DESIGNABLE FACTORS IN URBAN COURTYARD SOUNDSCAPE: A SCOPING REVIEW

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Abstract

As a quintessential urban element, courtyards foster restorative spaces within dense cities. However, their soundscapes remain underexplored compared with open urban spaces and indoor environments. Utilising the soundscape description system, this scoping review synthesised empirical evidence from 90 studies on the acoustic environments of urban courtyards. First, regarding sound characteristics, courtyards are not inherently quiet (SPL IQR = 49.15-59.07 dBA) but provide substantial sound attenuation. Because overall SPLs are moderate, design strategies can shift from noise mitigation to amplification of natural, human, and context-specific sounds. Second, diverse spatial configurations influence reverberation (RT = 1.05s), with boundary conditions, openness, and adjunct building elements (e.g. covered corridors, pavilions), serving as effective physical intervention strategies. Third, reported social and demographic aspects of users are primarily related to residential courtyards, exhibiting a dichotomous design narrative between domestic and public urban courtyard soundscapes. Finally, observed mesothermal climate classification and visually dominated environments fundamentally accentuate auditory perception. Regulating physical environmental conditions can facilitate feasible microclimatic soundscape strategies. To advance this, the review identifies underexplored opportunities for designing courtyard soundscapes through spatiotemporal acoustic properties, spatial geometry, and interactions between environmental domains.

Keywords: *courtyard, urban courtyard, acoustic environment, soundscape, soundscape description*

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1. Introduction

The courtyard constitutes a quintessential urban element, characterised by an open-to-sky space circumscribed by built enclosures [1]. This spatial configuration demarcates an inner precinct from the external environment while simultaneously fostering a sense of proximity [2]. Consequently, within the noise abatement approach, courtyards have been predominantly considered as self-protecting buildings, alongside podium and recessed buildings, serving to shield against or manipulate unwanted noise [3]. Similarly, previous studies explored the potential of courtyards to function as alternative quiet areas, providing short-term restoration in urbanised environments [4].

However, the soundscape approach marks a paradigm shift in environmental sound research, transcending beyond objective measurement to involve holistic user experience in specific contexts [5]. While extensive soundscape research has focused on open urban spaces and enclosed indoor environments, the consideration of soundscapes within semi-open spaces remains rather limited. Evaluating the subjective acoustic perception of urban courtyards poses a significant challenge. This is primarily attributed to the intricate acoustic propagation and diverse soundscapes inherent to these spaces. Fundamental works demonstrated differences in acoustic propagation between enclosed and semi-enclosed space [6], and across comparable urban forms with varying degrees of spatial openness [7]. In addition to the acoustic perspective, Krier (1988) documented the numerous morphological possibilities of urban courtyard forms [8].

Therefore, to ensure the applicability of urban courtyard soundscape design, it is necessary to systematically explore all the designable factors and their potential in the initial design process. To address this gap, the present study extends the fundamental dataset of a systematic literature review to investigate the existing acoustic environments in urban courtyards. By categorising findings across four established facets (sound, space, people, and environment), this scoping review aims to identify specific designable parameters and relevant contextual factors to guide future soundscape creation.

2. Methods

Building upon the definition established in the Introduction [1], this scoping review utilised the identical dataset from a PRISMA-based systematic review (currently in preparation) in relation to urban courtyard soundscapes, emphasising methodological trends, thematic focus, and interdisciplinary intersection. A total of 90 English-language studies were retrieved from the Scopus database, encompassing literature published up to June 2025 [9]. This dataset was compiled using lexicon-sensitive search queries (e.g. “courtyard” AND “acoustic” OR “soundscape”) (n=49), in conjunction with forward and backward citation searches (n=25), and snowball sampling selections (n=16).
In this review, an urban courtyard was operationalised as a semi-outdoor urban space that is partially or fully enclosed by built structures and functions as an intermediate space within the urban fabric. Records retrieved through related terms were screened against the working definition using textual descriptions, photographs, plans, maps, and site information. Quantitative morphological descriptors, (e.g. height-to-width ratio) were extracted where available. However, because these descriptors were not consistently reported across studies, they were not used as predefined eligibility criteria.
Given the multidisciplinary nature of soundscape research, the data extraction was structured according to the established soundscape description system framework [10]. This framework consists of four primary elements: (1) sound characteristics, (2) the acoustic effects of space, (3) the social demographic aspects of the users, and (4) the physical and environmental conditions. Data was extracted manually to systematically identify primary elements and their respective subcategories. The synthesis of results subsequently employed both quantitative content analysis and narrative synthesis to provide a comprehensive interpretation.
During the final eligibility screening, duplicate or overlapping data were removed during final eligibility screening from studies conducted in similar contexts to maintain robustness. In contrast, unique temporal data, especially SPL, were independently retained (e.g. [4], [11]).

