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Analyzing Temperature Variations and Vegetation Dynamics in Yasouj-Iran Using Satellite Imagery (2000-2020)

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ABSTRACT

Objective: This study aims to investigate the impact of urbanization on temperature changes and vegetation dynamics in Yasouj, Iran, over a 20-year period (2000-2020). The focus is on analyzing temperature variations (day and night) and vegetation cover, utilizing satellite imagery to identify trends and patterns related to urban development.

Methods: The research employed satellite data obtained from NASA's GIVANNI platform and Google Earth Engine (GEE) to analyze daily and night temperature patterns, as well as vegetation cover changes. The data were segmented into four five-year periods (2000-2005, 2005-2010, 2010-2015, and 2015-2020) to detect spatiotemporal variations in temperature and vegetation. GEE was utilized to create high-resolution maps, and spatial data analysis was conducted to identify the relationship between urban expansion, temperature changes, and vegetation dynamics.

Results: The study reveals a noticeable increase in surface temperatures, particularly during nighttime, correlating with urban sprawl. Vegetation cover exhibited both expansion and contraction over time, with significant reduction observed in urbanized areas. The study period from 2015 to 2020 showed a marked expansion of vegetation, while the 2005-2010 period saw significant decreases in vegetation in certain regions.

Conclusion: The findings emphasize the complex interaction between urbanization, temperature rise, and vegetation changes in Yasouj. The results underscore the importance of sustainable urban development strategies that prioritize green infrastructure to mitigate climate change impacts and enhance urban resilience. The study contributes valuable insights for urban planners and policymakers striving for climate-resilient cities.

1. Introduction

Understanding the interaction between land surface processes and climatic parameters has become increasingly critical in addressing environmental challenges such as global warming, urban heat islands, and ecosystem degradation (Huang et al., 2019). Land cover and land use (LCLU) play a vital role in influencing local and regional climatic patterns, particularly surface temperature variations (Mokhtarisabet et al., 2024). As land surfaces transition from vegetated areas to urban or impermeable landscapes, significant changes occur in energy balance, surface albedo, and evapotranspiration rates,

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all of which contribute to rising temperatures and altered climatic conditions (Forster et al., 2024).

Vegetation, as a key component of land cover, serves multiple ecological functions, including carbon sequestration, temperature regulation, and maintaining biodiversity (Wu, et al., 2024). However, rapid urbanization and land use changes have resulted in vegetation loss, leading to a decline in its regulatory functions. This, in turn, exacerbates the effects of climatic stressors on urban and rural environments (Wu et al., 2024; Mokhtarisabet et al., 2024). Surface temperature, a direct indicator of these transformations, has become a focal point in studies on climate change and land use dynamics (Patel et al., 2023). It is widely acknowledged that vegetation indices, such as the Normalized Difference Vegetation Index (NDVI), are inversely related to surface temperature, highlighting the cooling effect of vegetation (Hu et al., 2023).

Google Earth Engine (GEE) and NASA's Giovanni are powerful platforms for environmental monitoring and analysis, widely used in remote sensing and geospatial research. GEE provides a cloud-based infrastructure for large-scale geospatial data processing and analysis, offering access to an extensive repository of satellite imagery and geospatial datasets (Alvites et al., 2024). The platform enables users to conduct high-resolution spatial analyses, track temporal changes, and visualize data at various scales. Giovanni, developed by NASA, is a web-based tool designed to facilitate the exploration and analysis of satellite and climate data. It offers a user-friendly interface for accessing atmospheric, oceanic, and land surface data, making it an essential tool for studying environmental changes (Alvites et al., 2024). Both platforms have proven invaluable in studies of land use/land cover change, temperature variations, and vegetation dynamics, providing precise, up-to-date data that is crucial for understanding the impacts of urbanization and climate change. The integration of these tools in this study allows for a comprehensive analysis of the relationship between urban development, temperature fluctuations, and vegetation changes over time in Yasouj.

The effects of these changes are multifaceted, influencing not only atmospheric conditions but also hydrological cycles, soil stability, and ecosystem services. Numerous studies have explored the relationship between land use changes and surface temperature. For example, Ullah et al. (2024) demonstrated that urban expansion contributes to elevated temperatures due to the replacement of natural surfaces with materials that have higher thermal conductivity. Similarly, Mathew (2024) emphasized the role of surface temperature analysis in understanding global warming, agricultural drought, and urban heat island phenomena.

