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Research on Differences in Urban Sound Perception and the Equity of Public Space Experiences

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Abstract

The fairness of acoustic landscape experiences in urban public spaces has become a cutting-edge topic in environmental justice research. Starting from the theoretical framework of acoustic landscape equity, this paper comprehensively examines the mechanisms underlying disparities in urban sound perception and their impact on equitable spatial experiences. The study identifies four key dimensions of acoustic landscape equity: equitable spatial distribution, equitable noise regulation, equitable sound perception, and equitable acoustic health outcomes, which collectively form a logical chain spanning resource allocation to health consequences. Urban sound perception varies significantly due to physical environmental factors and social stratification, with marked differences in access to acoustic resources between high-income and low-income areas. Achieving acoustic landscape equity requires coordinated efforts in physical space governance, social participation mechanisms, and digital technology empowerment. Integrating acoustic landscape equity into urban public space governance constitutes a fundamental pathway toward building inclusive cities.

Keywords

soundscapes equity, differences in sound perception, public space experience, environmental justice, urban governance

Introduction

The acceleration of urbanization has made noise pollution one of the most severe environmental issues threatening public health. The World Health Organization ranks noise as the third major source of harmful pollution, after air and water pollution. However, there is a paradigm shift in understanding urban acoustic environments—from viewing sound merely as noise requiring control to recognizing it as a soundscape with social, cultural, and ecological significance. The International Organization for

Standardization defines a soundscape as the auditory environment perceived by people within a given setting, emphasizing its subjective nature and context-dependent characteristics.

With the rise of soundscapes research, the urban sound environment has shifted from a matter of technical governance to one of social equity. Different groups within urban spaces exhibit systematic disparities in their access to and experience of soundscapes: while some residents enjoy restorative effects derived from natural sounds such as bird songs and flowing water, others endure persistent disturbances from traffic and industrial noise. This constitutes not merely an environmental issue but a central concern of environmental justice—specifically, whether environmental benefits and burdens are distributed equitably among different populations (Gan, Li, Huang et al., 2026).

The concept of soundcape equity emerged as a theoretical response to this issue. Some scholars define urban forest soundcape equity as the ability of diverse groups to access positive soundcape resources equitably, avoid exposure to negative soundscapes, and achieve relatively balanced gains in perceptual experience and health benefits. Its core principle is to ensure that different social groups do not suffer systemic unfair treatment regarding the accessibility of soundcape resources, sound environment quality assurance, or enjoyment of health benefits due to socioeconomic status, geographical location, or group identity.

Integrating acoustic landscape equity into public space experience research holds significant theoretical importance. Public spaces serve as primary venues for residents 'daily lives and social interactions, where acoustic quality directly impacts users' experience quality, place attachment, and sense of belonging. When the acoustic experiences of certain groups are systematically overlooked or diminished, the fairness and inclusivity of public spaces become compromised. Differences in sound perception represent not merely sensory issues but also a reflection of social equity through auditory means.

1. Theoretical Framework and Core Dimensions of Sound Landscape Equity

1.1 Theoretical Foundations of Soundscapes' Fairness

The theoretical foundation of soundcape equity can be traced back to two traditions: environmental justice and landscape justice. The environmental justice movement originated in the United States in the late 1970s, asserting that all racial and social groups should have equal rights to access safe and healthy environmental resources and opposing the unfair distribution of environmental burdens. Building on this, landscape justice has expanded to emphasize the equitable allocation of landscape resources, fair access to ecosystem services, and public participation rights. These theories establish a value framework for soundcape equity, positing that soundscapes—being products of environmental resources and ecosystem services—should be allocated and accessed under principles of fairness (Yi & Zhang, 2025).

Acoustic landscape ecology provides analytical tools for assessing acoustic landscape equity. This discipline examines the composition, temporal and spatial variations, and impacts of acoustic landscapes from the perspective of ecosystem structure and function. Acoustic landscapes are considered a vital component of ecosystem services; positive ones (such as bird songs and flowing water) promote psychological well-being, whereas negative ones (like traffic noise and industrial noise) are associated with various health issues. Uneven spatial distribution of different types of acoustic landscapes leads to disparities in the enjoyment of ecosystem services.

Acoustic landscape equity must also address the issue of spatial justice in urban studies. Lefebvre's theory of urban rights demonstrates that the creation and distribution of urban space reflect power relations; in terms of acoustic landscapes, this translates to whose auditory experiences are recognized, whose demands are heard, and whose vocal spaces are protected. When the acoustic landscape experience of a particular group is marginalized, acoustic injustice is reproduced through deep-seated social structures.

1.2 Four Dimensions of Sound Landscape Equity

Acoustic landscape equity can be understood from four perspectives: equitable spatial distribution, equitable noise regulation, equitable acoustic landscape perception, and equitable acoustic landscape health, forming a logical chain for resource allocation toward positive health outcomes.

