Outdoor Thermal Comfort Mitigation Strategies in Historic Cities: A Bibliometric Review

Abstract

This article provides a systematic literature review on outdoor thermal comfort mitigation strategies in historic cities designated with UNESCO tangible and cultural world heritage. The bibliometric method was used to analyze descriptive statistics and bibliographic coupling. The emerging results being the Asian-centric nature of current literature and four clusters of mitigation strategies, including 1) Nature-based solutions; 2) Street geometry and urban planning; 3) Integrated strategies; and 4) Water-based strategies. This research helps define the current literature directions related to the theme and promotes further development for studies analyzing mitigation strategies for historic cities with rising temperatures.

Keywords

Historic cities, outdoor thermal comfort, urban heat island, world heritage & mitigation strategies.

1. Introduction

As the role of tourism is expanding globally, so are the effects of climate change. Rising temperatures are putting 1.2 billion people at risk to climate hazards, such as heatwaves, flooding, hurricanes and drought (World Bank, 2024) and the rates have tripled since 1982 (NoAA, 2024). The effects of a warming planet are especially felt in the regions where hot summers were already a reality, such as in coastal regions in the Tropics, or near the equator. The urban heat island (UHI) effect, where cities experiences higher temperatures than the surrounding rural areas, is caused by climate change and unregulated urban expansion (Wang & Zacharias, 2015; Zhang, et al., 2022). UHI causes unpleasant outdoor thermal comfort (OTC) levels for residents and tourists alike when visiting the city during heatwaves or in the summer months (Lai, et al., 2019). As

temperatures continue to rise, innovative solutions are being implemented internationally to help mitigate the negative effects of urban heat islands.

As increased temperatures decrease thermal comfort, the threat to sustained tourism numbers to hot cities expands. This is especially the case with cities that typically attract large numbers of tourists due to their cultural heritage offer and presence of UNESCO tangible cultural heritage sites.

Since the onset of outdoor thermal comfort research, many investigations center around mitigation strategies. Common mitigation strategies that align with the SDGs include nature-based solutions such as increasing tree canopy coverage and diversifying and expanding vegetation in urban parks (Ferrario et al., 2024). While there is a lot of literature focusing on mitigation strategies, many of which use urban cities as case studies, the designation of historic cities with UNESCO heritage has not yet been addressed.

The aim of this investigation is to conduct a detailed search of literature surrounding outdoor thermal comfort mitigation strategies in historic cities, answering the question: *What heat mitigation strategies have been previously studied in the context of historic cities enhancing outdoor thermal comfort?* By presenting a performance analysis bibliometric review, we highlight and discuss the most prominent themes found in research that use clear mitigation strategies to lower temperatures and increase thermal comfort in cities with one or more UNESCO World Heritage site of cultural and tangible importance. By providing an overview of research, we consolidate knowledge, helping professionals understand best practices, areas of improvement, and research gaps.

2. Methodology

This study conducted a quantitative bibliometric review using the PRISMA Protocol (Moher et al., 2015) from the Scopus database of research articles related to outdoor thermal comfort and historic cities. Ultimately, 20 scientific articles were found in the last 10 years on SCOPUS that analyze outdoor thermal comfort mitigation strategies in urban cities that have one or more

tangible, cultural UNESCO world heritage (with “thermal comfort” mentioned in abstract specifically).

3. Results

3.1 Descriptive Analysis - Identifying Trends

The final 25 articles were analyzed with Biblioshiny (Aria & Cuccurullo, 2017) software to analyze descriptive trends.

Most of the articles were published in 2019 and 2024 with a steady increase after 2020 and the covid-19 pandemic. No articles were published between 2008 and 2013 nor in 2018.

The majority of the research was conducted in China, with seven studies published between 2016 and 2024. The other countries leading in outdoor thermal comfort mitigation strategies in historic city analysis are Japan (4), South Korea (3), and Portugal (2).

Of the seven inhabited world regions (Asia, Africa, Europe, Middle East, North America, Oceania, and South America), only four resulted in analyses: Asia, Europe, Middle East and Oceania (see Figure 1). Asia produced 13 case studies analyses, followed by Europe’s 10.