In addition to urbanization, climatic factors such as temperature and precipitation play a crucial role in shaping vegetation dynamics (Liu et al., 2024). Studies conducted in China's Golden Triangle" region (Zhu et al., 2022) revealed that temperature, more than precipitation, is the dominant factor influencing plant growth in mountainous regions. Further research by Yang et al. (2024) reinforced the importance of air temperature as an indicator of vegetation sensitivity to climate change.

In this study, the following hypotheses are proposed to guide this study:

- Hypothesis 1: Urbanization in Yasouj has led to a significant increase in both daytime and nighttime temperatures, particularly due to the expansion of impermeable surfaces, contributing to the urban heat island effect.
- Hypothesis 2: Vegetation cover in Yasouj has undergone significant spatial and temporal changes, with a general trend of expansion in recent years, although urban development continues to result in localized reductions in vegetation, especially in the city center.

The city of Yasouj, located in southwestern Iran, serves as a unique case study for analyzing the interplay between climatic factors and land use dynamics. Over the past two decades, the region has experienced significant changes in both vegetation cover and temperature patterns, driven by a combination of natural and anthropogenic factors. This study seeks to investigate these changes, focusing on the temporal and spatial variations in vegetation and surface temperature from 2000 to 2020. By integrating satellite imagery and climatic data, this research aims to provide actionable

insights into the drivers of environmental change and propose strategies for sustainable urban and ecological management.

2. Material and Methods

2.1. Study Area

The city of Yasouj, the capital of Kohgiluyeh and Boyer-Ahmad Province, is situated in southwestern Iran. Geographically, it lies at 30°28′ north latitude and 51°36′ east longitude. This region, characterized by its mountainous terrain and semi-arid climate, serves as a vital ecological and hydrological zone, with the Karun River as its primary water source. Yasouj's diverse topography, ranging from high-altitude mountains to valleys, creates a unique environment for studying the interactions between vegetation dynamics and climatic variables (Saberi et al., 2024).

The area has experienced significant urbanization over the past two decades, making it an ideal case study for investigating land use and cover changes and their impacts on surface temperature and vegetation. Fig. 1 illustrates the geographical location of Yasouj within the national and regional context.

Fig. 1- Study Area

2.2. Data Collection and Processing

2.2.1. Satellite Data Acquisition Using Google Earth Engine

The analysis of temperature changes (day and night) and vegetation in Yasouj city from 2000 to 2020 was conducted using Google Earth Engine (GEE), a cloud-based geospatial analysis platform (Alvites et al., 2024). The study focused on four five-year intervals: 2000–2005, 2005–2010, 2010–2015, and 2015–2020. Satellite datasets were selected based on their relevance to the study objectives:

2.2.2. Data Preprocessing in GEE

Preprocessing steps were performed within the GEE environment to ensure data accuracy and reliability:

Temporal Filtering: Data were filtered by date to extract imagery corresponding to the four selected intervals.

Cloud Masking: Cloud-contaminated pixels were identified using the MODIS quality assurance layer and removed to ensure data integrity.

Spatial Subsetting: The study area was defined using a polygon shapefile delineating Yasouj's administrative boundaries. This boundary was used to clip all satellite datasets for focused analysis.

Aggregation: Monthly and seasonal averages were calculated for both LST and NDVI to capture temporal patterns while minimizing short-term variability.

2.3. Analysis Methods

2.3.1. Statistical Analysis

Statistical analyses were conducted directly within GEE or exported for further analysis in statistical software. Key steps included:

Temporal Trend Analysis: Linear regression models were applied to detect trends in LST and NDVI over the 20-year period.

Correlation Analysis: The relationship between NDVI and LST was quantified using Pearson correlation to understand the cooling effect of vegetation.

2.3.2. Mapping and Visualization

GEE was utilized to create high-resolution spatial visualizations, including:

Vegetation Map: NDVI-based vegetation maps were generated to highlight the spatial distribution and density of vegetation cover. These maps were used to identify areas with significant vegetation loss or recovery over the study period.

Daily Temperature Map: Daily land surface temperature (LST) maps were created to show the spatial patterns of daytime temperature changes, providing insights into urban heat islands and other localized temperature anomalies.

Night Temperature Map: Nighttime LST maps were produced to analyze temperature patterns during cooler hours, offering a complementary perspective on heat retention and surface cooling in different land cover types.

