# HOTTER for Whom?

## Assessing Boston's Vulnerability to Heat

### Introduction:

Based on a climate vulnerability assessment done by the City of Boston, extreme heat is considered to be a chronic climate hazard influencing the city's climate change throughout the 21st century with an average summer temperature of 76 degrees Fahrenheit by 2050. The urban heat island effect of the city further intensifies the severe health impacts of heat, specifically for certain socially vulnerable populations like older adults, children, people of color, low-income and disabilities.

The Heat Vulnerability Index (HVI) is a tool to identify vulnerable populations and areas that require heat mitigation interventions. The project focuses on identifying the priority census tracts of Boston using demographic and environmental indicators and analyzing the relationship between heat stress and the city's canopy cover.

### Methodology:

Indicators (See Table 1) were identified based on a study done by Reid et. al. for Boston. Principal Component Analysis (PCA) was used to reduce the correlated indicators to three uncorrelated components – **socioeconomic distress**, **age-component** and **environmental burdens**. The components were ranked using percentiles (called component scores), with higher percentiles indicating higher stress.

The study applied the concept of cumulative impacts to calculate the combined influence of multiple stressors using a multiplicative model. HVI was computed as a product of environmental burden and the average of socioeconomic distress and age-component. HVI has been mapped to display spatial variability of heat stress and highlight the priority tracts. Local Moran's I has been used to analyze the spatial autocorrelation of heat stress and canopy cover for census tracts.