Figure 2 shows the mitigation strategies tested throughout the 25 articles. They were categorized based on induced themes (listed in quantitative order) trees, water bodies, urban design, vegetative shading, grass, evapotranspiration, urban greening, porous materials, cool coating, sun sails, green facades, cooling surfaces, ventilation, radiative cooling, shrubs, and reflective pavement.

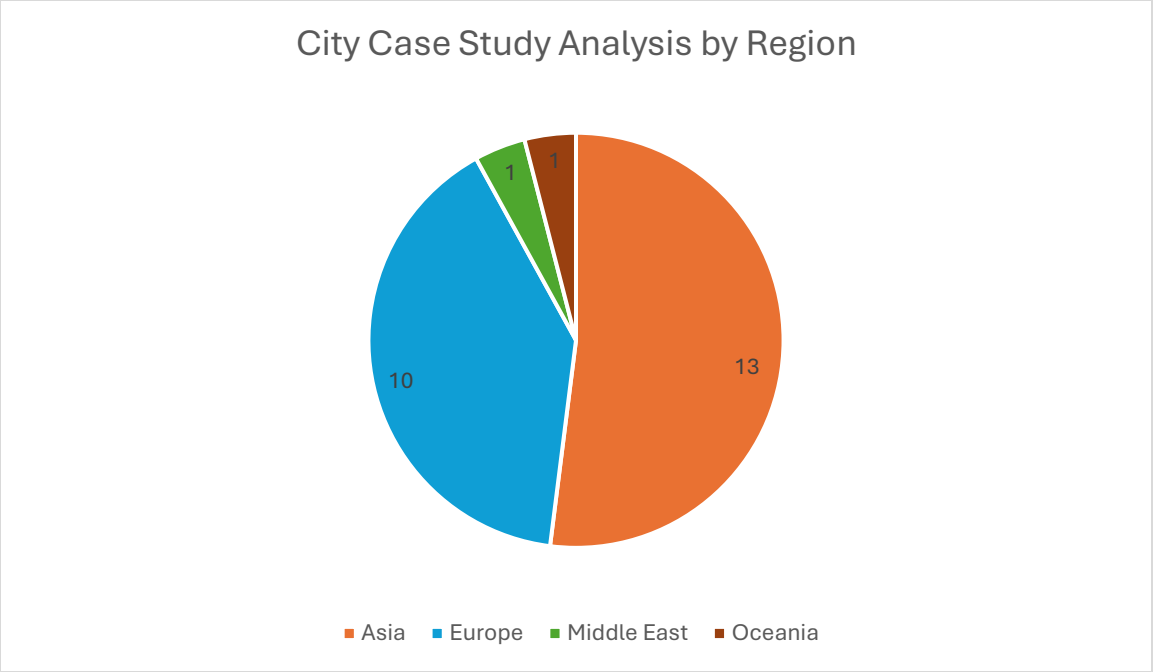

Fig. 1. Article Publication by Region

Note - No articles were written from Africa or the Americas (North or South).

Source: Elaborated by author with data taken from Scimago (2025)

