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An Introduction to the Institution

POLITECNICO DI MILANO DEPARTMENT OF ARCHITECTURE AND URBAN STUDIES

Politecnico di Milano is a public, scientific-technological university founded in 1863, dedicated to the education and research in engineering, architecture, and design. It is Italy's largest technical university in its domain. The university operates across seven campuses (in Milan, Lecco, Cremona, Mantova, Piacenza) to host its varied programmes.

It enrolls approximately 49,000 students, including undergraduates, masters, and doctoral candidates. Among these, about 8,800 are international students (distributed across levels). The staff comprises around 1,800 full faculty and 1,300 technical and administrative personnel. The university supports a network of laboratories, experimental infrastructures, and organized research structures.

Politecnico di Milano has a strong lab ecosystem: well-equipped, cross-disciplinary laboratories are used for experimentation, technology transfer, and collaborative innovation. Politecnico's 12 departments cover engineering, architecture, and design fields. Its **research agenda** emphasizes **sustainability, digitalization, climate resilience, built environment technologies, mobility and infrastructure, spatial planning, and design innovation**.

The **Research Office** centralizes support for project funding, proposals (especially Horizon Europe/Horizon 2020), and strategic research management.

According to the QS World University Rankings, Politecnico di Milano ranks 98th worldwide, becoming the first Italian university ever to enter the global top 100. In the QS World University Rankings by Subject 2025, it is positioned 7th globally in Architecture & Built Environment and 21st in Engineering & Technology.

The **Department of Architecture and Urban Studies (DAStU)**, at Politecnico di Milano, is a pivotal Italian department specializing in the integration of urban planning, policy, design, and advanced geospatial technology.
We bridge the gap between abstract technical data and actionable urban policy. Our core strength lies in analyzing complex urban challenges and translating those findings into site-specific design interventions for public spaces and mobility networks that promote resilience and equity in cities.

MAIN FIELDS: Urban Planning, GIScience, Urban Climate Adaptation, Urban Heat Island (UHI), Active Mobility (Walking, Cycling), Public Space Design, Equitable Cities

POTENTIAL CONTRIBUTION TO A CONSORTIUM

1. **Urban Planning, Policy and Design Leadership**: Ensuring that technical results are transformed into concrete design standards and policy frameworks that municipalities can adopt.
2. **Decision Support Tool Development**: Utilizing our expertise in GIScience to design the user-facing, intuitive front-end of any planning tool, maximizing its practical utility for city planners and minimizing the barrier between research findings and real-world application.
3. **Holistic Climate-Resilience Studies**: Beyond specific project data, we provide the foundational expertise to assess how multi-scalar climate impacts (from regional flood risk to micro-level heat stress) intersect with social vulnerability. This ensures the project's solutions are anti-fragile meaning they address climate risks comprehensively and contribute to long-term systemic adaptation, not just single-issue mitigation.

Understanding and tackling heat in urban areas

FROM CITY TO STREET: THE MULTI-SCALE EFFECTS OF HEAT ISLANDS AND IMPLICATIONS FOR PEDESTRIANS

Towards the Creation of Heat-Resilient Cities

Impact of heat waves on active mobility, health, and equity

We examine how heat waves affect pedestrian mobility and accessibility. It specifically explores the accessibility of key destinations on foot during extreme heat events and the associated heat-related risks.

Factors influencing the choice of routes and pedestrian accessibility

Various urban and environmental factors such as length, sidewalk width, vegetation, number of turns, amenities, slope, sky view factor, and thermal comfort are considered to estimate the impact on perceived distance.

GPS trajectories and pedestrian network

GPS trajectories are used to model pedestrian route choices.
A pedestrian network, including sidewalks and crosswalks, is used to design a framework to estimate Heat Exposure and Heat Risk.

Climate Change and Urban Heat Island

Urban Heat Island Effect

+2-7°C

Higher temperatures in cities vs. rural areas

The Growing Challenge

Climate change is intensifying heat wave frequency and severity, with significant implications for:

Energy consumption: Increased cooling demands

Air quality: Degradation during extreme heat events

Public health: Cardiovascular and respiratory diseases, heat exhaustion

Vulnerable populations: Children, the elderly, and medically vulnerable individuals are at the highest risk

How do people adapt to extreme urban heat?