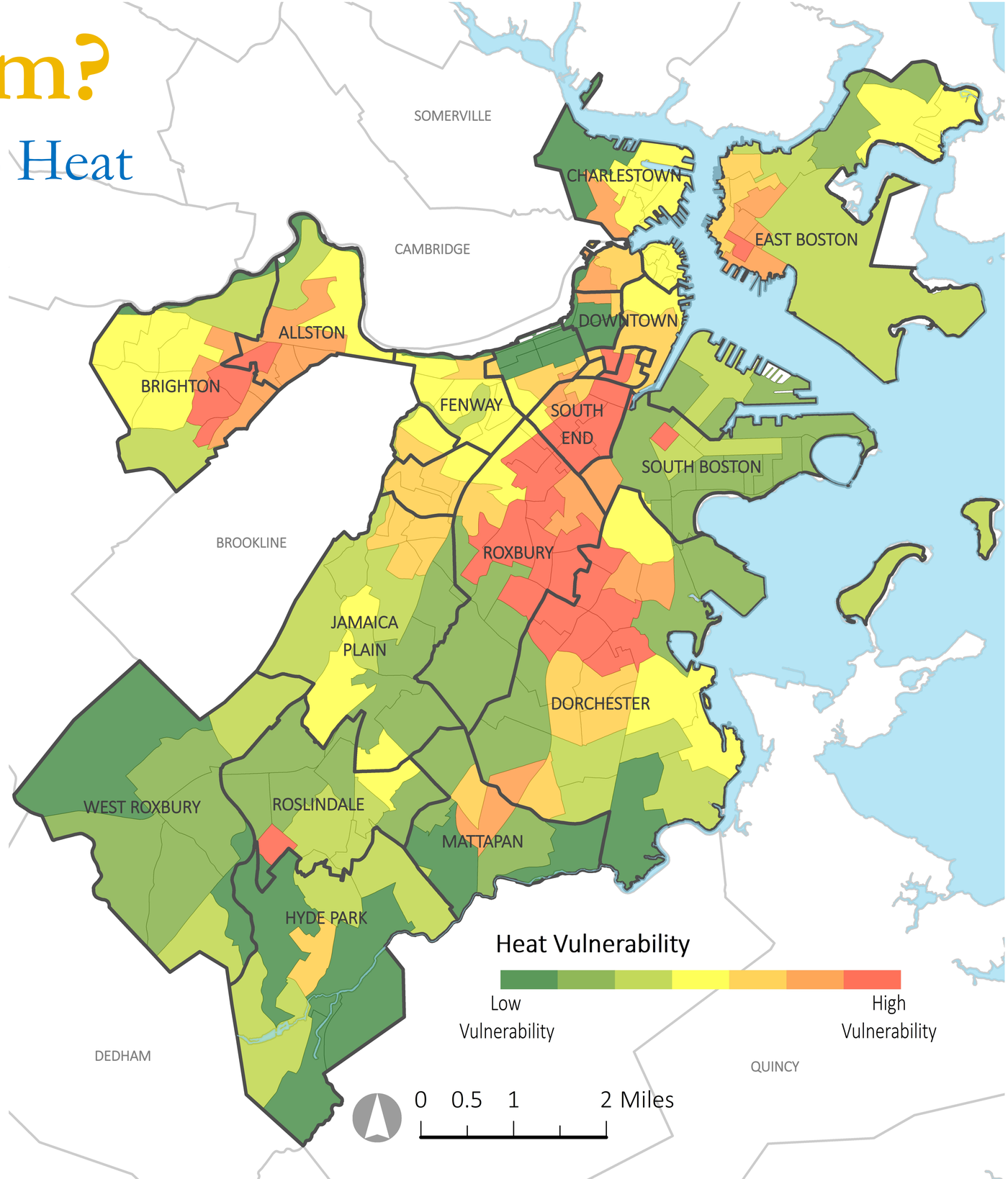


**Table 1:** Heat Vulnerability Indicators for Boston

| Indicators | Description |
|---|---|
| Young Children | Percentage of population under 5 years |
| Older Adults | Percentage of population over 65 years |
| Poverty | Percentage of population with income below poverty level |
| Disability | Percentage of population with disability |
| Linguistic Isolation | Percentage of population designated limited English-speaking |
| Race | Percentage of population that is non-White |
| Educational Attainment | Percentage of population with less than a High School Education |
| Impervious Surface | All man-made constructed surfaces, like buildings, roads etc. |
| Proximity to open spaces | Area within a half-mile walking distance of open spaces and parks |
| Mean surface temperature | Surface Temperature calculated using satellite imagery |

### Results:

The indicators used for the study showed significant correlations among each other. Based on PCA, the socioeconomic distress component includes high negative influences of poverty, disability, linguistic isolation, race and educational attainment. The environmental burden component comprises of negative influences of impervious surface, proximity to open spaces and a positive influence of mean surface temperature. Older adults and young children have high negative influences on the age-component. Figures 1–3 show the spatial variability of every component score across Boston.

The 90-100th percentile bin of HVI is made of 19 census tracts spread across Chinatown, Downtown, South End, Roxbury, Dorchester, Roslindale and Brighton. Table 2 includes fourteen of these tracts grouped into four clusters (based on location) with their corresponding canopy cover percentages.