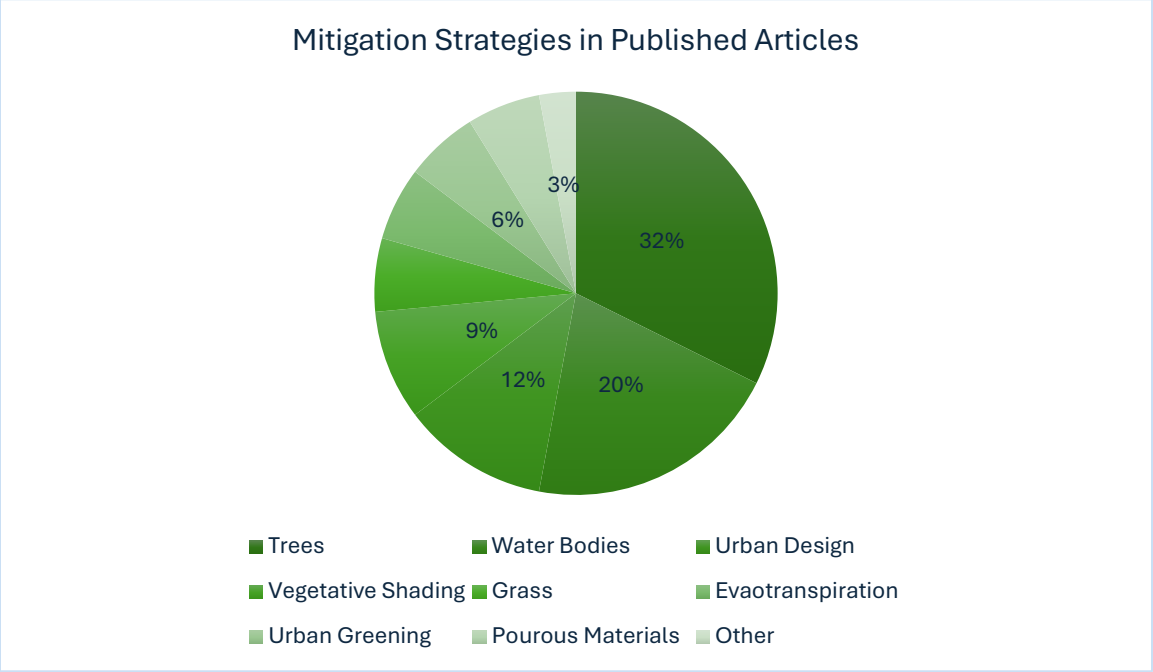

Fig. 2. Mitigation Strategy Tested

Note - "Other" includes Cool coating, Sun sails, Green facades, Cooling Surfaces, Ventilation, Radiative cooling, Shrubs & Reflective pavement – each with 1 reference.

3.2 Bibliographic Coupling - Emerging Themes

Emerging themes were identified using the bibliographic coupling method to map the relationship between the 25 articles (Donthu et al., 2021). Using the article analysis tool in VOSviewer (Van Eck and Waltman, 2009), the coupling yielded six clusters, four of which are connected by nodes, and two outlier clusters (see Figure 3). Each cluster revealed a common theme among the articles pertaining to their links and common references (Lim et al., 2022). The themes were deducted by the author by looking at the study methods, mitigation strategies, results, and recommendations. As the purpose of the investigation is to map articles referencing specific mitigation strategies, the clusters took the same form, each highlighting a different outdoor thermal comfort mitigation strategy.

The six themes deduced are 1) Nature-based solutions; 2) Street geometry and urban planning; 3) Integrated strategies; 4) Water-based strategies; 5) Urban green spaces based on remote sensing; and 6) Rehabilitation to existing structures.