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Urban Heat Island Contributing Factors

City Heat Drivers

How Surfaces, Buildings, Vegetation, and Waste Heat Shape Urban Temperatures

SURFACE PROPERTIES
Impervious materials like concrete and asphalt absorb and retain more heat than natural surfaces

URBAN GEOMETRY
Building height, spacing, and orientation affect wind flow and solar access

LACK OF VEGETATION
Reduced evapotranspiration and shade compared to rural areas

WASTE HEAT
Heat generation from transportation, industry, and building HVAC systems

Multi-Scale Analysis Approach

Understanding UHI at Different Spatial Scales

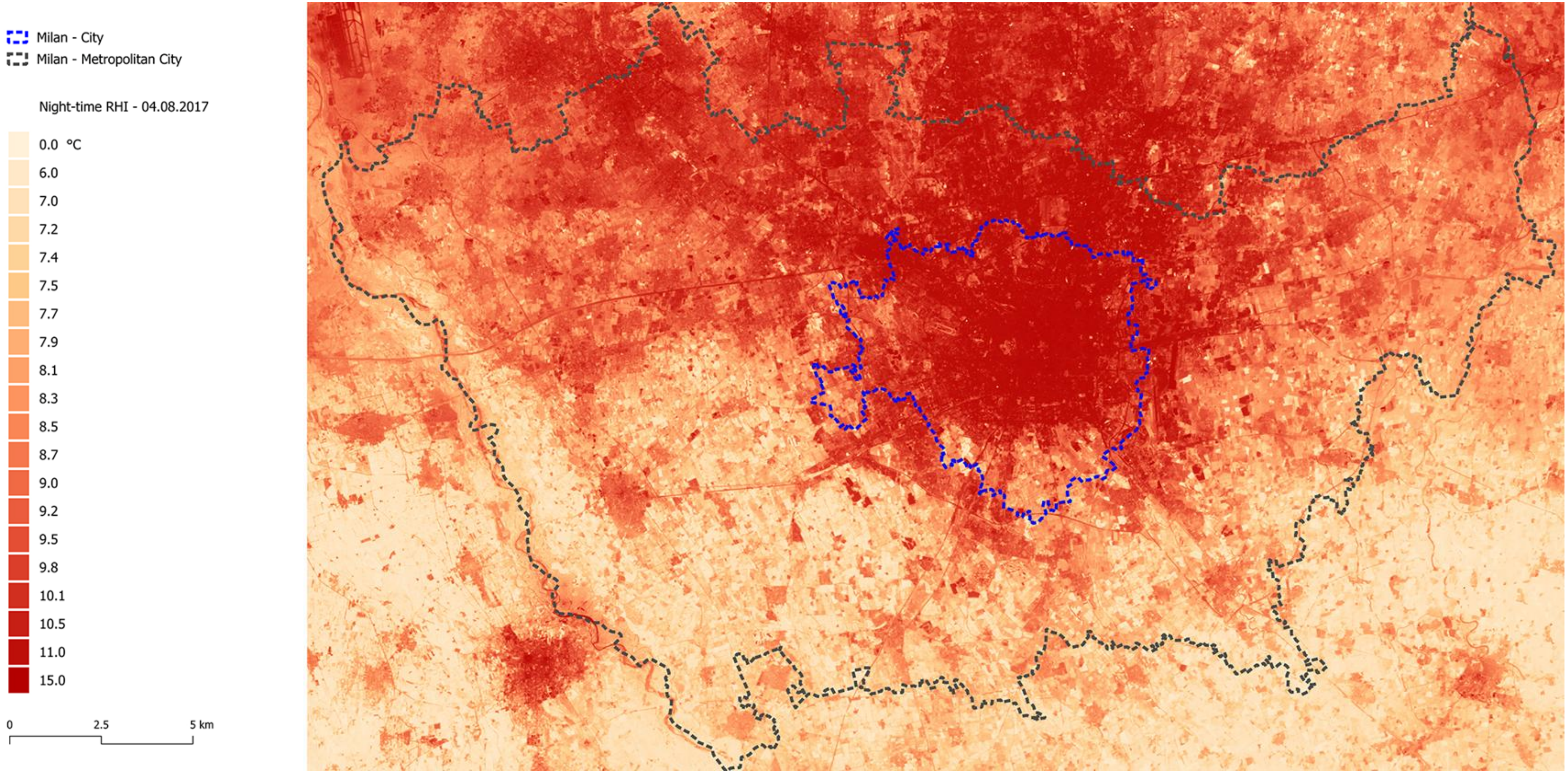
Adaptation strategies tailored to each spatial scale enhance effectiveness in reducing UHI impacts

REGIONAL SCALE	URBAN SCALE	INTRA-URBAN SCALE
Regional Heat Islands (RHI) Heat effects extending beyond city boundaries across metropolitan areas	City-Wide Analysis Temperature patterns within city limits vs. surrounding areas	Micro-Climate Thermal variations within neighborhoods and street canyons

Research Questions

- How do heat islands manifest across different scales?
- What are the key factors at each scale?
- How do these factors influence heat island intensity, and what Indicators do we need?
- What scale-specific strategies are most effective?

RHI in the Metropolitan Area of Milan



Intra-Urban Microclimate, T_{mrt}, and Drivers

Urban Canyon Analysis

Urban Canyon Geometry: Three urban canyons in Milan were studied, focusing on their geometry and vegetation presence.

Variation in Mean Radiant Temperature: T_{mrt} varies significantly between canyons due to differences in solar exposure despite similar air temperatures. ***T_{mrt} values above 55°C significantly increase health risks*** from heat stress in urban populations

Vegetation and Orientation: Tree presence and orientation greatly influence microclimates, highlighting the importance of vegetation in urban design.

