



Trees4HeatResilience:

Evaluating Tree Canopy Coverage to Reduce Air Conditioning Demand in Honduran Urban Neighborhoods

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Executive Summary

Introduction

Urban areas are at the forefront of the fight for climate resilience, with rising temperatures hitting cities the hardest. In tropical regions, rapid urbanization reduces green spaces and intensifies the urban heat island (UHI) effect, where built-up areas experience higher temperatures than surrounding rural zones due to heat-absorbing surfaces, limited vegetation, and heat from human activities. High-income countries often benefit from greater vegetation coverage, while lower-income countries face faster intensification of the UHI effect, making urban overheating a more urgent challenge. Limited tree canopy coverage further heightens this risk. Indoor overheating is also a concern, especially in buildings that rely on air conditioning. When these systems are turned off, such buildings are more vulnerable because they often lack passive cooling strategies, such as natural ventilation or nature-based solutions like trees. As a result, they are more vulnerable to the impact of rising outdoor temperatures.

Methodology

By combining AI segmentation techniques to detect tree canopy with census-based neighborhood air conditioning (A/C) usage data and OpenStreetMap (OSM) building footprint data, this research evaluates how urban greenery influences cooling demand in a low-income context where both environmental and social vulnerabilities are pronounced. This study addresses these gaps by focusing on a hot Honduran city, where A/C adoption is uneven and influenced by socio-economic conditions. The research question that guides the current study is: *To what extent does urban tree canopy coverage influence the use of A/C across diverse neighborhoods in the context of a hot Honduran city?* This approach not only extends the geographical and socio-economic scope of existing literature but also offers insights into how nature-based solutions like trees in cities can be leveraged to promote less A/C reliant communities in low-income tropical settings. This study focuses on neighborhoods of San Pedro Sula, the largest metropolitan area in Honduras. With a population of almost 2 million inhabitants, the city faces growing challenges from urban heat and uneven access to green infrastructure. To investigate the distribution of tree canopy and its relationship to neighborhood-level A/C usage, this research employed a multi-step analytical framework integrating various data sources and computational tools. In summary, the methodology followed four main phases:

1. Aerial images of San Pedro Sula neighborhoods were collected and partially labeled to identify tree canopies.
2. A pre-trained computer vision model was retrained for tree canopy segmentation and applied citywide.
3. The resulting tree coverage dataset was integrated with OSM building footprints and census A/C usage data to compute tree-to-building ratios.
4. Spatial regression analyses were then conducted to assess how tree coverage and related factors influence neighborhood-level A/C usage.

Key Findings

- Around 45% of San Pedro Sula is tree-covered, but unevenly; median coverage is 29.6%.
- Neighborhoods differ in *tree-to-building ratio* (median ratio 1.49:1, mean ratio 12.49:1), pointing to opportunities for targeted greening.
- A/C usage is also uneven: 26.1% of households report having a unit.

- Spatial regression shows that presence of trees in neighborhoods lowers A/C usage. A unit increase in the log *tree-to-building ratio* reduces A/C usage by 34–41%; raising the ratio from 1:1 to 3:1 cuts down usage by 38–45%.
- Count models estimate each unit increase in the *tree-to-building ratio* reduces household A/C likelihood by ~2.4% (95% CI: 0.6–4.2%).
- *Tree coverage* (area %) often reflects wealthier, low-density zones where A/C use remains high. The *tree-to-building ratio* better captures shading/cooling benefits on buildings.
- Overall, greening impact depends on placement: strategies should target low-coverage, high A/C (or heat-exposed), and socially vulnerable areas

Implications and Recommendations

This study demonstrates how AI-based tree mapping, census data, and spatial regression can guide targeted interventions to improve heat resilience in vulnerable urban neighborhoods. Practical applications include tree-planting, and other nature-based solutions out of the scope of this study (i.e., green roofs, green walls), to reduce heat exposure, lower A/C reliance, and improve thermal comfort. The main recommendations are:

- *Community co-design*: Humanitarian actors should partner with local residents to ensure culturally appropriate and sustainable green infrastructure projects, especially in thermally isolated neighborhoods with low tree coverage.
- *Integration into risk frameworks*: Urban heat resilience should be embedded in disaster risk reduction planning, linking it to early warning systems and climate migration strategies.
- *Focus on marginalized groups*: Adapt cooling solutions (i.e., shaded communal areas, passive cooling for homes with metal roofs) to the needs of low-income households, informal settlements, older adults, and women-headed households, who face the greatest heat related vulnerabilities.

Conclusion

For San Pedro Sula, Honduras, this study integrates AI-based tree mapping, census data, and spatial statistical modelling to identify neighborhoods with elevated A/C usage. Higher A/C usage is partly linked to limited tree presence (i.e. lower *tree-to-building ratio*) alongside built environment and socioeconomic factors, such as roof type (i.e. metal) and unmet basic needs. Urban greening strategies should go beyond simply adding trees and instead prioritize heat vulnerable neighborhoods with low canopy cover, high A/C reliance, and greater social vulnerability. Localized interventions, centered in nature-based interventions, centered in nature-based solutions adapted to specific neighborhoods, such as tree planting and passive cooling measures, can significantly reduce energy burdens, improve thermal comfort, and strengthen climate resilience for the most vulnerable.