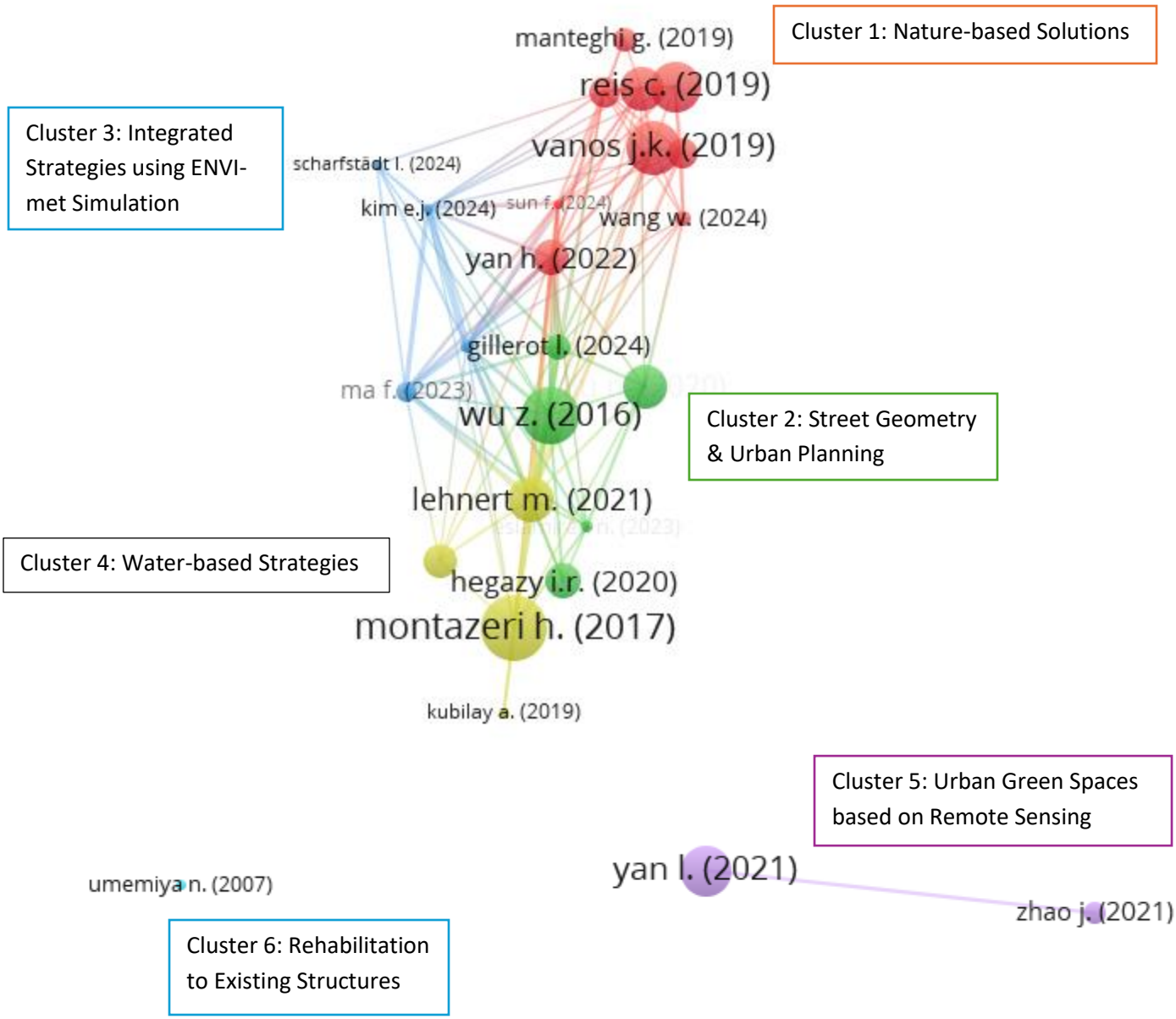

Fig. 3. Clusters Identified Through Bibliographic Coupling Analysis
Note – Clusters 5 and 6 were not linked to Clusters 1 through 4. They are included at the bottom of the model for reference.

4. Conclusions

4.1 Summary

This systematic literature review maps the leading literature in outdoor thermal comfort mitigation strategies in historic cities over the last two decades.

Through descriptive analysis trends in publication years; most productive countries, regions, and journals; and global citations were presented. The analysis showed most articles published in 2024 (5); China (7) and the greater region of Asia (13) as the most productive country and region.

Through bibliographic coupling, four defined research themes emerged in linked clusters, with two outlying clusters with no immediate linkage defined. The clusters are 1) Nature-based solutions; 2) Street geometry and urban planning; 3) Integrated strategies; 4) Water-based strategies; 5) Urban green spaces based on remote sensing; and 6) Rehabilitation to existing structures. These clusters highlight the mitigation strategies most discussed in literature relating to outdoor thermal comfort in historic cities.

Finally, this research presented an overview of current literature on mitigation strategies in warming historic cities. As climate change continues to affect the planet in many ways, scientific research is needed to provide data-driven solutions to the problems facing human populations. Temperatures remain on the rise and this research has provided a small step forward in the systematization of literature of historic cities experiencing negative outdoor thermal comfort.

4.2 Research Opportunities & Limitations

Various research opportunities emerged from bibliometric analysis. The descriptive analysis showed us the need to focus research on cities in Africa and the Americas as there were none present. It also presented a research gap in authors focusing on repeated investigations related to thermal comfort in historic cities as no authors wrote more than one article.

The bibliographic coupling presented a deficit in remote sensing analysis, and further analysis in each cluster, as the sample size was incredibly small. Future studies could expand the search to include keyword query results from the Web of Science and expand the parameters of historic city.

The limitations of this research include the limited sample size, as a bibliometric review usually analyzes large numbers of articles. With only 25 results, the results are sparse and without significant value.

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