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NEW CHALLENGES FOR XXI CENTURY CITIES

Multilevel scientific approach to impacts of global warming on urban areas, energy transition, optimisation of land use and emergency scenario

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TeMA Journal was established with the primary objective of fostering and strengthening the integration between urban transformation studies and those focused on mobility governance, in all their aspects, with a view to environmental sustainability. The three issues of the 2025 volume of TeMA Journal propose articles that deal with the effects of Global warming, reduction of energy consumption, immigration flows, optimization of land use, analysis and evaluation of civil protection plans in areas especially vulnerable to natural disasters and multilevel governance approach to adaptation.

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The cover image shows a composition of two photos of the Temple of Serapis in Pozzuoli (Italy). Giuseppe Mazzeo took them in January 2009 and March 2025. At the top, the 2009 image shows the temple flooded, with the pavement not visible. In the down, the 2025 image shows the temple’s pavement dry and exposed. The Temple of Serapis is one of the leading visual indicators of the bradyseism phenomenon in the Phlegraean Fields. The bradyseism phase, highlighted by comparison, started in the first years of this century, as shown by the data published by the National Institute of Geophysics and Volcanology (INGV) on the website dedicated to the phenomena (https://www.ov.ingv.it/index.php/il-bradisismo).

TeMA - Journal of Land Use, Mobility and Environment offers researches, applications and contributions with a unified approach to planning and mobility and publishes original inter-disciplinary papers on the interaction of transport, land use and environment. Domains include: engineering, planning, modeling, behavior, economics, geography, regional science, sociology, architecture and design, network science and complex systems.
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Contents

REVIEW NOTES

TeMA Journal of Land Use, Mobility and Environment

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REVIEW NOTES
Urban planning literature review

Exploring open and green space characteristics for climate change adaptation: a focus on the urban heat island

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Abstract
Starting from the relationship between urban planning and mobility management, TeMA has gradually expanded the view of the covered topics, always remaining in the groove of rigorous scientific in-depth analysis. This section of the Journal, Review Notes, is the expression of continuously updating emerging topics concerning relationships between urban planning, mobility, and environment, through a collection of short scientific papers written by young researchers. The Review Notes are made of five parts. Each section examines a specific aspect of the broader information storage within the main interests of TeMA Journal. In particular, the Urban planning literature review section presents recent books and journals on selected topics and issues within the global scientific panorama.
For the first issue of TeMA Journal volume no. 18, this section provides a comprehensive overview of the challenges and solutions related to the role of open and green spaces in climate change adaptation, with particular attention to the urban heat island effect. Using a variety of scientific sources and practical resources, this contribution aims to identify the key characteristics of these spaces that can influence adaptation strategies, examining the solutions proposed in the scientific literature, specifically in books, journals, and reports.

Keywords
Green Spaces; Open Spaces; Literature review; UHI.

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1. Introduction

The urban heat island (UHI) effect represents one of the most critical environmental challenges for contemporary cities (Bouketta, 2023), it results from heat accumulation in built areas due to dense urban morphology, high levels of impervious surfaces and human activities that alter the local climate (Bai et al, 2024). Rising global temperatures due to climate change increase this phenomenon, leading to raise energy consumption, health risks and a reduction in the quality of life for urban populations (Wang et al, 2022), so adapting to the UHI effect requires targeted strategies, in particular through the integration of open and green spaces in urban areas. Vegetation plays a crucial role in reducing temperatures through processes such as evapotranspiration and shading, which lower surface and air temperatures (Bowler et al., 2010); while green spaces, such as parks and tree corridors, are widely recognized for their cooling benefits, open spaces, including squares, parking areas and other built environments, play a crucial role in promoting urban climate resilience (Carpentieri et al., 2023). The use of reflective surfaces, permeable pavements, and shaded structures can enhance their cooling potential and complement the benefits of green infrastructure (Schmid et al., 2021). This persistent heat accumulation contributes to thermal discomfort and poses significant health risks, particularly for vulnerable populations such as the elderly, children, and individuals with pre-existing health conditions (Harlan et al., 2006). Additionally, the presence of water bodies within urban environments amplifies cooling effects by enhancing latent heat flux and evapotranspiration processes (Zhang et al., 2022). Given the complexity of urban heat dynamics, effective UHI mitigation strategies must integrate a mix of green and open spaces tailored to the specific climatic and morphological characteristics of each city (Gargiulo & Zucaro, 2023). The role of urban governance in implementing these strategies is essential, as it determines the spatial configuration and accessibility of cooling areas, ensuring equitable benefits for all residents (Gunawardena et al., 2017). Therefore this study want to explore how different characteristics of open and green spaces contribute to climate adaptation, drawing on scientific studies that assess their effectiveness in mitigating the UHI.