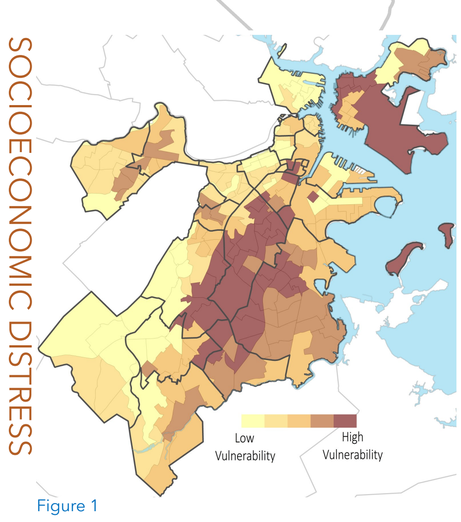


Figure 1

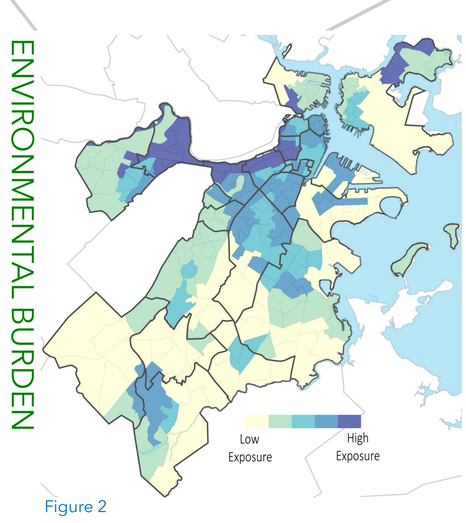


Figure 2

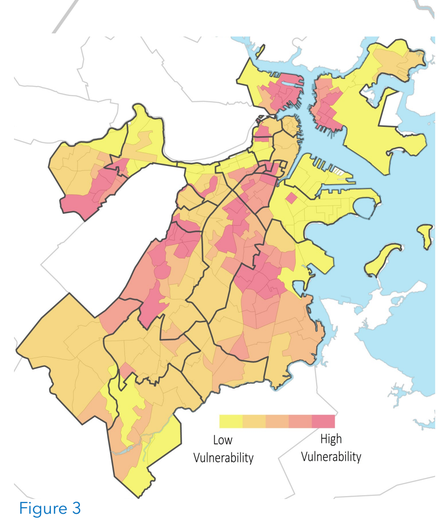


Figure 3

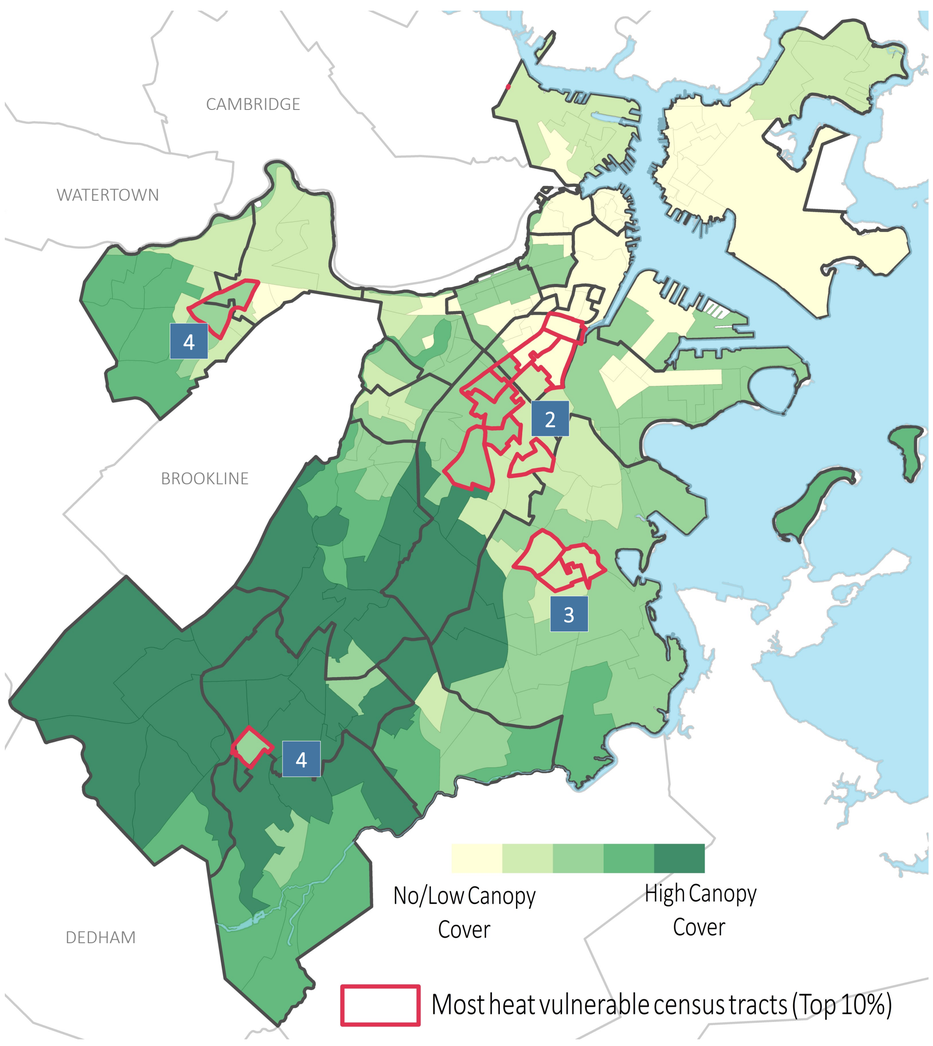


**Table 2:** Most Heat Vulnerable Census Tracts

| Cluster | Neighborhood | HVI Score | Canopy Cover | High Component Scores |
|---|---|---|---|---|
| 1 | Brighton | 57.3 | 10.8% | - High social vulnerability comprising of both high socioeconomic distress and high age-component scores |
| 2 | South End and Roxbury | 57.3–72.9* | 1.6–53.7% | - Very high social vulnerability comprising of both high socioeconomic distress and high age-component scores |
| 3 | Dorchester | 61.2 | 11.7% | - High social vulnerability comprising of both high socioeconomic distress and high age-component scores |
| 4 | Roslindale | 53.0 | 21.3% | - High socioeconomic distress and<br>- High environmental burden |

**Note:** The clusters mentioned in the table correspond to High-High and High-Low clusters of heat vulnerability.
** Cluster 2* includes nine census tracts. HVI of eight of the tract range between *57.3–58.9*. The cluster also includes *Chinatown*, which has a HVI of *72.9*. Chinatown has a very high social vulnerability score and environmental burden score.

### Discussion:

The Heat Vulnerability Index is a data-driven tool to quantify the impact of demographic and environmental factors on heat-related vulnerability for the city of Boston. The three components show some level heterogeneity in their spatial variability across the city.

The social vulnerability of Boston, which is an average of the socioeconomic distress and age-component, records high values for certain areas in neighborhoods like Roxbury, Dorchester, Chinatown, Mattapan and Jamaica Plain. These neighborhoods also indicate a relatively high exposure to environmental burdens. But the highest exposure is mostly concentrated in Back Bay, Beacon Hill, Allston and certain areas of East Boston. Most of the tracts showing heat stress are also associated with lower percentages of canopy cover (as shown in Table 2).

While the cumulative HVI helps to quickly identify the communities with a high susceptibility to impacts of extreme heat, an understanding of the spatial variability of the indicators is equally important for proposing strategic heat mitigation interventions.

**Data Sources:**
- American Community Survey, 2014-18;
- National Land Cover Dataset (NLCD) 2016, US Geological Survey;
- Landsat 8 OLI/TIRS 2018, US Geological Survey;
- MassGIS, Bureau of Geographic Information


**References:**
- Reid, Colleen E., Marie S. O'Neill, Carina J. Gronlund, Shannon J. Brines, Ana V. Diez- *Roux*, Daniel G. Brown, and Joel David Schwartz. "*Mapping Community Determinants of Heat Vulnerability*." Environmental Health Perspectives 117, no. 11 (2009): 1730-1736.
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- Laura Barron, Dominique Ruggieri, and Charles Branas. "*Assessing Vulnerability to Heat: A Geospatial Analysis for the City of Philadelphia*." Urban Science 2, no. 2 (2018): 38.
- City of Boston. *"Climate Projection Consensus"*. https://www.boston.gov/departments/environment/preparing-climate-change



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