SPATIAL ANALYSIS OF LAND SURFACE TEMPERATURE (LST) AND ITS RELATIONSHIP WITH THE URBAN MORPHOLOGY OF THE CITY OF OLINDA, PERNAMBUCO, BRAZIL

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Analyse spatiale de la température de surface du sol (tss) et sa relation avec la morphologie urbaine de la ville d'Olinda, Pernambuco, Brésil

Mots-clés : champ thermique, télédétection, climat urbain, Olinda
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Introduction

Urban Climate results from the interaction of urban factors with the regional climate and the pre-existing physical environment (Moreira *et al.,* 2023). Changes in the urban landscape, as well as in global temperature, lead to changes in the climatic patterns of cities. One of the main reflections of climate change in the urban environment is the increase in areas susceptible to Heat Islands. Thus, the Urban Heat Island has the potential to become one of the biggest problems associated with urbanization and industrialization, as the increase in temperature tends to increase the risks for human health (Manik and Syaukat, 2017).

This work aims to analyze the spatial variability of the land surface temperature of the municipality of Olinda, Pernambuco, Brazil, and its relationship with the urban morphology (coverage and structure) in order to identify the relationship between the urban landscape and the associated thermal field. Unbridled urbanization in Olinda has led to changes in the landscape, improper land use, alterations in drainage systems, and an increasing pace of vertical construction.

The municipality of Olinda is situated in the Metropolitan Region of Recife, on the coast of the state of Pernambuco, Brazil. With a population of 349,976, with 96% of the urbanized area, according to the 2022 Demographic Census , the municipality is the seventh most populous in the state of Pernambuco. Due to its location on the eastern coast of Brazil, the municipality of Olinda maintains monthly average temperatures above 18°C, low temperature variation, high relative humidity, and abundant precipitation throughout the year, which determines its climatic classification. According to Köppen Geiger (1961), it is classified as hot and humid tropical climate (As').

1. Methodology

The methodological procedures of this study are linked to the mapping of the urban morphology of the municipality of Olinda, represented by the land cover and the vertical structure of the landscape elements, as well as the spatial delineation of the surface temperatures, culminating in the analysis of the interaction between the urban space and the associated surface thermal field. On this occasion, the mapping of surface cover aimed to delineate the classes of built-up, vegetated, or water surfaces through the calculation of vegetation indices (NDVI Normalized Difference Vegetation Index) from bands 4 and 8 of the Sentinel-2 satellite images dated 23/03/2023 with a resolution of 10 meters. The characterization of the surface structure considered the vertical attribute of the surface in question, which interferes with the flow of wind and consequently the transport of atmospheric heat. For this purpose, Digital Terrain Models (DTM) and Surface Models (DSM) were used, obtained from LIDAR (Light Detection and Ranging) data, with 1 meter of spatial resolution. Finally, the surface temperature was estimated from the satellite images of the SLSTR sensor of the Sentinel-3 mission, made freely available by the European Space Agency. Two images from the same day, 23/03/2023, were obtained, pertaining to the night (00h) and daytime (12h) periods.

2. Results

As a result of processing the images, it was found that the municipality still has an extensive rural area to the west with dense vegetation on dissected hills and vegetation cover distributed throughout the municipality, occupying 48.5% of its total area (Table 1). Built surfaces occupy 51.5% of the area, mainly horizontal surfaces up to 6 meters in height. The verticalized areas are concentrated in the Casa Caiada neighborhood, in the northeastern part of Olinda.

Table 1. Classes of coverage and structure defined for the municipality of Olinda, Pernambuco, Brazil.

Classes	Subclass criteria	% of built-up area
1 Vegetation cover (VC)	-	**48.5**
1.1 VC ground-level	Up to 1.5 meters	1
1.2 VC shrubby	Between 1.51 and 3.00 meters	5.5
1.3 VC arboreal	Above 3.01 meters	27
2. Built-Up surface (BS)	-	**51.5**
2.1 BS exposed soil	Up to 1 meter	16.7
2.2 BS horizontal	From 1 to 6 meters	25.5
2.3 BS medium	From 6.1 to 20 meters	9
2.4 BS vertical	Above 20 meters	0.3

Analyzing the two images from the Sentinel-3 Satellite, a concentration of the highest temperatures was noticed on the east coast during the nighttime, linked to the slow process of heat loss by nocturnal radiation over these areas, whereas during the daytime there was a greater concentration of high LST values in the southwestern part of the city, in the Recife-Olinda conurbation area. Additionally, it was observed in both periods that there is a central strip from southeast to northwest with lower LST compared to the other pixels estimated on the date of analysis, related to two factors: the positioning of the relief, capturing winds and moisture from the action of the Intertropical Convergence Zone, active in the month of March, and the action of sea breezes during the daytime channeled by the Fragoso river entering the municipality. On the other hand, the southeastern portion of the municipality is located on the windward side and in a densely occupied area with little vegetation. This portion still showed high LSTs, being the most susceptible area to surface heat islands of the municipality, composed of the neighborhoods of Peixinhos, Vila Popular, and Jardim Brasil, areas with little or no vegetation cover, impermeable terrain, and Very High Social Vulnerability (Costa and Marguti, 2015).

Conclusion

The different features of Olinda's intraurban space, associated with its topography, generate processes with distinct intensities of surface heating, which interact with the atmosphere of the urban canopy layer. This interaction between surface temperature and the atmosphere of the urban canopy layer impacts the population as one of the variables responsible for thermal comfort perception, which varies according to the sensitivity of at-risk groups such as the elderly, children, and outdoor workers. For this reason, this study was important in identifying areas in cities most susceptible to high LST values, supporting future research aimed at investigating in more detail the other variables related to both environmental thermal comfort and the population's climate vulnerability.

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Bibliography

Costa, M. A.; Marguti, B. O., 2015 : Atlas da vulnerabilidade social nos municípios brasileiros. IPEA, 77 pages.

Moreira, A.B.; Duarte, C.C.; Matzarakis, A., 2023 : A Review of Urban Heat Studies in Recife—PE (Brazil): Urban Heat Scales, Landscape Inequalities and Future Perspectives. *Atmosphere*, 14, 1-17.

Manik, T.; Syaukat, S., 2017 : Comparative Vulnerability Assessment of Urban Heat Islands in Two Tropical Cities in Indonesia. *British Journal of Environment and Climate Change*, 7, 119–134.