3. Results

3.1. Spatial and Temporal Analysis of Daily Temperature Changes

The daily temperature maps for Yasouj city were analyzed over four time intervals: 2000–2005 (a), 2005–2010 (b), 2010–2015 (c), and 2015–2020 (d). The results indicate significant spatial and temporal variations in land surface temperatures across the study area (Fig.2).

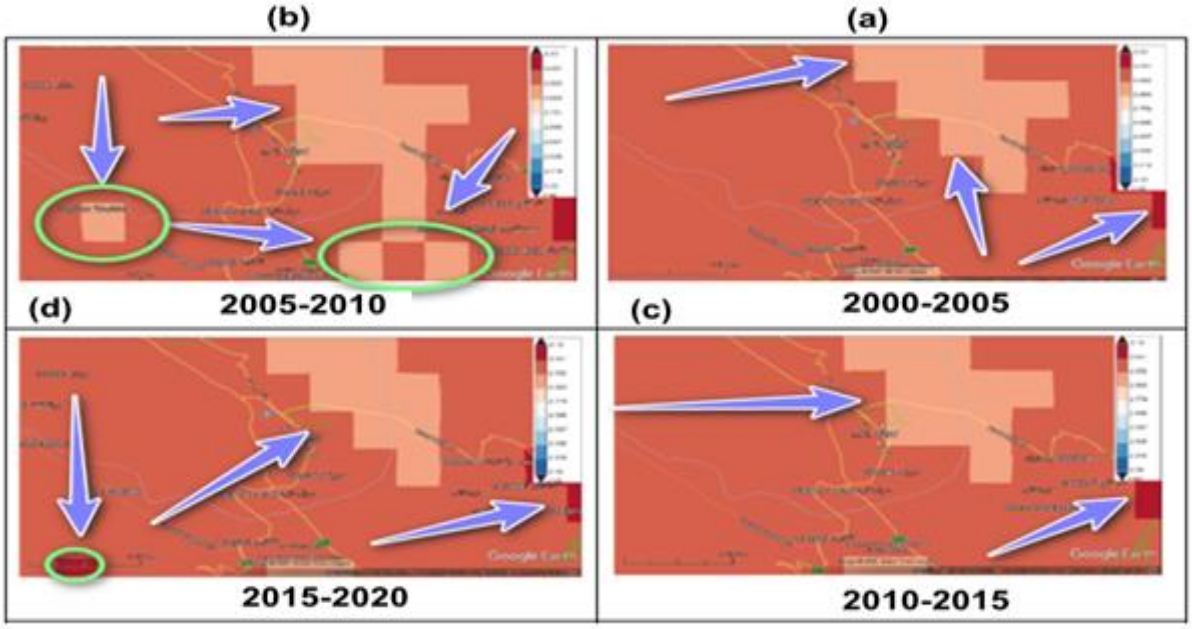

Fig. 2- Daily Temperature Map

- 2000–2005 (a):

The spatial distribution of temperature shows moderately high values across the city, with hotspots observed in urbanized areas and bare lands.

Vegetated regions in the northern and southeastern parts demonstrate relatively lower temperatures, reflecting the cooling effect of vegetation.

- 2005–2010 (b):

This period exhibits an overall increase in temperature, especially in urban expansion zones.

Specific areas (highlighted with arrows) show intensified heating, likely due to reduced vegetation cover and increased impervious surfaces.

- 2010–2015 (c):

The pattern of temperature increase continues, with prominent hotspots spreading further into surrounding areas.

Vegetated areas remain cooler, but their spatial extent appears to be shrinking, suggesting a gradual loss of vegetation.

- 2015–2020 (d):

The highest temperature levels are observed during this period, with significant urban heat islands expanding within and around the city center.

Minimal vegetated zones persist, predominantly in the southern region, serving as localized cooling areas.

- Key Observations

The maps highlight a clear trend of rising daily temperatures over the two decades, with the most pronounced changes occurring between 2015 and 2020.

Urbanization and land use changes, such as the conversion of vegetated areas to built-up land, are the primary contributors to temperature increases.

Vegetated zones consistently exhibit lower temperatures, emphasizing the critical role of vegetation in mitigating urban heat.

The results underscore the impact of rapid urbanization and vegetation loss on temperature dynamics in Yasouj city. Immediate actions, such as implementing sustainable urban planning and reforestation programs, are necessary to mitigate these adverse effects.

