

Urban heat wave patterns in Brussels (2004-2024): exploring the interplay between vegetation cover and built environment through remote sensing approach

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Abstract:

Urban heat waves pose increasing challenges to cities worldwide, with Brussels experiencing significant thermal stress events over the past two decades. This study investigates the relationship between heat wave occurrence, vegetation cover, and built-up density in the Brussels Capital Region using remote sensing data from 2004 to 2024. Land surface temperature (LST) data derived from Landsat 8 satellite imagery were analyzed alongside normalized difference vegetation index (NDVI) and built-up indices to understand their spatial and temporal correlations during heat wave events.

The analysis revealed that areas with vegetation cover below 30% consistently experienced elevated temperatures, with surface temperatures during heat wave events reaching up to 2.5°C higher compared to well-vegetated neighborhoods. In regions where built-up density exceeded 75%, LST values were on average 2.0-3.2°C higher than in areas with moderate urbanization (40-60% built-up cover). Temporal analysis indicated a 20% increase in the frequency of heat wave events and a 15% rise in their average duration from 2004 to 2024, with the most significant impacts observed in high-density urban districts. Furthermore, neighborhoods with vegetation loss exceeding 10% over the 20-year period saw an additional 0.8-1.2°C rise in surface temperatures during heat waves, highlighting the critical role of green spaces in moderating UHI intensities. These findings underscore the disproportionate thermal stress faced by densely urbanized areas, emphasizing the necessity for targeted urban greening interventions.

Keywords: Urban Heat Island (UHI); Landsat; climate change; thermal heat; built environment.