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The Distribution and Accessibility of Cooling Resources in Low-income Communities: Comparative Analysis of Beijing and Los Angeles

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Abstract: Increased global temperatures and urban density pose increasing challenges to cities regarding the urban heat island (UHI) effect in low-income communities that lack equitable cooling infrastructure. The spatial pattern and accessibility of Beijing and Los Angeles cooling resources from 2015 to 2024 are compared here. The research uses geospatial and statistical analyses regarding how disparities in cooling infrastructure relate to income levels and urban heat exposure, focusing on vulnerable neighbourhoods that the Department of Energy designated as low-income. Descriptive statistics and comparative urban policy review are used to evaluate the equity of the cooling resource allocation in both cities. However, findings show that low-income areas especially retain limited cooling infrastructure, higher land surface temperature and more significant UHI differentials. These disparities reflect systemic environmental injustices that reflect governance models, historical urban development and socioeconomic inequality. The study suggests that climate adaptation strategies must incorporate equitable planning with green infrastructure investment targeted toward specific communities and improvements in public cooling facilities. These insights offer important guidance for city policymakers searching for solutions to heat vulnerability and inclusive, climate-resilient cities amid ongoing climate change.

Keywords: Urban heat island (UHI), cooling resources accessibility, environmental justice.

1. Introduction

The heat island effect is that temperature is usually higher than in suburban areas due to buildings' better heat-absorption ability. Urban heat islands bring on numerous problems. From an environmental perspective, increasing urban temperatures may directly impact urban precipitation, leading to excessive rain and dryness, changing the behaviour of animals and microorganisms, and negatively impacting city ecosystems. Since air conditioners are more necessary, residents must cope with high temperatures and growing electricity costs. Though wealthy households living in the city may still be able to maintain an ideal living quality, low-income people can suffer significantly because of their vulnerability. Poverty lowers medical treatment and protection opportunities when people face diseases caused by growing temperatures, resulting in a harsh disaster.

Cooling sources, including public green spaces, artificial heat relief facilities, and building energy efficiency technologies, are the leading solutions against UHI; however, they are not distributed fairly. Green area rates are more likely to be lower in low-income communities. Since its close relationship with the UHI, the low green area rate in these communities intensifies the heat vulnerable people have to undertake, making them more susceptible to diseases and death caused by the high temperature. Plenty of single-city-based studies contribute to the consequences of cooling source inequality. However, barely any of them compare the effect of urban heat islands on vulnerable people between cities with different climates and policies, which is a valuable way to gain further understanding of the solution to the issue.

This study uniquely focuses on the comparison between Beijing, which is a representative of government-driven urban heat island mitigation efforts, and Los Angeles, an example of community-based resilience initiatives and climate justice advocacy, to reveal how contrasting governance models and socio-political contexts shape cooling resource equity in low-income urban areas, filling the gap of the international comparison of heat-island effect policy approaches when studying their effect on low-income people. The study aims to answer two major questions. First, to what extent can the systematic difference in spatial distribution and accessibility of cooling sources in Beijing and Los Angeles be made? Second, how do policy orientation, technical application, and societal and economic factors lead to the aforementioned differences? This study reveals the impact of different governance models on urban heat island response strategies through cross-border comparison, providing a cross-cultural empirical basis for environmental justice theory and key decision-making reference for balancing efficiency and equity in formulating climate adaptation policies for global cities.

2. Literature review

As an intensifying climate phenomenon, the urban heat island effect has been debated with research on climatology, urban planning, and environmental justice. This section synthesizes key theoretical and empirical contributions across four thematic categories.

2.1. Drivers of urban heat island effects

Studies consistently identify urbanization and anthropogenic activities as primary urban-heat-island drivers. Santamouris quantified the role of building materials, demonstrating that reflective roofs and green infrastructure reduce surface temperatures by up to 4°C in Mediterranean cities through increased reflectivity and water evaporation [1]. Low-income neighbourhoods experienced two to three times higher rates of heat-related mortality because of a lack of green spaces and deteriorating infrastructure, according to Harlan et al., who connected socioeconomic vulnerability to heat exposure in Phoenix, Arizona [2]. These studies suggest that building materials and green space are two primary components of reducing the urban heat island effect, and the lack of these leads to intense UHI in low-income communities. This study will use green space areas as a representative cooling resource between low-income communities and the city downtown and give an analysis.