3. Results and Discussion

This section presents the synthesis, exemplifies key results, and discusses the plausible directions. These findings provide insights into the design of urban courtyard soundscapes.

3.1 Sound characteristics

Sound pressure level (SPL) serves as the primary parameter for assessing acoustic environments. The synthesis indicates that a substantial proportion of reviewed cases (49%) exceed 55 dBA(Figure 1). This indicates that courtyards should not automatically be assumed to be quiet environments [12] . Despite this, 54% of cases demonstrated a distinct SPL attenuation, with the difference between outside and inside courtyard levels exceeding the 10 dB perceptible threshold [13]. This underscores the courtyards’ potential to mitigate unwanted sound and transform psychological expectations of comfort and relaxation.
Nevertheless, the overall distribution of SPL (IQR = 49.15–59.08 dBA) suggests that considerable courtyard environments remain within moderate ranges and soundscape research encourage the alternative approaches. Specifically, for SPL conditions below 65-70 dBA, previous studies recommends shifting the focus to designing sound types for perceived acoustic comfort assessment [10].

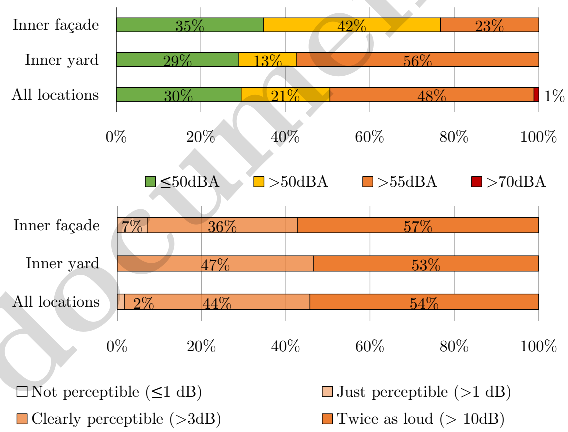

Figure 1. Distribution of SPL within urban courtyards (top) and SPL difference between outside and inside urban courtyards (bottom) across different measurement locations

Sound types are instrumental in soundscape design. The analysis identifies that earlier publications predominantly focused on road traffic noise mitigation. Concurrently, numerous studies documented the variation in sound types, in relation to active sounds from human activities, and passive sounds from natural or artificial elements. Beyond the typical urban sounds, several studies investigated the perceptual effects of mechanical sounds, including aircraft, HVAC systems, and technical installations (e.g. [14], [15]). In contrast, a distinct cluster of studies focused on context-sensitive soundmarks, such as church bells and religious ceremonies [16], which play a vital role in grounding the soundscape evaluation within a specific cultural identity.

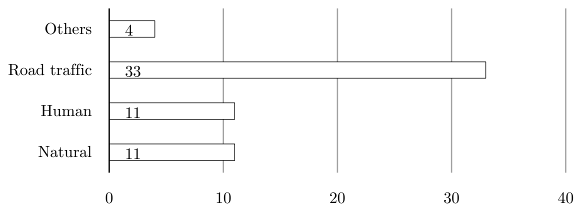

Figure 2. Distribution of identified sound types

Source-receiver location is intrinsically linked to the cognitive ability to differentiate sounds based on proximity. Furthermore, these spatial characteristics are amplified when the SPL and sound type remain constant [17]. Consequently, this review adopts a spatial distance for its narrative synthesis. The analysis indicates that simulated studies preliminarily emphasised external sound sources at immediate distances (37 of 51), where courtyard configurations often obscure audio-visual convergence.
Regarding receiver locations, the analysis highlights promising findings for soundscape design where measurement points extended beyond the inner yard (56 of 72) to the adjunct spaces, including inner facades, balconies, and covered corridors, to capture the perceived acoustic environments (e.g. [18], [19]) For example, Zhang et al. (2023) revealed perceptible SPL differences between corridors are due to spatial distance and source direction [19].
Source movement is a crucial factor in urban courtyard soundscape design, as road traffic noise acts as a highly mobile sound source.
Beyond introducing sound types, amplifying specific spectra substantially shapes soundscapes. Additionally, future strategies should carefully curate specific sound sources, including distance and direction, temporal variations, and localised source movement, integrating them into comprehensive soundscape design.

3.2 Acoustic effects of space

Extending beyond designing the sounds, acoustic propagation, attenuation, and perception are governed by the physical boundaries, making spatial configurations the next designable factors.
Reverberation has recently emerged as a descriptor for documenting the acoustic quality of urban courtyards [20]. According to the analysis, the median reverberation time (RT) of 87 cases was 1.05 seconds (IQR 0.82-1.76; SD 0.683). Notably, 43% of analysed cases exhibited RT ranging from 1 to 2 seconds, a duration deemed suitable for appreciating street music in open urban spaces. However, optimal RT thresholds for general-purpose daily activities within urban courtyards remain underexplored and require further investigation.