Spatial distribution equity refers to the balanced spatial distribution of acoustic landscape resources and equal access to positive acoustic environments. Natural acoustic landscapes are predominantly found in large green spaces, ecological reserves, and high-quality residential areas, while densely populated zones and low-cost communities often lack such conditions. Urban centers experience significant human activity impacts, whereas suburban areas benefit from greater natural acoustic diversity. This disparity stems from structural inequalities in urban planning, as high-quality acoustic landscapes are concentrated in specific regions, depriving other residents of opportunities for psychological well-being through natural acoustic experiences.

Noise regulation fairness assesses whether the noise reduction benefits of green infrastructure are equally distributed among different populations. Urban forests mitigate noise through vegetation barriers and shielding effects, but their efficacy is influenced by factors such as vegetation structure and forest belt width; variations in noise reduction capacity across regions directly lead to disparities in noise exposure. High-density green spaces can form continuous acoustic barriers, whereas open green spaces have limited effectiveness. Uneven distribution of noise mitigation resources results in persistent population differences in noise exposure.

Acoustic landscape perception equity refers to the degree of equality in how various groups subjectively perceive acoustic environments. The same physical sound environment elicits different experiences depending on individuals' social identities, cultural backgrounds, and personal histories.

High-income groups are more likely to reside near high-quality green spaces and enjoy natural sound exposure, whereas low-income communities face greater noise exposure and are often overlooked in urban planning. Perception equity also involves the question of "who gets their voice heard"; when certain group preferences are excluded from planning discussions, inequities manifest in more subtle forms (Wang, Yu, & Liu, 2025).

Soundscaping equity in health refers to the widespread accessibility of soundscaping's wellness benefits. Exposure to natural soundscapes offers health advantages such as stress reduction and improved focus, but uneven distribution of access to soundscapes can exacerbate health inequalities. The needs of vulnerable groups—children, the elderly, and people with disabilities—are often inadequately addressed, and existing research lacks sufficient coverage. These four dimensions collectively form an analytical framework for soundscaping equity.

2. The Formation Mechanism of Differences in Urban Sound Perception

2.1 Spatial Differentiation of Physical Environment and Acoustic Landscape Resources

The spatial configuration of urban soundscapes is shaped by both natural conditions and human-made environments. Regarding natural soundscapes, vegetation coverage, biodiversity levels, and water body distribution significantly influence the abundance of positive sound sources such as bird songs and flowing water. Urban forests and parks exhibit superior sound quality due to their high biodiversity, yet these resources are unevenly distributed: suburban areas and ecological reserves demonstrate greater acoustic richness, whereas urban centers and densely populated zones suffer from limited natural sound resources due to human activities. In terms of noise pollution, major traffic arteries, industrial zones, and commercial districts serve as primary noise sources, with their spatial distribution correlating with urban functional zoning; high-density residential areas experience heightened noise exposure. Variations in building density and height further exacerbate this imbalance, as high-density architectural clusters not only amplify noise through reflection but also create acoustic barriers, making noise exposure difficult to characterize using a simplistic "center-periphery" model.

2.2 The Differentiation between Socioeconomic Status and Acoustic Landscape Experiences

The differentiation of acoustic landscape experiences is related to socioeconomic status. Most international studies indicate that in low-income areas and among residents of ethnic minorities, exposure to traffic and industrial noise is higher, their residential locations are closer to noise sources, and access to high-quality acoustic landscape resources is limited. However, the urban environment in China exhibits a distinct pattern: based on data from 9,791 community noise complaints, it can be concluded that high-income communities experience higher levels of noise exposure compared to low-income communities, with greater inequality, as evidenced by a Gini coefficient exceeding 0.8. This counterintuitive finding is linked to rapid urbanization in China, as high-income communities are

predominantly located in city centers or areas with concentrated commercial activities and are subject to elevated levels of environmental noise. This highlights the need to recognize the social context-specific variations in the patterns of acoustic landscape inequity and avoid applying Western perspectives indiscriminately. Socioeconomic status influences individuals' capacity to cope; high-income groups can mitigate noise impacts through adequate sound insulation and green space accessibility, whereas low-income groups often lack such resources.

2.3 The Mechanism behind Differences in Social Perception

The subjectivity of soundscapes means that physical acoustic environments can only be perceived through individual psychological, cultural, and social contexts. Factors such as age, gender, cultural background, duration of residence, and place attachment all influence how people evaluate acoustic environments. The fundamental mechanism behind perceptual differences lies in "soundcape expectations": different groups hold distinct expectations and evaluation criteria for the same neighborhood's sound environment; residents and tourists exhibit vastly different preferences. When urban renewal prioritizes tourist expectations over local residents', community needs are often overlooked. Another mechanism involves socially constructed auditory attention—individuals 'selective focus on sound environments is shaped by social identity and life experiences. While long-term exposure to noisy environments may lead to adaptation, this doesn't eliminate health risks; cumulative effects from prolonged exposure often harm health in subtle ways. Certain groups 'auditory experiences remain systematically ignored during planning processes; children's sound perception differs significantly from adults', yet this disparity is rarely considered. These perceptual disparities ultimately reveal issues of sonic power: what sounds are deemed desirable, which ones receive attention, and what auditory experiences are accepted. When soundcape planning focuses solely on objective acoustic metrics while ignoring subjective perceptions, perceived inequities in sound environments are covertly reproduced beneath the veneer of technical governance (Rui, Cai, & Wu, 2024).

