For special session: Cities Under Pressure: Building Resilience and Adapting to Climate Challenges

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Testing Heat Mitigation Strategies in Mediterranean Cities: A Practical Application of a Methodological Framework

Abstract

The increasing frequency and intensity of heat waves present significant challenges for Mediterranean cities, particularly affecting urban tourism and residents' quality of life. The Cool Noons Project responds to this challenge by testing innovative heat mitigation strategies across five Mediterranean cities: Budva, Dubrovnik, Imola, Lisbon, and Marseille. This paper describes the practical application of a comprehensive methodological framework designed to assess three key aspects: cooling efficacy of urban interventions, attractiveness of cool paths and cooling interventions for tourists, and overall experience enhancement for both visitors and residents. The methodology employs diverse data collection techniques including satellite imagery, thermal cameras, weather stations, GPS tracking, and Wi-Fi-based location tracking, complemented by innovative survey approaches such as QR code-accessible questionnaires strategically placed along urban paths. Preliminary implementation experiences reveal both successes and challenges in the methodological approach. The involvement of local stakeholders through focus groups has proven essential for identifying contextually appropriate cooling solutions, while real-time ecological momentary assessment via mobile surveys and microclimatic data collection presents both opportunities and limitations for capturing authentic thermal comfort perceptions. This paper offers valuable insights for researchers and practitioners working on climate adaptation in urban tourism contexts, highlighting the importance of integrating multiple data sources and balancing technological sophistication with practical implementation constraints.

1. Introduction

Urban tourism represents a vital economic sector for many Mediterranean cities, with the region attracting millions of visitors annually (Mejjad et al., 2022). However, climate change poses substantial challenges to this sector, with increasing frequency and intensity of heatwaves significantly impacting thermal comfort in urban spaces (Agulles et al., 2022; Caldeira & Kastenholz, 2018). Mediterranean cities are particularly vulnerable to these effects, necessitating adaptive strategies to maintain their attractiveness as tourism destinations while ensuring comfort and safety for both visitors and residents (Karimi & Mohammad, 2022; Lopes et al., 2021).

Several heat mitigation approaches have been explored in recent research, including expanding green spaces, creating shaded areas (Santamouris et al., 2020; Wong et al., 2021), implementing water features (Langie et al., 2022), and deploying advanced cooling technologies (Pezzuto et al., 2022). These interventions aim to reduce ambient temperatures and enhance thermal comfort in urban environments. However, the effectiveness of these strategies requires rigorous evaluation to inform future urban planning and policy decisions (Lopes et al., 2022).

The Cool Noons Project was developed to address the challenge of excessive heat in Mediterranean cities by testing innovative heat mitigation strategies. Spanning five pilot cities—Budva (Montenegro), Dubrovnik (Croatia), Imola (Italy), Lisbon (Portugal), and Marseille (France)—the project aims to improve thermal comfort during peak heat periods for both tourists and residents. Building on the methodological framework outlined by Caldeira et al. (in press), this paper describes the practical application of this framework in assessing cooling interventions across the pilot cities.

2. Methodological Framework Implementation

2.1 Overview

The applied methodological framework integrates multiple data collection techniques to evaluate three key aspects:

1. Heat reduction efficacy of cool paths and intervention areas
2. Attractiveness of these paths and solutions for tourists
3. Experience enhancement for visitors and residents

Implementation followed three major phases:

1. Initial assessment of existing cool paths and baseline data collection
2. Stakeholder engagement and selection of cooling solutions
3. Implementation and post-intervention assessment

2.2 Stakeholder Involvement Process

A crucial aspect of the project has been the engagement of local stakeholders in identifying and selecting appropriate cooling solutions. In each pilot city, focus groups were conducted with diverse participants including residents, tourism industry representatives, environmental specialists, urban planners and municipal officials.

Using a design thinking approach in some of the cities, group discussions identified several potential heat mitigation interventions. These collaborative sessions generated diverse cooling solutions informed by both stakeholder expertise and resident experiences. The final selection of interventions to be implemented was made by municipal technicians who evaluated options based on budget constraints, technical feasibility, anticipated cooling merit, and alignment with existing urban planning frameworks. This systematic evaluation process ensured that chosen interventions balanced innovation with practical implementation considerations.

2.3 Data Collection Methods

2.3.1 Assessing Cooling Efficacy

To evaluate whether the cool paths and interventions effectively reduce temperatures, multiple technological tools were deployed:

- Satellite imagery to monitor land surface temperatures
- Thermal cameras to record precise temperature conditions on the cool paths
- Weather stations gathering data on temperature, humidity, wind velocity, and solar radiation

A key component of the study in Lisbon involved the deployment of a movable weather station, which enabled the monitoring of microclimatic conditions along both shaded and non-shaded pedestrian routes. The station collected baseline meteorological data prior to the implementation of cooling interventions, as well as post-intervention data to assess their efficacy in mitigating urban heat. This high-resolution, in-situ monitoring captured variations in temperature, humidity, and wind speed, providing empirical evidence of the thermal benefits of different shading and cooling solutions. This dataset is now being integrated with real-time feedback from visitors and residents, enhancing the accuracy of our impact assessment.