3.2. Spatial and Temporal Analysis of Night Temperature Changes

The night temperature maps for Yasouj city were analyzed over four time intervals: 2000–2005 (a), 2005–2010 (b), 2010–2015 (c), and 2015–2020 (d). These maps represent the spatial distribution of nighttime land surface temperature (LST), providing insights into the cooling dynamics of the study area during night hours (Fig. 3).

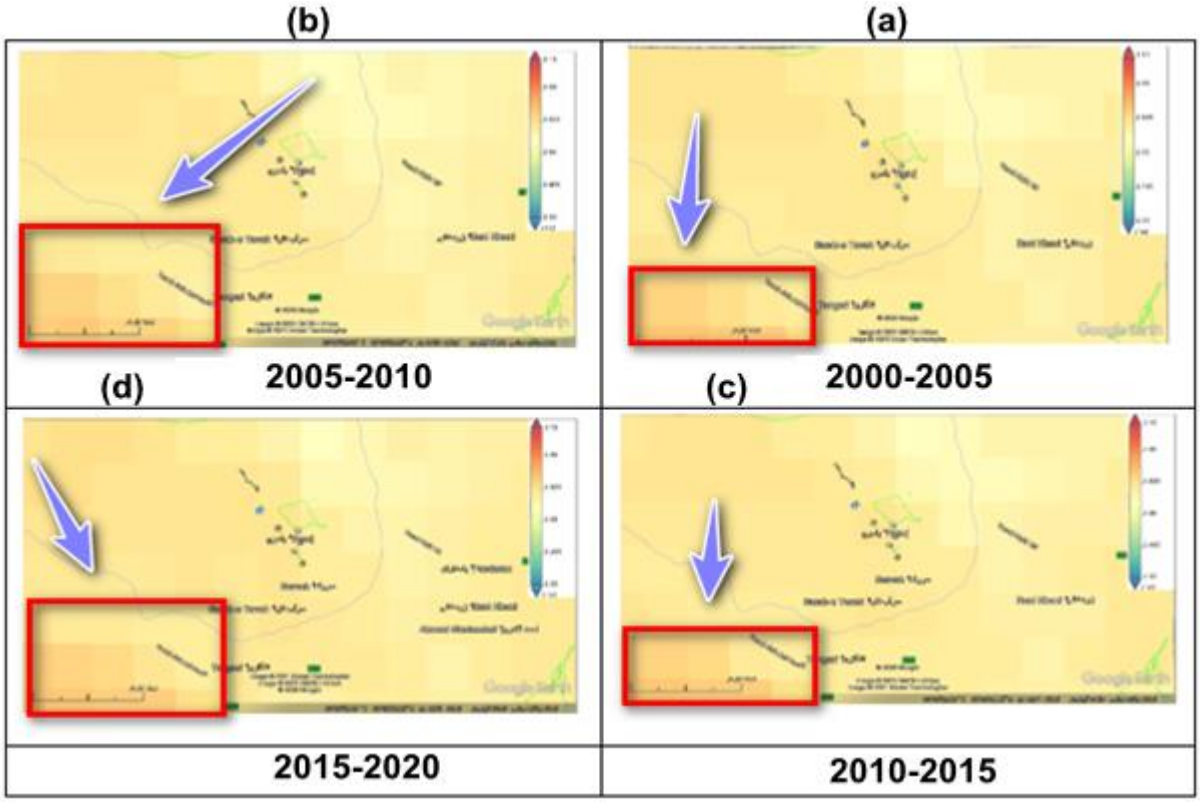

Fig.3 - Night Temperature Map

- 2000–2005 (a):

The spatial distribution of night temperatures during this period reveals moderate cooling, with the lowest temperatures observed in vegetated and sparsely developed regions of the city.

The urban center, particularly the areas with higher built-up surfaces, shows slightly higher night temperatures, likely due to heat retention from impervious surfaces.

- 2005–2010 (b):

This period shows a slight increase in nighttime temperatures, particularly in the southwestern part of the city, marked by expanding urbanization and a reduction in vegetation.

Vegetated areas continue to demonstrate cooler nighttime temperatures, with urban heat islands becoming more pronounced, especially near major roadways and industrial zones.

- 2010–2015 (c):

Nighttime temperatures continue to rise, with significant urban heat island effects becoming evident in the city center and surrounding areas.

