineering, University of Patras (in Greek)
2. Malaperdas, G. (2019). The influence and impact of bioclimatic indicators on the evolution of biosociety. a geoarchaeological approach. World News of Natural Sciences, 24
3. Lifeasti Homepage, https://app.lifeasti.eu/, last accessed 2025/03/02
4. Shishegar, N. (2014). The impacts of green areas on mitigating urban heat island effect: A review. The International Journal of Environmental Sustainability, 9(1), 119
5. Irfeey, A. M. M., Chau, H. W., Sumaiya, M. M. F., Wai, C. Y., Muttil, N., & Jamei, E. (2023). Sustainable mitigation strategies for urban heat island effects in urban areas. Sustainability, 15(14), 10767
6. Parker, D. E. (2010). Urban heat island effects on estimates of observed climate change. Wiley Interdisciplinary Reviews: Climate Change, 1(1), 123-133
7. Deilami, K., Kamruzzaman, M., & Liu, Y. (2018). Urban heat island effect: A systematic review of spatio-temporal factors, data, methods, and mitigation measures. International journal of applied earth observation and geoinformation, 67, 30-42
8. Climatebook Homepage, https://climatebook.gr/, last accessed 2025/03/02
9. Cui, Y., Xu, X., Dong, J., & Qin, Y. (2016). Influence of urbanization factors on surface urban heat island intensity: A comparison of countries at different developmental phases. Sustainability, 8(8), 706
10. Akbari, H., Pomerantz, M., & Taha, H. (2001). Cool surfaces and shade trees to reduce energy use and improve air quality in urban areas. Solar energy, 70(3), 295-310
11. Gong, C., Yang, R., & Li, S. (2024). The role of urban green space in promoting health and well-being is related to nature connectedness and biodiversity: Evidence from a two-factor mixed-design experiment. Landscape and Urban Planning, 245, 105020
12. Mohajerani, A., Bakaric, J., & Jeffrey-Bailey, T. (2017). The urban heat island effect, its causes, and mitigation, with reference to the thermal properties of asphalt concrete. Journal of environmental management, 197, 522-538
13. Ürge-Vorsatz, D., Cabeza, L. F., Serrano, S., Barreneche, C., & Petrichenko, K. (2015). Heating and cooling energy trends and drivers in buildings. Renewable and Sustainable Energy Reviews, 41, 85-98
14. Tzavali, A., Paravantis, J. P., Mihalakakou, G., Fotiadi, A., & Stigka, E. (2015). Urban heat island intensity: A literature review. Fresenius Environmental Bulletin, 24(12b), 4537-4554
15. World Bank. Economic Profile: Municipality of Kalamata (English). Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/099100124053513632
16. Aniello, C., Morgan, K., Busbey, A., & Newland, L. (1995). Mapping micro-urban heat islands using Landsat TM and GIS. Computers & Geosciences, 21(8), 965-969
17. Amindin, A., Pouyan, S., Pourghasemi, H. R., Yousefi, S., &Tiefenbacher, J. P. (2021). Spatial and temporal analysis of urban heat island using Landsat satellite images. Environmental Science and Pollution Research, 28, 41439-41450
18. Rousta, I., Sarif, M. O., Gupta, R. D., Olafsson, H., Ranagalage, M., Murayama, Y., ... & Mushore, T. D. (2018). Spatiotemporal analysis of land use/land cover and its effects on surface urban heat island using Landsat data: A case study of Metropolitan City Tehran (1988–2018). Sustainability, 10(12), 4433
19. Twumasi, Y.A., Merem, E.C., Namwamba, J.B., Mwakimi, O.S., Ayala-Silva, T., Frimpong, D.B., Ning, Z.H., Asare-Ansah, A.B., Annan, J.B., Oppong, J., Loh, P.M.,

Owusu, F.,Jeruto, V.,Petja, B.M., Okwemba, R., McClendon-Peralta, J., Akinrinwoye, C.O. and Mosby, H.J. (2021) Estimation of Land Surface Temperature from Landsat-8 OLI Thermal Infrared Satellite Data. A Comparative Analysis of Two Cities in Ghana. Advances in Remote Sensing, 10, 131-149

20. Andronis, V. (2022). "Remote Sensing Techniques for Highlighting the Dynamics and Characteristics of Mediterranean Vegetation," School of Rural and Surveying Engineering and Geoinformatics, Doctoral Dissertation, National Technical University of Athens (in Greek)
21. de Réotier, P. D., Gubbens, P. C. M., Yaouanc, A., & Bertin, A. (2021). Using ArcGIS Software and Remote Sensing Technology to Predict Land Surface Temperature (LST) for Monitoring Ecological and Climate Change in Hor Al-Dalmaj, Southern Iraq
22. Ndossi, M. I., &Avdan, U. (2016). Inversion of land surface temperature (LST) using Terra ASTER data: a comparison of three algorithms. Remote Sensing, 8(12), 993
23. Salwan, A. A., Ahmed, A. A., & Salim, M. A. (2021). Using ArcGIS Software and Remote Sensing Technology to Predict Land Surface Temperature (LST) for Monitoring Ecological and Climate Change in Hor Al-Dalmaj, Southern Iraq. In IOP Conference Series: Earth and Environmental Science (Vol. 790, No. 1, p. 012076). IOP Publishing
24. Malaperdas, G. (2022). Techniques for drawing and mapping a Cultural Route. e-Review of Tourism Research, 19(2), 280-307
25. Malaperdas, G.D. (2022): Returning to the past for the revival of the future: analyzing the value of old maps for the preservation of cultural heritage. In: Digital Approaches to Cartographic Heritage Conference Proceedings (Jan 2022). https://www.academia.edu/96676953