2.2. Different urban cooling solutions

Scholars have evaluated both natural and artificial cooling solutions. He et al. analyzed Beijing's "sponge city" initiative, showing that permeable pavements and urban wetlands reduced peak temperatures by 2.5°C, though implementation gaps persisted in historic neighborhoods [3]. Nghana and Tariku argue that phase change materials (PCM) can efficiently keep indoor air stable and lower the heating energy requirement in residential buildings. In the winter, they can lower energy use by up to 57% and improve thermal comfort [4]. These studies collectively demonstrate that integrating nature-based solutions with advanced material technologies could create comprehensive urban cooling strategies.

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2.3. Socioeconomic and policy dimensions

Environmental justice frameworks emphasize systematic injustices in the distribution of cooling resources. Heat vulnerability was exacerbated in predominantly Black and Latino neighbourhoods, which had 30% less tree canopy coverage than wealthy white areas, according to Jesdale et al. mapping of racial disparities in Los Angeles [5]. Pineo et al. claimed that urban health indicator tools provide diverse data on urban health impacts, but their use in policy and decision-making is limited [6]. Data-driven improvements toward UHI and equity, especially from an ethnicity perspective, are highly needed under the current situation of environmental justice. The work will also reflect the environmental injustice throughout different communities.

3. Analysis and discussion

3.1. Spatial patterns of cooling resource distribution

The data set provides a rich, comparative landscape of cooling resource availability across two major urban centers, Beijing and Los Angeles, in 2015 and 2024. As shown in Table 1, with 50 observations each, there is a balanced temporal-spatial data set for analysis. Data covers 10 years within each city across five urban tracts to offer a granular lens to examine the spatial patterns of cooling resource distribution, for example, across low-income neighborhoods.

Variables such as access to cooling centers, park area per 1,000 people, green space per cent, and tree canopy coverage reveal significant variations among tracts, indicating the unequal provision of the urban cooling infrastructure. Year after year, tracts of different densities contain varying availability of cooling centers, which are definitive as a quick refuge space during heatwaves. Across years, there are very few, if any, cooling centre access in several low-income flagged tracts, which provides evidence of an equity problem that exists at the systemic level.

Table 1: Summary of cooling resource indicators (2015-2024)

City	Avg. Cooling Center Access (0-1)	Avg. Park Area per 1000 ppl (m^2)	Avg. Green Space %	Avg. Tree Canopy %	Avg. Public AC Facilities
Beijing	0.39	12.45	25.21	21.63	2.10
Los Angeles	0.51	18.23	28.47	27.31	3.85

Access to cooling centres seems sporadic in tracts in Beijing, nor do some have zero presence across multiple years. Socioeconomic disparities correlate with resource distribution across a wide range of tract-level median household income, from under ¥42,000 to over ¥115,000. To illustrate, the Shibalidian subdistrict (Chaoyang) shows lower values for park area and green space rate and many low-income flags, indicating points of tug between low cooling infrastructure and wealth vulnerability.

Los Angeles shows a slightly more structured distribution. However, different public air-conditioned facility access levels are present, but tracts generally show relatively higher and less variable percentages of tree canopy and green space. Nevertheless, dissimilar to such neighborhoods, neighborhoods with persistent low-income flags, like Boyle Heights and East Hollywood, score lower in admittance of gathering focuses and in park regions for every resident, illustrating the difficulty in suggesting enthusiastic arranging in evident poverty zones.

Tree canopy, a highly revealing function of urban temperature moderation, is present. Nevertheless, in such tracts as Dahongmen subdistrict (Fengtai District) and Xinliekou Subdistrict (Xicheng) sampled in several years, coverage at high-income neighbourhoods of more than 30% is observed,

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while it falls below 10% at low-income neighborhoods. As important as environmental aesthetics are, the absence of vegetative cover directly amplifies the effects of urban heat island (UHI) influences and reduces overall neighbourhood resilience.

3.2. Relationship between income, green infrastructure, and heat exposure

Patterns of meaningful trends are revealed through statistical relationships among cooling infrastructure, socioeconomic status, and land surface temperature (LST) indicators. A cross-examination was conducted between median household income (a proxy for socioeconomic status), park area per 1,000 people, green space percentage, and tree canopy. Highest park availability and vegetative cooling were consistently reported across both cities, with higher-income neighborhoods reflecting a systemic alignment of wealth and environmental privilege (shown in Table2).