The spatial extent of cooler areas (green regions) has noticeably reduced, and more widespread temperature increases are observed, suggesting further urban development and the loss of vegetation cover.

- 2015–2020 (d):

This period exhibits the highest nighttime temperatures, especially in the central urbanized areas, where the heat island effect is most intense.

The areas with the highest temperatures are located near the urban sprawl, particularly in the west and southeast of Yasouj. The reduction in cooler zones is clear, reflecting the continued conversion of vegetated areas to built-up land.

- Key Observations

The night temperature maps clearly show a trend of increasing nighttime temperatures over the past two decades, particularly in urbanized areas.

Urban heat islands have become more pronounced over time, with reduced cooling during the night due to the loss of vegetation and the expansion of impervious surfaces.

Vegetated regions still provide some cooling effect, but their extent has diminished, contributing less to moderating temperature changes.

The results reveal a clear pattern of rising nighttime temperatures in Yasouj city, driven by urbanization and the loss of vegetation. The urban heat island effect is becoming more pronounced, especially in the most developed parts of the city. These findings highlight the need for sustainable urban planning that prioritizes green spaces and mitigates the impacts of urban heat islands.

3.3. Spatial and Temporal Analysis of Vegetation Changes

The vegetation maps for Yasouj city were analyzed over four five-year periods: 2000–2005 (a), 2005–2010 (b), 2010–2015 (c), and 2015–2020 (d). The results reveal a noticeable trend of both expansion and reduction in vegetation across the study area, with distinct spatial and temporal changes observed in each period (Fig. 4).

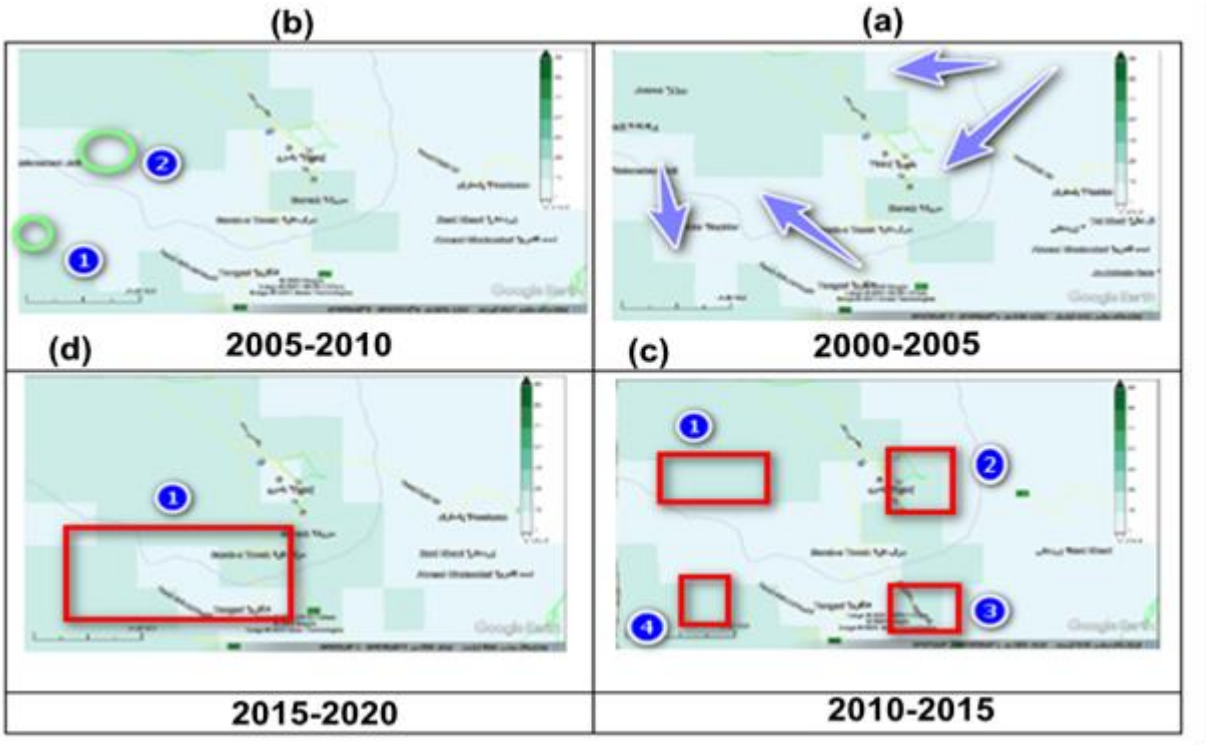

Fig. 4- Vegetation Map

- 2000–2005 (a):

During this period, vegetation cover is relatively stable, with some vegetation in the western and northern regions. The vegetated areas were mostly concentrated around the outskirts of the city and near natural reserves. The green areas demonstrate moderate vegetation, though further development of urban areas started to appear in the southern parts of Yasouj.