Geometry and Orientation Effects

Height-to-Width Ratios: Height-to-width street ratios influence thermal comfort by controlling sunlight exposure and airflow.

Street Orientation Impact: East-west oriented wider streets receive more heat exposure compared to shaded narrower streets.

Role of Vegetation: Trees and vegetation provide essential shading, reducing heat in geometrically constrained urban areas.

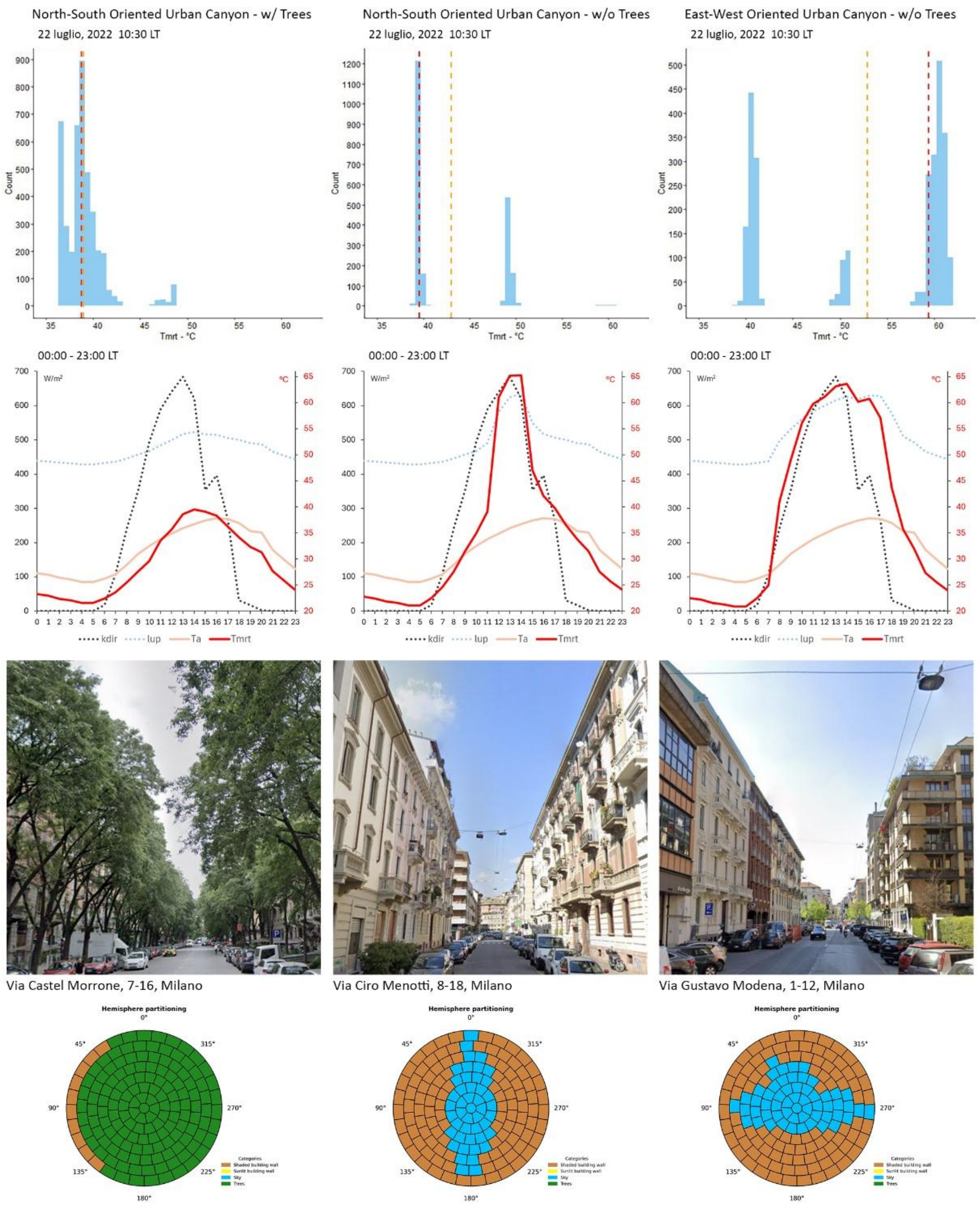
T_{mrt} and Urban Geometry

N-S Canyon with Trees
T_{mrt} remains close to air temperature (~31.3°C) 0 hours above 55°C threshold. Tree coverage can eliminate health-critical temperatures

N-S Canyon without Trees
Moderate solar exposure H/W ratio: 1.14 (better shading). Orientation and geometry are also significant

E-W Canyon without Trees
T_{mrt} can exceed air temp by 20°C up to 8 hours above 55°C threshold

Canyon Type	Ta (°C)	Tmrt (°C)	Hours >55°C
N-S w/ Trees	31.3	~31.3	0
N-S w/o Trees	31.5	~45	2
E-W w/o Trees	31.8	~55	8