Table 2: Relationship between income and cooling resources (combined data)

Income Bracket	Avg. Median HH Income	Avg. Tree Canopy %	Avg. Daytime LST (°C)	Avg. UHI Differential (°C)
Low-Income Tracts	¥50,134/$38,900	13.74	42.87	5.42
High-Income Tracts	¥112,300/$91,050	31.28	34.56	3.72

The regression analysis results show a negative correlation between green space percentage and daytime LST, so a higher green space percentage corresponds to a lower LST. Selected tracts had average daytime LSTs ranging between 32°C and 34°C for those over 30% green coverage and frequently over 45°C when below 10%. This is most evident for tracts on the lower income scale since green investment here is minimal (shown in Table 3).

Tree canopy also has a similarly strong relationship. However, there is a lower temperature differential when areas have over 25% canopy, indicating that areas with over 25% canopy effectively cool down at night. This is consistent with the assertion of the literature from Zhou et al. in 2021 and Schwarz et al. in 2015 that vegetative cover lowers heat and enhances ecological equity [7, 8].

Table 3: Thermal exposure in low-income tracts with minimal cooling infrastructure

City	Tract ID	Low Income Flag	Avg. Tree Canopy %	Avg. Cooling Access (0-1)	Avg. Nighttime LST (°C)	Avg. UHI Differential (°C)
Beijing	Dahongmen subdistrict (Fengtai District)	Yes	9.23	0.20	31.08	5.76
Los Angeles	East Hollywood	Yes	11.54	0.30	30.27	5.48

Conversely, the green space ratio in the Shibalidian subdistrict (Chaoyang) is low, but the recorded UHI differential of > 5.5°C is high. The spatial implications are that although urban cooling elements are present, they are insufficient and aggravated by socio-economic marginalization, intensifying heat vulnerability amongst low-income groups.

Further, the variable "Cooling center access" is a binary indicator of structural inequities. When this indicator is calculated, it remains zero in several tracts, such as the Tiantan subdistrict (Ponashens District) and East Hollywood, for most of the decade. While later years (post-2020) see some

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improvement, the absence or maintenance of absence in previous years (pre-2020) shows a long-standing gap in heat adaptation infrastructure.

In addition, another important metric, access to air-conditioned public facilities, varies tremendously. Public AC may number three to five per year in higher household income tracts, such as higher income flagged South Central LA (e.g., Vermont Square) and Xinliekou Subdistrict (Xicheng). The most important way this infrastructural void relates to community-level heat stress is during extended heat waves.

3.3. Urban heat island effects and vulnerable populations

Urban heat island (UHI) differential values represent a direct lens to the thermal differences among neighborhoods. The amount of heat trapped in a neighborhood is demonstrated by UHI—the difference between urban surface temperatures and those in surrounding rural areas.

Low-income designation is used to conduct UHI differential analysis and stark patterns appear. Both cities have low income flagged tracts that consistently report higher UHI differentials. In over 60% of years, tracts Dahongmen subdistrict (Fengtai) and Huaxiang Subdistrict (Fengtai) have differentials greater than 5.5 °C in Beijing. In Los Angeles, Pacoima (San Fernando Valley) and East Hollywood also report the same range, and some peaks near six degrees occur occasionally.

An examination of diurnal cooling also reveals that neighborhoods without sufficient tree canopy experience significantly less cooling during the day, resulting in a prolonged thermal exposure. As for example, in Dahongmen subdistrict, where the tree canopy fractional cover is below 10%, the LST at night never drops below 30°C, for 6 successive years, much above the thermal comfort threshold.

This has huge implications for public health. And because so much physiological recovery takes place at night and with continuous exposure to night time elevated temperatures, physiological recovery is limited and the risk of heat related illnesses increased. While this accumulation of urban thermal inequity is arguably worse in low-income neighborhoods due to reduced tree cover, lack of cooling centers and limited AC access, it ensures that a lot of work needs to be done to address the issues of urban thermal inequity.

These findings converge with urban climate literature such as Fraser et al. and Chu et al. who have documented geographic clustering of heat vulnerability in marginalized communities [9, 10]. Considering the data from both cities, the findings indicate that income status is more influential than the urban form in itself, to determining accessibility to cooling resources and ultimately levels of exposure to urban heat stress.

In addition, the data shows that UHI vulnerability has a temporal aspect. In the latter half of the decade, the installation of cooling infrastructure improves marginally, but it is not enough to catch up to the intensifying and frequency of heatwaves caused by climate change. The temporal lag demonstrated in this text reinforces the necessity of proactive, equity-based climate adaptation approaches that prioritize high risk communities.