2005–2010 (b):

This period shows a slight decrease in vegetation in some parts of the city, particularly in the southern and southwestern regions. Areas marked by green circles indicate regions where vegetation cover has diminished, likely due to urban expansion, agricultural development, or land conversion to other uses.

Despite the decrease in some areas, certain northern and eastern parts of Yasouj experienced stable or minor increases in vegetation cover.

- 2010–2015 (c):

Vegetation changes became more prominent during this period, with a mix of expansion and reduction in different areas. In the southeastern part of Yasouj, there was a notable increase in vegetation cover, likely driven by reforestation efforts or reduced agricultural activity.

At the same time, urban sprawl continued to reduce vegetation in the central and southern areas, leading to a noticeable decrease in vegetation cover.

- 2015–2020 (d):

The most significant changes in vegetation were observed in this period, with a substantial expansion of vegetation cover in several areas of the city. Areas marked by red rectangles show clear expansions in vegetation, which might be due to environmental policies promoting green spaces, as well as natural

growth in some less-developed areas.

However, some areas, especially in the south, continued to experience reductions in vegetation cover due to ongoing urbanization.

- Key Observations

The trend over the 20 years shows an overall positive change in vegetation, especially in the latter half of the study period. The most significant vegetation expansion occurred from 2015 to 2020, with the northern and eastern parts of Yasouj seeing notable improvements in vegetation cover.

The regions marked with green circles in earlier periods (2005–2010) demonstrate a decrease in vegetation cover, likely caused by urban development and changes in land use.

Despite the positive trend in vegetation growth, the southern areas continue to lose vegetation due to urbanization and industrial expansion.

The results of the vegetation analysis indicate a mixed pattern of vegetation expansion and loss in Yasouj city over the past two decades. While the northern and eastern regions have experienced significant vegetation growth, urbanization in the southern parts of the city has led to a reduction in vegetation cover. The expansion of green spaces in recent years (2015–2020) suggests that conservation efforts may be having a positive impact. However, continued monitoring and sustainable urban planning will be essential to ensure the preservation and expansion of vegetation in the face of ongoing urbanization.

4. Dissussion

Land cover and vegetation dynamics are crucial indicators of environmental health and urbanization impacts, particularly in rapidly developing cities like Yasouj. Over the last two decades, the area has witnessed significant changes in both temperature and vegetation, reflecting broader global climate and land-use transformations. This study aimed to assess temperature variations (daytime and nighttime) and vegetation changes in Yasouj from 2000 to 2020 using satellite imagery obtained from Google Earth Engine and NASA's Giovanni platform. By analyzing these changes in four distinct five-year periods, this research provides valuable insights into the interaction between urbanization, land use, and climate change.

The results revealed a clear upward trend in both daytime and nighttime temperatures in Yasouj over the last two decades. From the analysis of temperature maps, it was evident that urbanization played a central role in this rise. The urban heat island (UHI) effect, characterized by significantly higher temperatures in urban areas compared to surrounding rural zones, became more prominent after 2015, with the most significant increases observed from 2015 to 2020. These findings are consistent with studies in other regions, where urbanization led to higher surface temperatures, particularly in developing cities (Nayak et al., 2023; Zafar et al., 2024).

The shift towards higher temperatures, particularly at night, aligns with global trends highlighted by previous research that demonstrates the increasing intensity of UHI effects as cities grow and natural landscapes are replaced by built environments (Joshi et al., 2024). This warming trend is concerning as elevated nighttime temperatures can exacerbate health problems, increase energy consumption for cooling, and disrupt local ecosystems (Singh et al., 2020). The results of this study support the findings of Mustafa et al. (2021), who reported a significant correlation between land-use dynamics and surface temperature increases. The expanding urban footprint of Yasouj, particularly after 2015, likely contributed to the growing heat island effect, further validating the need for sustainable urban planning to mitigate temperature extremes.