Via Castel Morrone, 7-16, Milano
Via Ciro Menotti, 8-18, Milano
Via Gustavo Modena, 1-12, Milano

Evidence-Based Mitigation Strategies

Multi-Scale Intervention Framework

Indicators:

- **RHI**: Air and Surface Temperature, LULC
- **UHI**: Air and Surface Temperature, Urban Density (buildings' height, roughness) and Materials (Evapotranspiration)
- **Urban Canyon**: Solar radiation (T_{mrt}), UTCI or PET, Urban Geometry (and shadow)

VEGETATION-BASED SOLUTIONS

Most effective across all scales

- Regional corridors and Forestation
- Urban tree canopy
- Green roofs and facades

SURFACE MODIFICATIONS

High-albedo materials and permeable surfaces

- Cool roofs and pavements
- De-paving initiatives
- Reflective urban materials

URBAN DESIGN PRINCIPLES

Canyon geometry and orientation optimization

- Height-to-width ratios
- Building orientation
- Wind corridor design

POLICY INTEGRATION

Coordinated governance across scales

- Zoning modifications
- Building codes updates
- Collaborative governance

Key Takeaways

- **Multi-scale approach**: UHI phenomena manifest differently at regional, urban, and intra-urban scales
- **Regional impact extends beyond cities**: Agricultural areas contribute significantly to heat islands
- **Vegetation is the most effective intervention**: Consistent cooling benefits across all scales
- **Micro-scale variations are critical**: Within single heat islands, temperature can vary dramatically
- **Urban geometry matters**: Canyon orientation and H/W ratios significantly affect thermal comfort

The Case of Barcelona: Green Axes

Carrer Consell de Cent and Carrer d'Enric Granados, 2018 and 2024

Carrer Consell de Cent and Carrer de Roger de Lluria, 2018 and 2024

© hayespromenade.org, Google Street View. *A community-powered campaign for a permanently pedestrianized Hayes Street*

The Case of Barcelona: Green Axes

Carrer Consell de Cent and Carrer d'Aribau, 2018 and 2024

Carrer Consell de Cent and Rambla de Catalunya, 2018 and 2024

© hayespromenade.org, Google Street View. *A community-powered campaign for a permanently pedestrianized Hayes Street*

The Climate-Mobility Paradox

Cities are promoting sustainable mobility while facing unprecedented climate challenges

Challenge: Climate change is intensifying heatwaves globally

Response: Cities incentivizing walking and cycling over auto use

Paradox: Heat stress may reduce willingness to walk

Impact: Threatens sustainable mobility transition efforts

Research Question

How does heat stress affect pedestrian route choice and accessibility to public transit?

Why This Matters

Public Health

- Heat exposure during walking
- Vulnerable populations at risk
- Quality of life impacts

Equity Concerns

- Disadvantaged groups are more affected
- Unequal heat exposure
- Transportation justice

Environmental Sustainability

- Modal shift away from cars
- Reduced GHG emissions
- Climate adaptation strategies

Planning Implications

- Infrastructure investment decisions
- Transit accessibility planning
- Urban design frameworks

A pedestrian network-based framework

Case Study

- Origins: Homes
- Destinations:
  Bus and Subway stops,
  Parks, Amenities,
  Public schools
- Network: Pedestrian Network
- Trip Generation based on origin weights
- Trip Distribution based on:
  - Destination weights
  - Street network attributes
  - Behavioral nuances:
    . Walk only up to a threshold (800 m)
    . Exponential distance decay function
    . Detour up to 15%