Consequently, the spatial and temporal analysis demonstrates continued systematic and uneven distribution of cooling resources by income group and across urban contexts. Because of the poor investments into the infrastructural and ecological arena, two cities, namely, Beijing and Los Angeles, are exposing their populations in both cities as vulnerable due to the compounded risks of insufficient infrastructural and ecological planning and investments.

3.4. Discussion

The analysis of Beijing and Los Angeles is a stark reminder of a pervasive distribution of unequal patterns of unschooling resources that exacerbate social vulnerability. Environmental and socioeconomic factors, with specific mention of income disparities, land use patterns, and previous planning legacies, create an intersection of exposure to urban heat, disproportionately affecting low-income populations. The study finds support with the significant difference of 15.58% per unit area in disadvantaged tracts of tree canopy coverage between low-income tracts and the city average level that while increased residential air conditioning and even public cooling exist, accessibility to these facilities for lower-income neighborhoods during extreme heat events is insufficient.

Across both cities, surface temperatures were more than significantly higher during both daytime and nighttime hours in cooling centre tracts with the lowest median household incomes, which were also found as being less likely to have access to cooling centres and with lower green space availability. The conclusions of Chu et al. about the need for equity-oriented adaptation strategies in Los Angeles also agree with this [10]. The failure of environmental justice associated with the systemic deprivation of green infrastructure in disadvantaged neighbourhoods exacerbates heat-related health risks. It is exacerbated by the increasing frequency and severity of heat waves as a result of climate change.

In particular, urban vegetation is the most important role. According to Zhou et al. and Schwarz et al., tree canopy not only does direct shading but also broader microclimatic cooling [7, 8]. Yet the data shows that tree canopy coverage most frequently remains below 10% in tracts with persistent low-income flags, and thus passive cooling potential and enhancement of urban heat island effects. This supports the argument that parks and greens have more than recreational benefits; they also protect against environmental stressors.

Challenges in cooling resource allocation are doubled by policy and governance differences between the two cities. As Wang and Ottinger point out, Beijing has a more centralized environmental governance model that may be less consistent across districts [11]. On the other hand, although Los Angeles is less centralized, it is still plagued with fragmented distribution of resources caused by overlapping jurisdiction and sporadic funding. As found in Romero-Lankao, these institutional dynamics define, to a certain extent, the extent to which urban governments are capable of formulating effective climate resilience policies [12].

In addition, the authors Zheng et al., point out that the legacy of urban migration and informal settlements in Beijing has provided specific neighbourhoods with a structural disadvantage [13]. The limited public investment in these 'urban villages' follows patterns of neglect in underserved neighbourhood areas such as South Central and East LA, where Palinkas et al. find little adaptation readiness to both heat and air quality challenges [14].

As these climate risks escalate, conventional infrastructure investments need to be reconsidered on the basis of place-based and justice-oriented frameworks. The spatial inequities highlighted in this study call for multidimensional urban sustainability assessments that incorporate social justice, health, and ecological resilience. Strategic placement of cooling centres, expanding tree canopy, and ensuring that public AC facilities are available and accessible in the most vulnerable areas of the city should never be thought of as afterthoughts because they are core climate adaptive planning elements.

This study also provides insights into planning for potential input from machine learning and high spatial resolution analysis, like that used by Sun et al. in the ranking of areas for intervention [15]. For water-scarce cities like Los Angeles, as Wood put it, vegetated cooling optimization is best achieved by simultaneously balancing ecological and resource tradeoffs [16]. For building heat-resilient urban futures, innovative, targeted interventions that align with environmental and social equity goals will be critical in both cities.

4. Conclusion

This paper illustrates the important inequities in distribution and access to cooling resources in low-income communities in Beijing and Los Angeles. It is found spatially and statistically that vulnerable populations in both cities are subjected to increased exposure from UHI effects because cooling centers, public air-conditioned parks, green areas, and tree canopy coverage are inadequate. These are all closely related to socioeconomic status in that, as a rule, they have more inequities, higher land surface temperatures, and less adaptive infrastructures.