3. The Transformation Path from Perceptual Differences to Experience of Equity

3.1 Physical Space Governance: Bridging Disparities in Soundscapes Resource Distribution

Addressing disparities in acoustic landscape resource distribution hinges on the rational planning of urban green infrastructure and coordinated control of noise sources. Research demonstrates that enhancing accessibility to green spaces, improving their acoustic service value, optimizing urban forest structures, while strengthening ecological restoration and planning interventions in vulnerable areas can significantly improve acoustic landscape equity. Key approaches include: establishing more community parks and pocket parks in regions with high noise exposure and low green space coverage; utilizing scientifically selected tree species and multi-layered vegetation communities to enhance noise

reduction and shielding effects of green spaces; and incorporating acoustic landscape equity as a mandatory requirement in green space planning. Concurrently, effective noise source control is essential—improving urban traffic management, reducing road noise levels, strengthening construction noise management, and properly arranging spatial relationships between noise-sensitive buildings and residential areas—all of which effectively narrow noise exposure gaps among different populations.

3.2 Social Participation Mechanism: Ensuring Diverse Auditory Experiences Are Heard

Effective soundscaping governance cannot rely solely on top-down technical measures; it also requires bottom-up social participation. Participatory soundscaping design integrates residents, users, and stakeholders throughout the identification of soundscaping issues, solution development, and outcome evaluation, thereby bridging the gap between planning authority and public soundscaping experiences. The core principle of this approach is that defining soundscaping challenges inherently involves political processes. When planners define noise issues and ideal soundscapes based solely on professional expertise, they risk neglecting or distorting the auditory experiences of certain groups. Participatory tools such as community hearings, sound walks, and soundscaping workshops provide platforms for diverse groups to voice and negotiate their needs, enhancing the legitimacy and responsiveness of soundscaping planning. Empirical studies demonstrate that deeply engaged resident participation not only effectively identifies soundscaping issues but also fosters mutual trust between residents and planners, laying the foundation for sustainable governance. However, participatory practices must address the inherent bias of "who is eligible to participate"—while middle-class and highly educated individuals tend to be more active in public affairs, voices from low-income and marginalized groups are often marginalized. Therefore, participatory designs should proactively engage vulnerable populations and employ diverse engagement mechanisms to ensure comprehensive representation of all soundscaping demands (Zhang, Kwan, & Ma, 2024).

3.3 Technological Empowerment and Cognitive Renewal: Toward Soundscapes of Justice

Digital technologies have provided new momentum for identifying and addressing acoustic landscape equity. Diverse data from IoT sensors and field monitoring can establish spatiotemporal acoustic databases to dynamically track acoustic parameters; artificial intelligence demonstrates high precision in sound source identification, acoustic classification, and prediction, while convolutional neural networks excel in biological sound recognition; high-resolution remote sensing and LiDAR technologies accurately quantify urban three-dimensional green coverage and canopy structure, compensating for the limitations of traditional monitoring methods; virtual acoustic landscape experiments enable rapid evaluation of perceptual differences among diverse populations under different design schemes, providing scientific basis for equity-oriented planning. However, technological tools cannot automatically ensure equity—they may fall into a "quantification trap," reducing complex acoustic equity issues to measurable metrics while overlooking non-quantifiable

perceptual variations and cultural significance. Therefore, technological empowerment must be accompanied by value reflection, with social equity indicators such as the Gini coefficient and Theil index incorporated into acoustic equity assessment systems rather than relying solely on objective acoustic parameters. The ultimate realization of acoustic equity requires fundamental shifts in urban governance perspectives, elevating acoustic landscapes from ancillary aspects of urban aesthetics to central elements of environmental justice, recognizing that the distribution and access to acoustic resources are crucial dimensions of social equity. In urban renewal, community planning, and public space design, acoustic equity should be prioritized as a foundational consideration rather than an afterthought—only then can auditory-based urban justice transition from concept to reality (Zhang, Zhang, & Liu, 2022).

4. Conclusion

There exists a connection between disparities in urban sound perception and fairness in public space experiences, reflecting a shift from sensory issues to matters of justice regarding acoustic environments. Acoustic environment fairness encompasses four key dimensions: equitable spatial distribution, fair noise regulation, balanced sound perception, and sound-related health equity, forming a comprehensive analytical framework that spans resource allocation, perceptual experience, and health outcomes. Research indicates that acoustic resources are stratified both spatially and across socioeconomic levels, with these factors reinforcing each other to create structural inequities in acoustic environments. These perceived disparities further demonstrate that acoustic fairness extends beyond mere resource allocation; it fundamentally concerns the rights of listeners—specifically, who is truly heard.

Achieving acoustic equity requires the coordinated efforts of physical space governance, social participation mechanisms, and technological empowerment, alongside a renewed understanding of urban governance paradigms—by elevating acoustic equity from a secondary aspect of urban aesthetics to a core issue of environmental justice. Only when public spaces achieve genuine auditory inclusivity can cities become shared homes where all residents enjoy equitable access.

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