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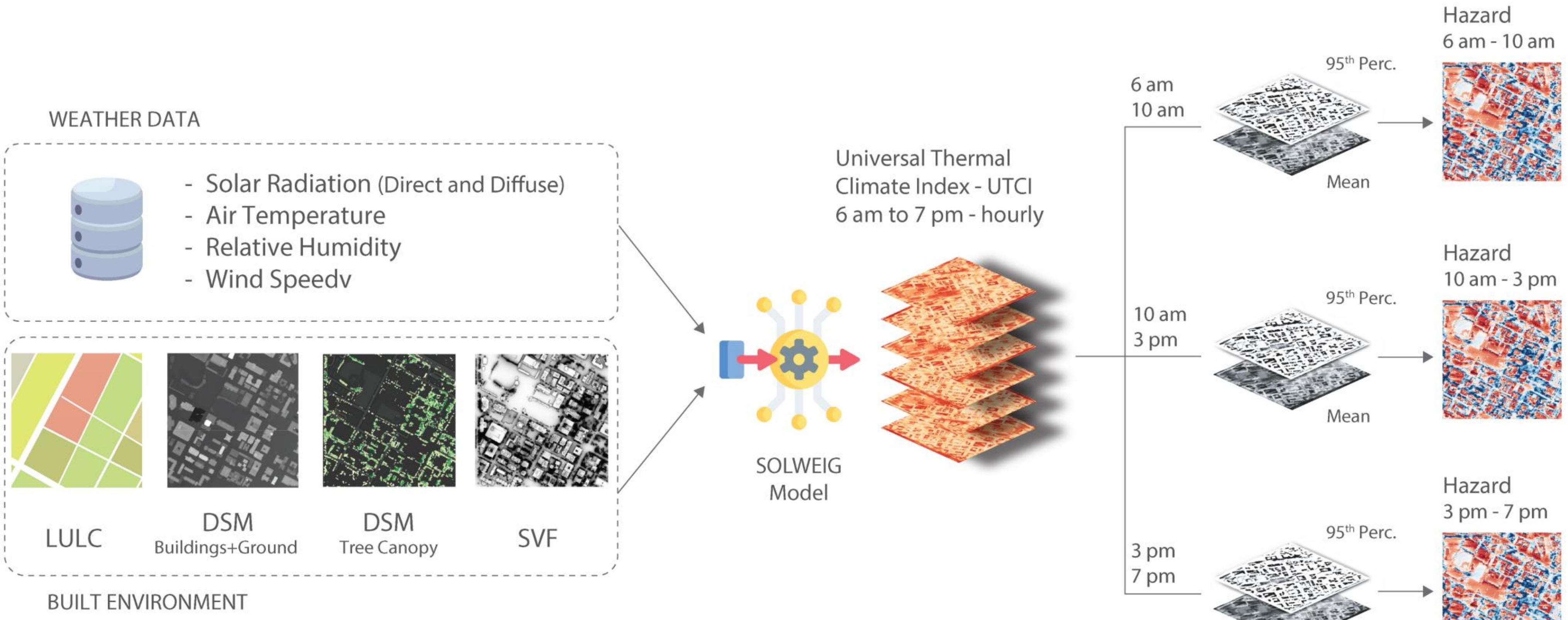
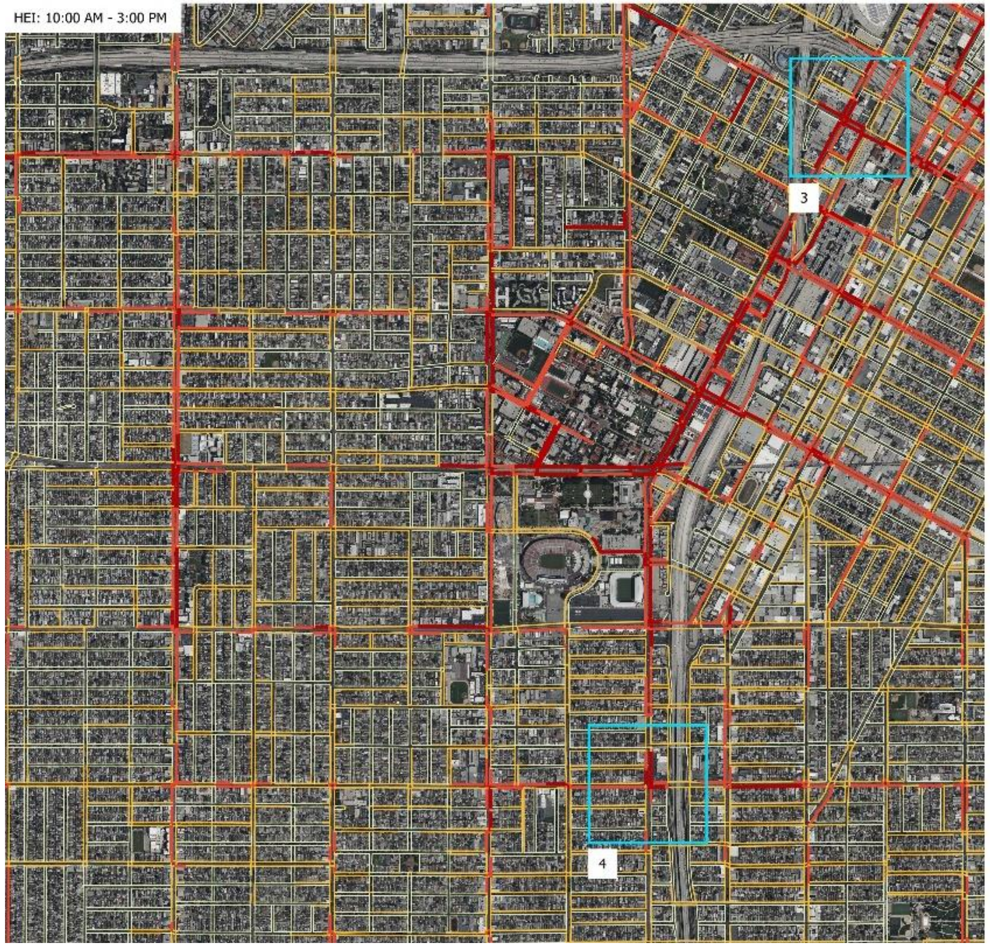
Heat Hazard: Universal Thermal Climate Index

- Hourly very-high 1-meter resolution UTCI for an extreme heat event
- Mean and 95th percentile are calculated over daylight hours (8 am – 6 pm) for each pixel during a heatwave event
- Three time periods are considered: morning, mid-day, and afternoon