2. Agreements and strategies developed at international level

Various international policies and agreements recognize the importance of green and open spaces in climate adaptation strategies, for example the European Green Deal and the EU Green Infrastructure Strategy promote nature-based solutions to create climate-resilient cities. At the global level, the Paris Agreement and the United Nations Sustainable Development Goals (particularly SDG 11: Sustainable Cities and Communities) emphasize the need to integrate urban green spaces into climate policies (Gargiulo & Zucaro, 2020).

At regional and municipal levels, many cities have implemented specific regulations to promote urban greening, mandate green roofs, and protect open spaces. The European Commission has launched initiatives encouraging Member States to develop green infrastructure projects that mitigate the urban heat island (UHI) effect and enhance overall urban resilience and, additionally, innovative urban planning strategies are incorporating new technologies to optimize green space management, ensuring long-term environmental and social benefits. Green spaces contribute not only to climate adaptation but also to biodiversity conservation, improved air quality, and enhanced public health, reinforcing their essential role in sustainable urban development.

3. Morphological characteristics of open spaces and their role in UHI adaptation

In contemporary urban governance management, there is a growing shift towards a holistic perspective of urban systems, which emphasizes adaptation to the impacts of climate change. This approach emphasizes the need to understand the complex interactions between urban components and their responses to environmental

challenges, both expected and unexpected (Carpentieri et al., 2024). A key aspect of this discourse is the role of open spaces, their morphology and their impact on urban heat island (UHI) adaptation, infact the research shows that green infrastructure, such as tree cover, vegetation and water bodies, play a critical role in adapting to UHI effects by reducing surface and air temperatures through shading and evapotranspiration (Bouketta, 2023). The presence of greenery within urban open spaces contributes to the creation of urban cooling effects, which provide optimal thermal comfort to pedestrians (Bouketta, 2023; Wang & Gou, 2024) and the cooling potential of these spaces depends not only on vegetation structure and impervious surface reduction, but also on the spatial configuration of buildings and urban form. Wang and Gou (2024) showed that open spaces enclosed by low-density buildings provide the highest levels of thermal comfort, while those surrounded by a combination of green spaces and high-density built environments exhibit reduced cooling effectiveness. Open space characteristics, including vegetation, pavement type, and water elements, interact with urban form to shape microclimatic conditions.

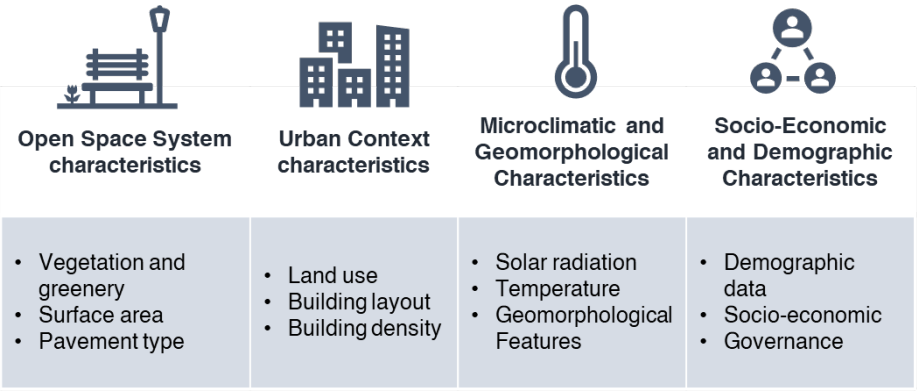
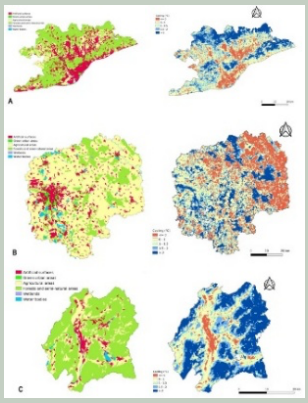


Fig.1 Definition of urban characteristics (Carpentieri et al., 2024)

The literature categorizes these elements into four main groups: open space system, urban context, microclimatic and geomorphological characteristics, and socio-economic and demographic characteristics (Carpentieri et al., 2024). Among them, the open space system, including vegetation, surface, and pavement type, is particularly relevant for UHI adaptation. The proportion of green cover, grass, and permeable surfaces contributes to surface cooling, while the spatial distribution of parks and courtyards improves airflow and reduces localized heat accumulation (Nirnac et al., 2022). In addition, the materials used in paved surfaces influence urban albedo and exposure to solar radiation, further impacting microclimatic conditions (Shen et al., 2022). The urban context also plays a key role in regulating microclimate, infact the land use, the building density, and the building layout affect the effectiveness of open spaces in reducing urban heat. High building density and compact urban fabrics tend to retain heat, amplifying UHI effects, while a strategic combination of open spaces and low-density buildings promotes better air circulation and heat dissipation. Furthermore, urban infrastructure elements, such as shading systems and tree corridors, influence solar radiation exposure and temperature variation (Das et al., 2022). Microclimatic and geomorphological characteristics, including solar radiation, wind patterns, humidity, and temperature variations, further determine the cooling capacity of urban open spaces. Factors such as global solar radiation, mean radiant temperature (MRT), and land surface temperature (LST) are critical to assess UHI intensity (Zhang et al., 2022). Urban wind flow, dictated by street orientation and building configuration, facilitates natural ventilation and enhances cooling effects (Rajagopalan et al., 2014). Similarly, the presence of water bodies in urban areas contributes significantly to thermal regulation by absorbing and dissipating heat (Patle & Ghuge, 2024). Finally, socio-economic and demographic characteristics influence the accessibility and use of open spaces. Population density, age distribution, lifestyle and governance structures determine how urban spaces are maintained and integrated into climate adaptation strategies (Cruz et al., 2021). Effective policy interventions, supported by government and local institutions,