These environmental data are currently being collected throughout the summer season across the pilot cities. Once gathered, these objective measurements will be integrated with self-declared thermal perception data obtained through the survey instruments. This integration of objective environmental measurements with subjective comfort assessments will provide a more holistic understanding of how physical temperature reductions correlate with actual human comfort experiences in the intervention areas.

2.3.2 Evaluating Attractiveness for Tourists

Tourist movement patterns were tracked using:

- GPS tracking with consenting participants
- GIS mapping of visitor movements

In Lisbon, an innovative smartphone application was implemented that integrated both GPS tracking capabilities and ecological momentary assessment tools. This dual-function app allowed for simultaneous collection of spatial movement data and real-time thermal comfort feedback from participants as they navigated through the city.

Understanding the relationship between weather conditions and tourist movement patterns is crucial for this project. Research indicates that extreme heat can significantly alter visitor behaviour, potentially leading to avoidance of certain areas, shortened activity durations, and modified itineraries (Caldeira & Kastenholz, 2028). By correlating spatial movement data with thermal conditions, the project can identify thresholds at which heat begins to influence decision-making and movement patterns. Additionally, these insights help clarify whether cool paths genuinely attract more visitors or merely serve those who would traverse these routes regardless of thermal conditions.

2.3.3 Assessing Experience Enhancement

The project employed innovative survey methodologies to capture visitor and resident experiences:

1. **Ecological Momentary Assessment via QR Codes and a smartphone app:** QR codes were strategically placed along both cool and regular paths, directing participants to brief in-situ surveys about their immediate thermal comfort and satisfaction. Additionally, a dedicated smartphone app was used to engage hotel guests through a personal approach, encouraging them to provide real-time feedback on their experiences. This approach intended to capture real-time perceptions while minimizing respondent burden. However, collecting in-loco feedback in real-time was confirmed to be a challenging task.
2. **Comprehensive Post-Visit Surveys:** Longer surveys distributed through hotels and tourist information centers gathered detailed feedback on the overall experience, including thermal comfort, satisfaction with cooling interventions, and behavioral adaptations.

Encouraging people to scan signs and respond while on-site, as well as persuading hotel guests to download the app and participate, posed difficulties in terms of response rates as expected. In Dubrovnik, one practical approach involved distributing water bottles with QR codes printed on them, inviting survey responses. In Lisbon, a digital screen at a local market near a mitigation solution being tested displayed an invitation to participate. The response rate to longer questionnaires was also low when not facilitated through a personal approach. However, the involvement of various stakeholders and the continuous solicitation of responses throughout the summer months should enable the achievement of the target response numbers deemed reasonable for each city. Data collection is ongoing, with perseverance and testing of strategies to maximize engagement and response quality.

3. Concluding Remarks: Challenges, Integration, and Future Steps

This study explores a multi-method approach to evaluating heat mitigation strategies in Mediterranean cities, combining microclimatic monitoring, real-time user experience assessment, and post-visit surveys. However, the implementation of this approach has encountered several logistical, technical, and data integration challenges

Collecting in-loco, real-time feedback remains a complex task. Encouraging individuals to engage with QR codes in public spaces or download an app requires tailored incentives and proactive engagement strategies. The experience of distributing water bottles with QR codes in Dubrovnik and using an interactive screen in a Lisbon market illustrates the need for context-sensitive recruitment approaches.

The deployment of movable weather stations necessitated careful calibration and placement to ensure comparability of baseline and post-intervention data. The integration of microclimatic data with self-reported thermal comfort assessments requires robust methodological alignment to avoid inconsistencies in spatial and temporal resolution.

A key challenge lies in merging the subjective perceptions of thermal comfort (from in-situ surveys and post-visit responses) with objective meteorological data. Ensuring meaningful cross-comparison between these datasets is critical for drawing reliable conclusions on the efficacy of cooling interventions.

Despite these challenges, the study is generating a rich, multi-dimensional dataset that will allow for a rigorous, evidence-based evaluation of urban heat mitigation strategies. The integration of high-resolution microclimatic monitoring with user experience data enhances the potential for scalable and replicable solutions. The findings from this study are expected to provide actionable insights for decision-makers, enabling the implementation of climate-responsive urban interventions based on well-informed strategies.

Future analyses will focus on synthesizing these diverse data streams to provide a comprehensive evaluation of cooling solutions, offering a replicable framework for other cities facing similar climatic challenges.

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