Heat Exposure: Universal Thermal Climate Index

Heat Exposure Index (HEI) - Identification of most heat-stressed sidewalks



3 models:
- 6 am to 10 am
- 10 am to 3 pm
- 3 pm to 7 pm

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Effect of heat on pedestrian behavior and accessibility

Route Characteristics Measured

Physical Attributes

Route Length: Directly from GPS trajectories

Number of Turns: Angle changes ≥45° between segments

Sidewalk Width: Weighted average along route

Environmental Attributes

Amenities: Business establishments

Sky View Factor (SVF): Street enclosure

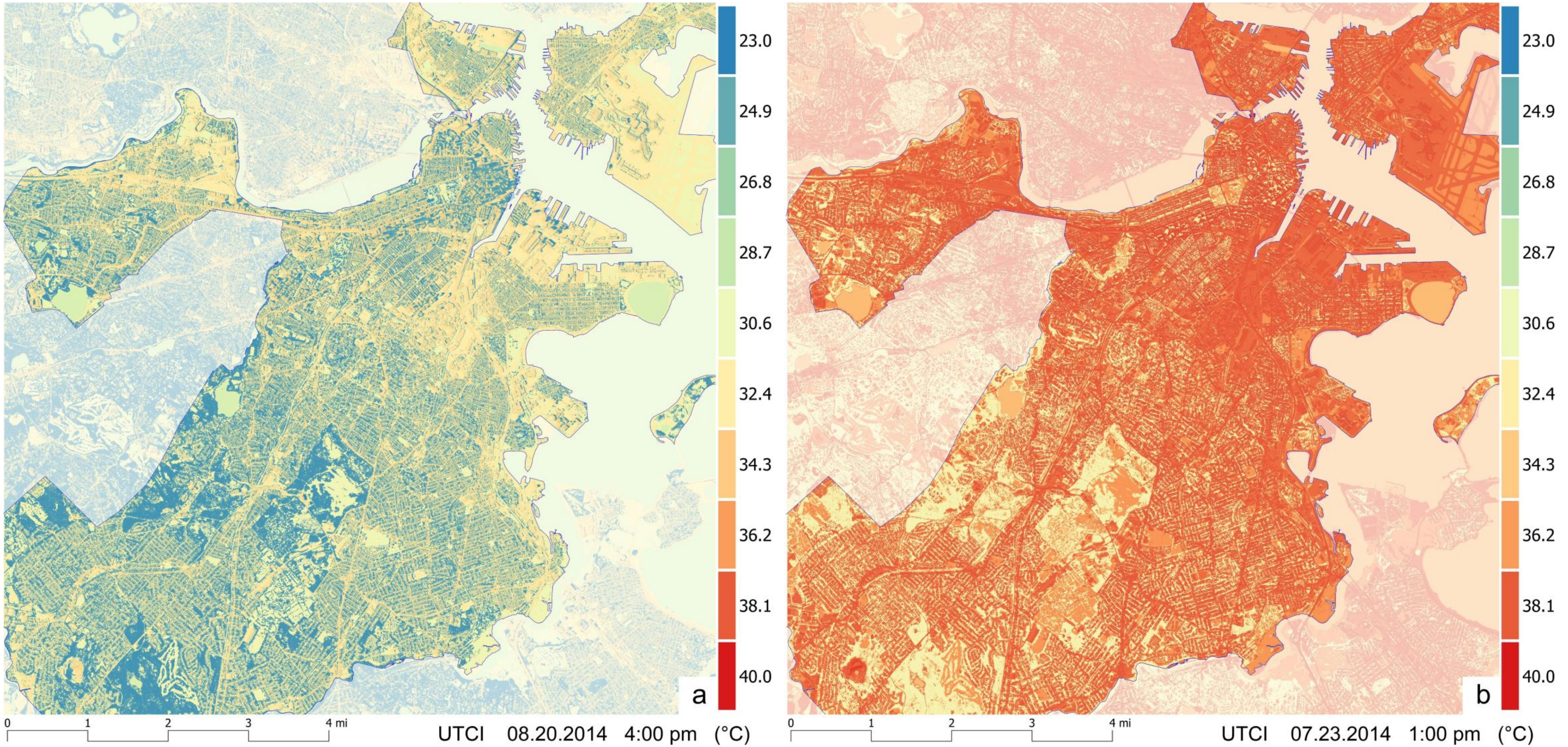
NDVI: Vegetation index from

UTCI: Universal Thermal Climate Index

Study Area: Boston, MA

- **Population:** 650,000+ residents
- **Density:** 3rd most dense large US city
- **Walkability:** WalkScore 83 (3rd nationally)
- **Commuting:** 17% bike/walk to work
- **Peak summer:** Up to 95°F (35°C)
- **2021:** 40+ days over 90°F
- **Policy:** "Climate Ready Boston" initiative