The analysis of vegetation cover from 2000 to 2020 revealed a mixed pattern of vegetation expansion and reduction across the study area. Notably, the most significant vegetation expansion occurred between 2015 and 2020, primarily in the northern and eastern parts of Yasouj. This

expansion could be attributed to local reforestation efforts, improved land management practices, or a natural recovery process in less urbanized areas. These findings align with the results of studies in other regions where land cover improvements were linked to better environmental management practices and vegetation recovery (Gao et al., 2020).

However, the results also indicate a concerning decline in vegetation cover in certain areas, especially the southern and southwestern parts of Yasouj. These reductions are likely a direct consequence of urban expansion, agricultural intensification, and land conversion, as observed in similar studies across the globe. The regions with reduced vegetation (as highlighted by green circles in the vegetation maps) reflect the pressures of urbanization, where green spaces are replaced by built infrastructure. These findings highlight the ongoing challenges cities face in balancing development with environmental sustainability.

The mixed results in vegetation dynamics underline the need for targeted policies to promote urban greening and mitigate the adverse effects of urban sprawl. The positive trend observed in vegetation cover during the 2015–2020 period suggests that efforts to enhance green spaces and preserve natural areas are beginning to show results. This supports the argument made by previous studies that urban green spaces can play a crucial role in mitigating temperature increases and enhancing the overall quality of life in cities (Adıgüzel, 2023).

The analysis of both temperature and vegetation changes in Yasouj underscores the importance of integrating climate adaptation strategies into urban planning. The rise in temperatures, particularly at night, and the mixed vegetation trends, highlight the urgency of addressing the UHI effect through the creation of more green spaces, tree planting initiatives, and the implementation of sustainable land-use practices.

Additionally, the findings emphasize the need for continuous monitoring of land-cover changes and temperature variations, which can serve as critical indicators for assessing the effectiveness of climate change mitigation strategies. The positive trend in vegetation expansion observed during the last five-year period should be built upon, with an emphasis on urban greening to reduce the impact of the urban heat island effect and improve overall environmental quality.

5. Conclusion

This study underscores the intricate relationship between urbanization, temperature changes, and vegetation dynamics in Yasouj. Through the analysis of satellite imagery spanning two decades (2000-2020), significant trends in both temperature and vegetation cover were identified. The findings demonstrate that as urbanization has accelerated in the region, surface temperatures, particularly at night, have risen, likely contributing to the intensification of the urban heat island (UHI) effect. Concurrently, vegetation cover has shown a mixed trend, with areas of expansion as well as significant reduction, primarily driven by urban sprawl and land-use changes.

The results of this research highlight the pressing need for sustainable urban development strategies that focus on the preservation and enhancement of natural ecosystems. Protecting and expanding green spaces within urban areas are essential steps in mitigating the adverse effects of climate change, including reducing local temperature extremes and improving the quality of life for urban residents. The importance of integrating green infrastructure into city planning cannot be overstated, as it not only helps combat UHI effects but also contributes to improved air quality, enhanced biodiversity, and greater resilience to climate impacts.

Moreover, the study provides valuable insights for policy makers, urban planners, and environmental researchers. The findings emphasize the need for continuous monitoring of land cover and temperature changes to evaluate the effectiveness of climate adaptation measures and to guide urban planning decisions. There is also a growing recognition that urban greening, tree planting, and

the protection of natural landscapes should be prioritized to ensure a sustainable, climate-resilient future.

Based on the findings of this study, several recommendations can be made:

- Urban Greening Initiatives: Implement large-scale tree planting and green space development projects to mitigate the UHI effect and improve the urban climate.
- Sustainable Land-Use Planning: Encourage policies that promote sustainable land use and urban expansion, prioritizing the protection of natural habitats and vegetation.
- Climate Resilience Strategies: Integrate climate resilience into urban planning by promoting green infrastructure, which can help cities adapt to the impacts of climate change.
- Continuous Monitoring: Establish long-term monitoring programs using remote sensing technologies to track changes in land cover, temperature, and vegetation, aiding in adaptive management and decision-making.
- Public Awareness and Education: Promote community involvement in urban greening initiatives, raising awareness of the benefits of green spaces and sustainable urban development.

In conclusion, this study not only contributes to the understanding of urban environmental changes in Yasouj but also serves as a model for other cities facing similar challenges. By adopting sustainable urban development strategies, cities can enhance their resilience to climate change and ensure a healthier, more sustainable future for their inhabitants.

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