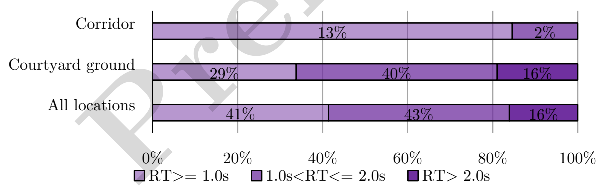

Figure 3. Distribution of reverberation time

Spatial geometry plays a fundamental role in shaping acoustic behaviour. The synthesis identifies a wide range of courtyard dimensions, with widths ranging from 5 to 286 m (SD=33.80), lengths from 2.7 to 286 m (SD=44.84), and heights from 2 to 121 m (SD=15.04).

Aspect ratios, particularly length-to-width and height-to-width, are therefore adopted as key descriptors of spatial form (Figure 4). The results indicate a general tendency towards spatial openness, characterised by relatively low Height-to-Width ratios, that influence acoustic propagation, and the order of reflections.

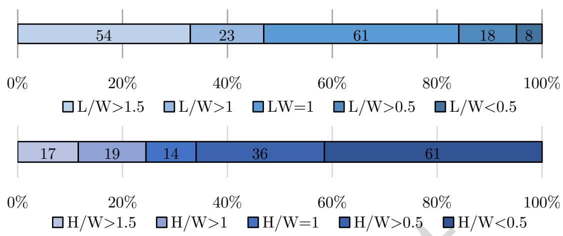

Figure 4. Distribution of Length-to-Width (top) and Height-to-Width (bottom) ratio

Beyond basic geometry, architectural planning further modifies acoustic environments. While rectangular layouts remain the most prevalent, polygonal and irregular layouts were identified in real-word case studies (e.g. [6], [21]). Façade features such as protrusions and recesses contribute to sound diffusion and reflection, thereby altering perceived acoustic conditions [18], [22].
Boundary conditions distinguish courtyards from other urban forms and directly affect sound attenuation. The synthesis indicates that 38% of identified intervention strategies achieve perceptible sound reduction exceeding the 10 dB threshold (ΔSPL), demonstrating the effectiveness of spatial modifications in mitigating noise (Figure 5).

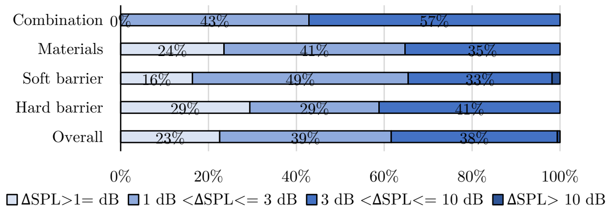

Figure 5. Distribution of ΔSPL of overall intervention type, different intervention strategies, and combinatory

The degree of openness further categorises courtyard typologies into fully enclosed and partially enclosed forms. Fully enclosed courtyards are typically associated with continuous building blocks, whereas partially enclosed courtyards are formed by multiple adjacent buildings, creating complex sound propagation paths through openings [23]. In some cases, sequential courtyard arrangements further extend these acoustic interactions [24].
In addition, adjunct architectural elements along inner façades, such as balconies, covered corridors, and canopies, play a significant role in modulating sound distribution and creating distinct acoustic zones (e.g. [18], [25]). For example, Chen (2022) demonstrates that variations in corridor design can significantly

enhance subjective preference for sound environments during musical activities [18].

Reflection patterns are further influenced by surface material characteristics. Diffusely reflecting materials, such as plaster, brick, and vegetation, are commonly employed, while specular materials, including glass and façade cladding, remain prevalent in contemporary designs (Figure 6). The integration of vegetation is particularly effective in increasing sound diffusion and scattering, thereby attenuating acoustic reflections [26]. Additional obstructive elements, such as pavilions, outdoor furniture, tree canopies, and water features, can also act as acoustic scatterers, modifying internal sound fields and influencing sound propagation (e.g. [26]).

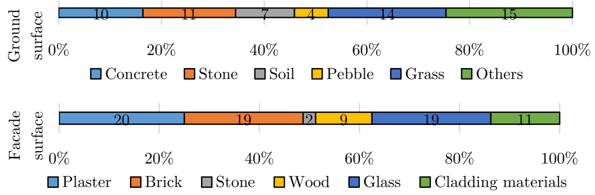

Figure 6. Distribution of surface materials at inner yard (top) and inner façade (bottom)

General background sound, typically represented by the L90 parameter, further characterises courtyard acoustic environments. The limited available data (n = 3 studies; 27 cases) indicate a median L90 of 50.2 dBA (IQR = 47.3–55.7), suggesting that baseline sound conditions may influence the audibility of subtle acoustic events.

