Urban Heat in Nashville: The Impact of Impervious Surfaces on Surface Temperatures

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Introduction

Urbanization significantly alters local climates through the creation of impervious surfaces, such as roads and buildings, which absorb and retain heat. This phenomenon, known as the Urban Heat Island (UHI) effect, results in higher land surface temperatures (LST) in urban areas compared to surrounding rural regions.

This study examines the relationship between impervious surface coverage and LST in Nashville, Tennessee, focusing on the following questions:

1. How are impervious surfaces distributed across Nashville?
2. How does LST vary in areas with different levels of impervious surface coverage?
3. What patterns emerge when comparing LST and impervious surface data?

By addressing these questions, the project highlights the environmental impacts of urbanization and identifies hotspots where mitigation strategies, like increasing vegetation, could help reduce surface temperatures.

Methods and Data

This study used MODIS LST data (MOD11A2) to analyze land surface temperatures and NLCD 2019 impervious surface data to assess urban development. Community Planning Area boundaries from Nashville GIS were used to define the study area.

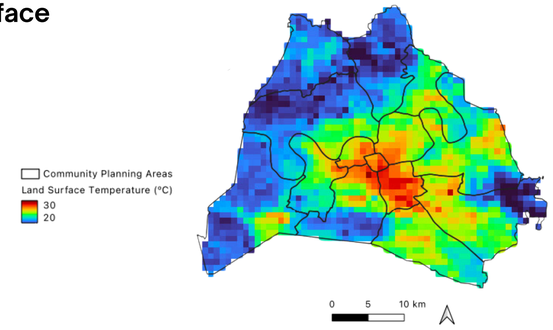
All datasets were reprojected to EPSG:4326 and clipped to the study area in QGIS. Maps were created to visualize LST, impervious surface distribution, and their overlap, highlighting patterns between urbanization and surface temperatures.

For my analysis, LST and impervious surface layers were combined to identify patterns and relationships.

Results

Figure 1: Heatmap of Land Surface Temperature in Nashville

Higher temperatures (27–30°C) occur in urbanized areas, while cooler areas (20–23°C) are found in regions with lower development and more natural land cover.



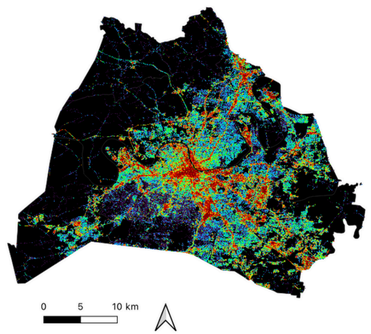
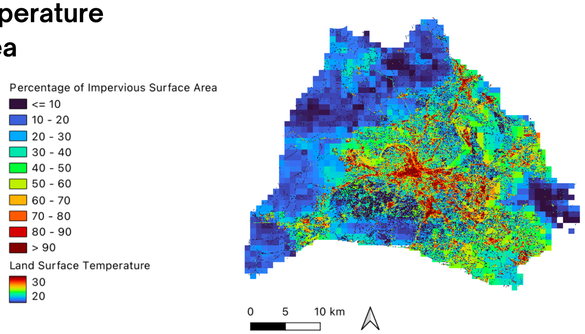


Figure 2: Distribution of Impervious Surfaces in Nashville

Impervious surfaces (e.g., roads, buildings) are densest in downtown Nashville (>90%), with lower percentages in rural, less urbanized areas (<10%).

Figure 3: Land Surface Temperature and Impervious Surface Area

Areas with high impervious surface percentages align with higher surface temperatures, highlighting the relationship between urbanization and increased heat.



Discussion

Key Findings

- High impervious surface areas (>70%) align with elevated surface temperatures (>27°C), highlighting the Urban Heat Island effect.
- Cooler areas (<23°C) are concentrated in regions with more vegetation and less development.

Implications

- Urban heat can increase energy demands and heat stress, particularly in highly developed areas.
- Expanding green infrastructure could mitigate rising temperatures.

Limitations

- LST data is from a single time period and does not capture seasonal variations.
- The coarse resolution of MODIS data limits local-scale analysis.

Future Work

- Examine seasonal trends in LST.
- Evaluate the impact of green infrastructure on temperature reduction.

Conclusion

This study highlights the strong relationship between impervious surfaces and elevated land surface temperatures in Nashville. Urban areas with high impervious coverage experience the greatest heat impacts, emphasizing the need for sustainable urban planning

Expanding green spaces and implementing cooling strategies can help mitigate the UHI effect and improve urban resilience. Future research should explore seasonal trends and assess the effectiveness of mitigation measures.