UTCI in Boston



The Perceived Length

Heat stress significantly affects pedestrian route choice, but only when alternatives exist
UTCI is the 3rd most important variable after route length and turns

All Summer Trips

6.6m
per °C above 26°C (not significant)

Trips offering at least one higher-UTCI alternative

80.8m
per °C above 26°C($p < 0.001$)

21.7m
26°C to 29°C per °C increase

44.0m
29°C to 32°C per °C increase

64.3m
Above 32°C per °C increase

Implication: Higher temperatures feel increasingly burdensome to pedestrians who perceive distances longer

Pedestrian Accessibility to Transit in Boston

Walkshed Analysis

Study Area: 15 MBTA Commuter Rail stations in Boston

Catchment Radius: 800 meters (standard walking-to-transit threshold)

Four Walkshed Types Compared:

1. **Geometric Distance:** Simple network distance
2. **Perceived Distance (no UTCI):** Includes all route attributes except heat
3. **Perceived Distance (typical summer):** Includes UTCI effects
4. **Perceived Distance (hottest day):** Maximum heat stress scenario

Heat stress reduces pedestrian accessibility by **75% on typical summer** days and **90% on the hottest days**

Accessibility Reductions

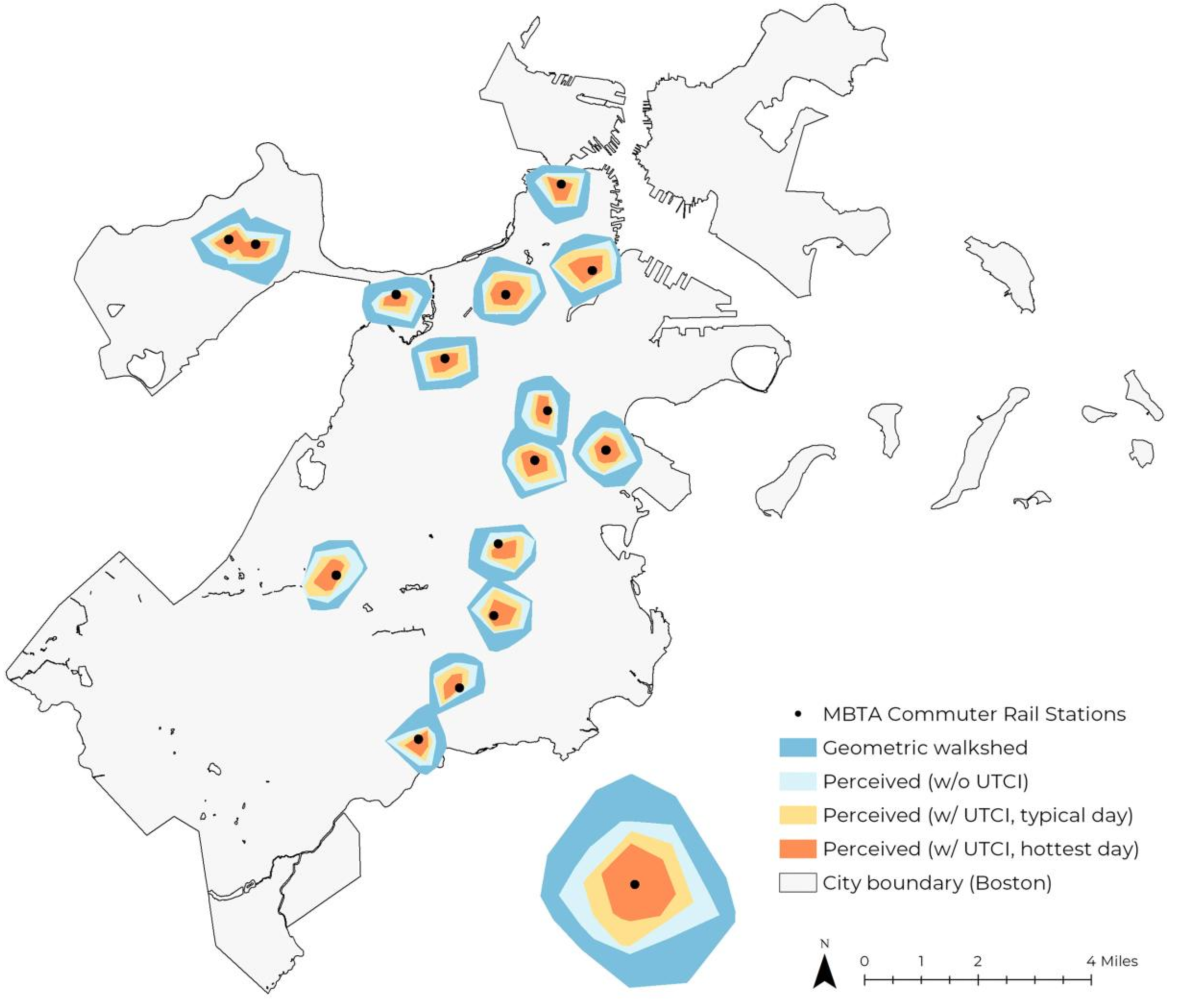
100%
Baseline: Geometric Distance
8,936 people on average