are essential to increase the resilience of cities to UHI effects through strategic urban design and planning (Pigliautile et al., 2021).

Urban Heat Island Mitigation by Green Infrastructure in European Functional Urban Areas



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Publication year: 2021

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This study evaluates the ecosystem service of microclimate regulation provided by green areas in 601 European cities. The findings highlight that urban green infrastructure (UGI) significantly reduces urban temperatures, with an average cooling effect of 1.07°C and peaks of up to 2.9°C in some areas. The research underscores the need for strategic integration of UGI into urban planning to enhance adaptation and mitigate climate risks. Notably, a tree covers of at least 16% is required to achieve a 1°C reduction in urban temperatures.

European Commission - More vegetation in targeted urban areas can mitigate extreme heat

A JRC-led study published in *Nature Communications* demonstrates that targeted greening efforts in heat-prone areas are more effective than uniform city-wide vegetation distribution. By analyzing 200 cities worldwide, the study emphasizes the importance of precise spatial planning in mitigating heat stress. The research supports policy recommendations that prioritize localized green interventions to reduce heat exposure and improve urban livability.

Retrieved from:
https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/more-vegetation-targeted-urban-areas-can-mitigate-extreme-heat-2023-05-31_en

Demonstrating heat stress in European cities

Urban areas experience higher temperatures than rural surroundings due to artificial infrastructure and human activities, causing health risks. The UrbClim® model, using C3S ERA5 climate data, maps urban heat islands for 100 European cities at 100m resolution. This data helps urban planners implement green infrastructure and adaptation strategies, such as cool spots and green roofs, to mitigate heat stress and improve urban resilience. The tool is free and accessible.

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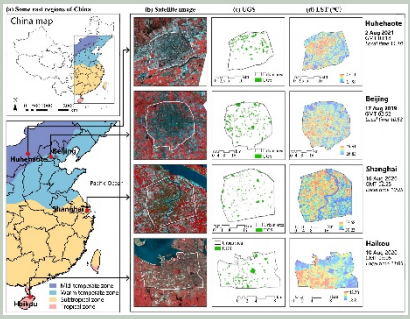
How can urban green spaces be planned to mitigate urban heat island effect under different climatic backgrounds? A threshold-based perspective



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A comparative analysis of four Chinese cities with varying climatic conditions reveals that the cooling intensity of urban green spaces depends on local climate backgrounds. The study identifies key factors, such as the presence of water bodies and vegetation density, that influence the effectiveness of urban greening strategies. These findings offer practical guidelines for designing urban landscapes that maximize cooling benefits.

How can urban green spaces be planned to mitigate urban heat island effect under different climatic backgrounds? A threshold-based perspective

The EU Green Infrastructure Strategy promotes the development of urban green spaces as a tool for climate mitigation and biodiversity conservation. This policy-driven approach underscores the multifunctionality of green infrastructure, which not only reduces heat stress but also enhances water management, air quality, and public well-being. Integrating green infrastructure into urban planning ensures long-term sustainability and resilience against climate change.

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https://environment.ec.europa.eu/topics/nature-and-biodiversity/green-infrastructure_en#:~:text=Well%2Ddesigned%20urban%20green%20spaces,well%2Dbeing%20of%20urban%20residents.

4 Conclusion

Climate adaptation strategies, in particular to reduce UHI effects, cannot only count on traditional green spaces such as parks and tree canopies. Built open spaces, including public squares, brownfields and brownfield sites, offer valuable opportunities for climate adaptation interventions. Urban policies must therefore recognise the interconnected role of natural and built environments in mitigating temperature extremes. Strategies that incorporate green and open spaces into urban planning will increase the adaptability of cities to climate change, reduce heat-related health risks and improve overall urban quality of life. Future research should focus on implementing hybrid solutions that combine nature-based interventions with innovative urban design techniques. By harnessing the combined potential of green infrastructure and open space adaptation, cities can build more climate-resilient environments for present and future generations.

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