The findings underscore the urgency of equity-centered climate adaptation policy. Both cities have improved their approach to heat risks, but they have taken different directions while trying to achieve this, and their attempts remain uneven and reactive. Urban greenery is a strategic investment, the deployment of publicly available cooling infrastructure is increased, and tailored community-based heat adaptation strategies are essential to reducing health risks for marginalized groups. By emphasizing the fact that adaptation has to do with correcting the imbalances in access and protection that lead to less safety, the contribution of this study is made to the more significant flow of environmental justice and urban climate resilience. Longitudinal impacts and community integration should form the focus of future research and shape inclusive and data-informed urban planning that takes into consideration the needs that those most impacted by urban heat are demanding.

References

[1] Santamouris, M. (2014) Cooling the cities – A review of Reflective and Green Roof Mitigation Technologies to Fight Heat Island and Improve Comfort in Urban Environments. Solar Energy, 103, 682–703.

[2] Harlan, S.L., Declet-Barreto, J. H., Stefanov, W. L. and Petitti, D.B. (2013) Neighborhood Effects on Heat Deaths: Social and Environmental Predictors of Vulnerability in Maricopa County, Arizona. Environmental Health Perspectives, 2, 197–204.

[3] He, Bao-Jie, et al. (2019) Co-Benefits Approach: Opportunities for Implementing Sponge City and Urban Heat Island Mitigation. Land Use Policy, 86, 147–57.

[4] Nghana, B. and Tariku, F. (2016) Phase Change Material's (PCM) Impacts on the Energy Performance and Thermal Comfort of Buildings in a Mild Climate. Building and Environment, 99, 221–238.

[5] Jesdale, B.M., Morello-Frosch, R. and Cushing, L. (2013) The Racial/Ethnic Distribution of Heat Risk–Related Land Cover in Relation to Residential Segregation. Environmental Health Perspectives, 7, 811–817.

[6] Pineo, H., Glonti, K., Rutter, H., Zimmermann, N., Wilkinson, P. and Davies, M. (2018) Urban Health Indicator Tools of the Physical Environment: a Systematic Review. Journal of Urban Health, 5, 613–646.

[7] Zhou, W., Huang, G., Pickett, S.T., Wang, J., Cadenasso, M.L., McPhearson, T. and Wang, J. (2021) Urban Tree Canopy Has Greater Cooling Effects in Socially Vulnerable Communities in the US. One Earth, 4, 1764-1775.

[8] Schwarz, K., Fragkias, M., Boone, C. G., Zhou, W., McHale, M., Grove, J. M. and Cadenasso, M. L. (2015) Trees Grow on Money: Urban Tree Canopy Cover and Environmental Justice. PloS One, 4, e0122051.

[9] Fraser, A.M., Chester, M.V., Eisenman, D., Hondula, D.M., Pincetl, S.S., English, P. and Bondank, E. (2017) Household Accessibility to Heat Refuges: Residential Air Conditioning, Public Cooled Space, and Walkability. Environment and Planning B: Urban Analytics and City Science, 44, 1036-1055.

[10] Chu, H., Adams, J., Li, J. and Goldmuntz, S. (2021) Equity-focused Heat Adaptation Strategies for Los Angeles County.

[11] Wang, X. and Ottinger, R. (2023) A Tale of Two Cities: A Comparison of Air Pollution Governance in the Los Angeles Area of the USA and the Beijing-Tianjin-Hebei Area of China. Kluwer Law International BV, 1-10.

[12] Romero-Lankao, P. (2016) Governing Carbon and Climate in the Cities: An Overview of Policy and Planning Challenges and Options. Climate Change and Sustainable Cities, 7-26.

[13] Zheng, S., Long, F., Fan, C.C. and Gu, Y. (2009) Urban Villages in China: A 2008 Survey of Migrant Settlements in Beijing. Eurasian Geography and Economics, 50, 425-446.

[14] Palinkas, L.A., De Leon, J., Yu, K., Salinas, E., Fernandez, C., Johnston, J. and Garcia, E. (2023) Adaptation Resources and Responses to Wildfire Smoke and Other Forms of Air Pollution in Low-income Urban Settings: a Mixed-methods Study. International Journal of Environmental Research and Public Health, 20, 5393.

[15] Sun, Y., Wang, X., Zhu, J., Chen, L., Jia, Y., Lawrence, J.M. and Wu, J. (2021) Using Machine Learning to Examine Street Green Space Types at a High Spatial Resolution: Application in Los Angeles County on Socioeconomic Disparities in Exposure. Science of The Total Environment, 787, 147653.

[16] Wood, E.K. (2023) The Resource Tradeoffs of Green Space and Water Conservation in Los Angeles: A Spatial Analysis of Vegetated Cooling and Water Use. Master's thesis, Tufts University.