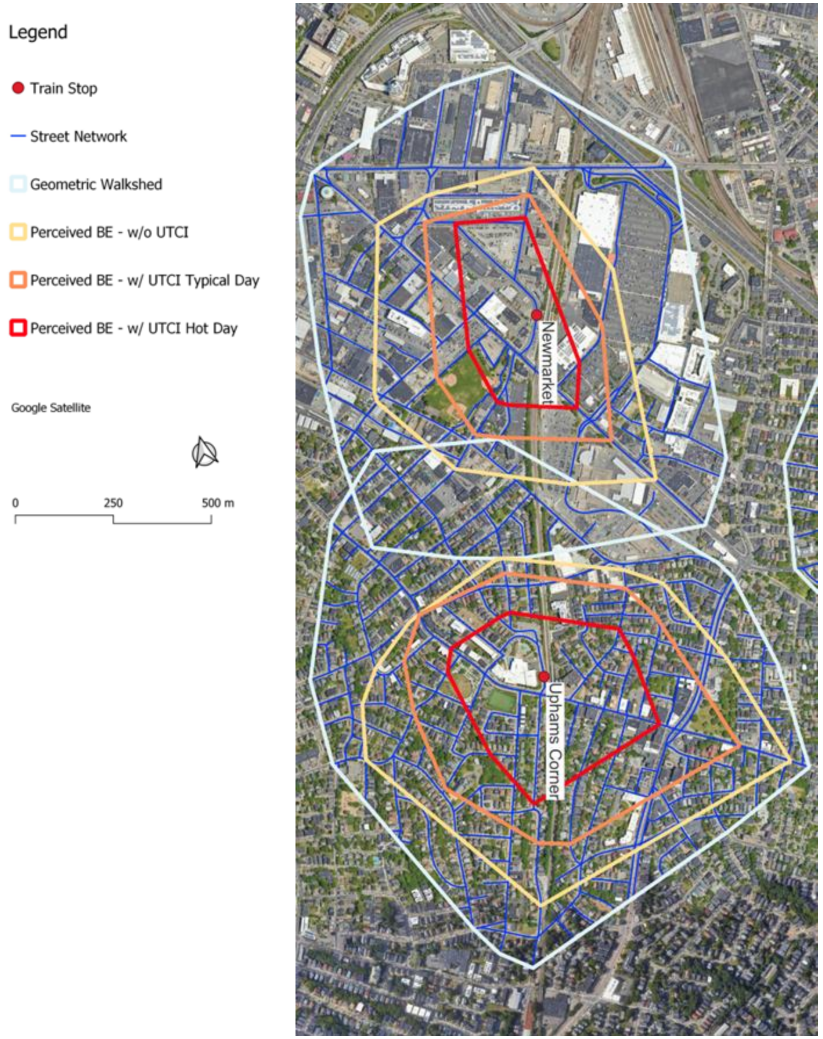
44.1%
Without Heat Effects
3,941 people

25.9%
Typical Summer Day2,314 people

9.5%
Hottest Summer Day
849 people

Urban Heat and Pedestrian Accessibility





Newmarket Station

1,868
Baseline residents

17.4%
Access w/o heat (325 people)

2.2%
Typical summer (42 people)

0%
Hottest day (0 people)

Key Takeaways

Heat stress significantly affects pedestrian route choice and dramatically reduces accessibility to public transit

Major Findings:

- **80.8 meters** perceived distance penalty per 1°C UTCI above 26°C
- **Non-linear effects**: Heat stress impact increases exponentially

  21.7m (26°C to 29°C), 44.0m (29°C to 32°C), 64.3m (Above 32°C per 1°C UTCI increase)
- **75-90% accessibility reduction** on hot summer days
- **Equity concerns**: Higher impact on non-White residents
- **Built environment matters**: Urban greenery provides significant protection

Contributing Factors:

- Lower vegetation density in minority neighborhoods
- Limited access to climate mitigation infrastructure
- Poor climate-proof transit design
- Housing affordability constraints in cooler areas

Transportation planners and urban designers must **integrate climate considerations** into their frameworks to support sustainable mobility while protecting vulnerable populations

Planning for Sustainable Mobility

Transportation Planning

- Improve transit coverage
- Revise transit catchment area calculations
- Climate-sensitive accessibility planning
- Heat-aware infrastructure investment

Technology Applications

- Heat-aware routing applications
- Real-time thermal comfort mapping
- Climate-responsive transit planning
- Predictive accessibility modeling

Urban Design

- Climate-conscious street design
- Strategic tree canopy placement
- Building-shade optimization
- Heat-resilient walking networks

Policy Recommendations

- Update accessibility standards
- Climate justice in transportation
- Heat emergency protocols
- Green infrastructure mandates

Urban heat solutions are most effective when a big-picture vision is paired with small-scale thinking that keeps everyday mobility safe and comfortable

THANK YOU