Heat Equity Planning and Green Infrastructure

Subjects: Regional & Urban Planning

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As the global temperature and rapid urbanization continue to rise, urban heat islands (UHIs) also continue to increase across the world. Following the heat equity concept, UHIs disproportionately impact disadvantaged or overburdened communities. Green infrastructure (GI) has been at the forefront of UHI mitigation efforts, including nature-based solutions like parks, pervious open spaces, wooded areas, green roofs, rain gardens, and shade trees.

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1. Introduction

In the present climate crisis, the urban heat island (UHI) effect is an increasingly common phenomenon that results in surface temperatures in many urban neighborhoods that are disproportionately higher than nearby suburban areas. Excessive urban development patterns in the USA are a leading cause of UHI, resulting in a rise in urban and rural air temperatures by 0.24 °C and 0.16 °C per decade, respectively [1]. Other contributing factors include heat re-radiating off urban structures—exacerbated by the preponderance of non-reflective; water-resistant surfaces and a lack of vegetated moisture-absorbing surfaces—and increased greenhouse gas emissions [2][3].

2. Heat Equity Planning

Prior research has underscored how the UHI effect has negatively impacted cities' levels of air pollution, energy consumption, and human health, thereby endangering humans, the environment, and the economy due to localized temperature increases [2]. In general, the number of heat-related mortalities in the USA has gradually increased and exceeded the deaths caused by other extreme weather events, especially for health-sensitive and poor populations [4][5]. Other human impacts of extreme heat include irritability, symptoms of mental depression, breathing difficulty, cramps, and non-fatal heat stroke [2].

Heat exposure, however, is not evenly distributed across built environments, in large part because of historical inequitable urban planning policies, such as redlining and interstate siting, and design decisions triggering heat-related risks in disadvantaged neighborhoods [6]. The concept of "heat equity" refers to the development of policies and practices that reduce the inequitable distribution of heat-related risks across different populations within the same urban area [7]. Disadvantaged communities aim for heat equity due to the disproportionate impact of the UHI effect and its associated health-related risks on vulnerable populations such as children, the elderly, racial and ethnic minorities, people without housing, individuals with limited or no education, and those with pre-existing

conditions, especially in areas characterized by high population density and an abundance of man-made structures and buildings [2][8][9]. The UHI effect not only exacerbates in economically disadvantaged areas but also presents a persistent challenge in ensuring equitable services to these communities, especially as climate change accelerates [10]. Scholars have thus begun demanding urban planners include heat equity within the broader EJ agenda to ensure all members of a community, regardless of socioeconomic status, have access to thermally safe indoor and outdoor environments [6].

In an ever-changing climate within an increasingly urbanized world, the UHI effect and its various mitigation techniques have become exceedingly prevalent in scholarly literature [11]. Contemporary UHI mitigation techniques such as shade structures, reflective materials, cool or green roofs, cool pavements, and urban greening can save energy, lower the cost of energy, improve air quality, and counter global warming [12]. Many researchers have identified urban greening or green infrastructure (GI) techniques as some of the most effective strategies to mitigate UHI and decrease the impacts of global warming [10][13][14], although their spatial distribution in cities presents important issues of equity and spatial justice [9][15][16][17].

Given the well-documented spatial disparity among urban GI projects, it is important to understand how urban planners approach and implement these projects. Studies have determined the suitability of locations for different GIs by examining the environmental, economic, and social aspects of each location, as well as the proposed project's ability to address specific community concerns and how receptive the local government and residents are to the said project [18][19]. Planners also need to deeply consider the potential for GI projects to result in green gentrification, which threatens to displace residents from their root communities [20][21].

Understanding public perceptions of GI as a critical UHI mitigation technique can help better inform the GI planning process, as these perceptions directly impact the community buy-in, adoption, and success of GI projects [22][23][24][25]. Prior research suggests that residents often have strong opinions and feelings about specific types of GI and their placement within their neighborhoods, especially as they relate to concerns about appearance, maintenance, seasonality, and perceived benefits [26]. Thus, it is also important to help educate community residents about GI so that their perceptions are based on accurate scientific knowledge [27].

UHI mitigation through careful GI planning, installation, and maintenance is a step toward climate resilience, but prior research suggests that while most people know about climate change, their degrees of concern are not proportionate. A study conducted in 2008 in both Houston, Texas, and Portland, Oregon, showed 92% and 98% of respondents were aware of climate change, but only 82% and 90% expressed concern, and only about half indicated the willingness and ability to change their behavior to mitigate climate change. These findings suggest a disconnect between awareness or perception of climate change and the need to act [28], despite additional research finding that having specific knowledge of how climate change can impact communities and what solutions are available is more impactful in generating concern than general knowledge of science alone [29].

Another study in 2017 emphasized the necessity of incorporating the UHI effect into building design and performance simulation, illustrating the impact of climate change on building performance over the past decade [30].

Considering the effects of the UHI on predicted building energy consumption in four South American Pacific coastal cities revealed an increase in their energy demand by 15% to 200% [30]. The UHI significantly alters building performance, affecting energy consumption and subsequently raising heating and cooling costs, disproportionately impacting disadvantaged neighborhoods. While the UHI may contribute to a reduction in indoor heating needs during cold months, it substantially amplifies the demand for indoor cooling during warm months, resulting in higher energy consumption for building cooling, which becomes costly both monetarily and environmentally [2].

Residents' perceptions directly influence the level to which they value/appreciate urban greening or GI projects and assume ownership of them. Additionally, understanding the inequitable spatial distribution of urban GI projects can help city officials and urban planners take appropriate steps to minimize any greenspace deficiencies in disadvantaged neighborhoods. More research is needed, however, to understand community perceptions of how GI mitigates the UHI effect, how GI decreases the impacts of climate change at the local level, and how community residents would respond to the types and placement of GI in their neighborhoods.

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