Sound around space plays a critical role. External acoustic environments, including adjacent streets and building configurations, propagate into courtyards and shape overall soundscape perception. While some courtyards are directly exposed to surrounding urban sounds others are embedded within larger building complexes and function as more acoustically insulated environments [27], [28].

Overall, these findings demonstrate that a complex interaction between geometry, boundary conditions, material properties, and surrounding contexts, shapes courtyard soundscapes. Advancing this generality, urban courtyards offer significant opportunities for acoustic interventions through identity, including control of degree of openness and the integration of associated architectural and landscape elements.

3.3 Social and demographic aspects of the users

Individual characteristics significantly mediate soundscape assessment, irrespective of physical designable factors. Consequently, the social, demographic, and cultural backgrounds of the occupants must be detailed.

Social and demographic characteristics across the reviewed literature reported a balanced gender distribution and highlighted two primary age cohorts: adolescents (predominantly university students) and the general adult population. Beyond age, specific social characteristics, including the purpose of the visit, religious beliefs, and frequency of use, demonstrated the differences in soundscape preferences across analysed courtyards [16], [29]

Cultural characteristics, primarily represented by geographical location, further influence these acoustic preferences. Urban courtyard soundscapes (n=22) are predominantly explored in two distinct regions: Western Europe and East Asia (Figure 7). This geographical dichotomy highlights a critical need for planners to employ localised acoustic strategies rather than relying on universal assessment.

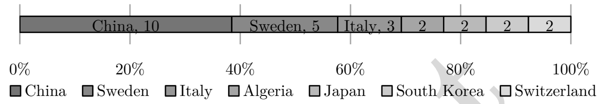

Figure 7. Distribution of cultural characteristics (by geographical location)

Acoustic conditions of the user are intrinsically linked to various building typologies (Figure 8). Excluding performance venues, courtyard typologies significantly cluster along a spectrum from the domestic-public realm (e.g. residential complexes vs university campuses) to context-sensitive environments (e.g. cultural sites). Additionally, factors such as user density, as reported in several studies (e.g. [11]), may further influence perceived acoustic environments by affecting both sound generation and crowd-related perception.

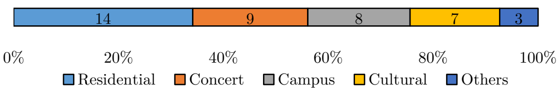

Figure 8. Distribution of building typologies

While user characteristics are inherently difficult to design for, understanding their expectations can significantly leverage soundscape design. For example, residential courtyards demand strict acoustic zoning to ensure calmness, privacy, and daily relaxation. In contrast, public courtyards tolerate higher acoustic activity, and courtyards situated within cultural or heritage sites actively require the integration of local soundmarks to enhance the unique sense of place.

3.4 Physical and environmental conditions

While human perception is inherently multi-sensory, the evaluation of a soundscape is intertwined with its physical and environmental conditions. Extreme microclimates and contradictory visual characteristics substantially shift auditory judgement

Environmental conditions, at a macro perspective, are represented by the Köppen-Geiger Climate Classification (Figure 9). The literature reveals a concentration of studies conducted in temperate and continental climates (Group C and D), where the environment naturally facilitates reciprocal enhancement across sensory domains, often without the interference of extreme weather stress (e.g. tropical (A), arid(B), polar (E)).

Physical microclimates at the courtyard level dictate two actionable design narratives. First, when thermal conditions moderately exceed established comfort ranges, the strategic introduction of specific sound types (e.g. water sounds) actively drives subjective perception back into the comfort zone [28]. Conversely, leveraging spatial courtyard configurations to regulate the microclimate (e.g. providing shade or ventilation) serves as a necessary architectural prerequisite, indirectly but significantly improving baseline thermal comfort, and thereby enhancing overall acoustic satisfaction.

While lighting characteristics were inconsistently reported across the reviewed literature, systematically documenting these factors remains essential for future research.

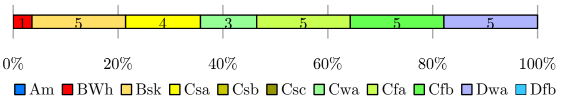

Figure 9 Distribution of Köppen-Geiger climate classifications across the review. Main groups are A = tropical, B = arid, C = temperate, and D = continental

Visual characteristics reciprocally influence auditory perception. Across 22 studies, architectural aesthetics (n=8) and landscape appreciation (n=14) directly modulated acoustic evaluations. For example, Yilmaz et al. (2003) demonstrated that establishing audio-visual congruency actively alleviates the perceived oppressiveness of enclosed courtyard environments [30]. Conversely, unattractive or visually contradictory courtyard settings severely exacerbate perceived acoustic annoyance and suppress the user's motivation to utilise the outdoor space [31]. Therefore, visual landscape architecture must be treated not merely as aesthetic dressing, but as a critical aural-visual acoustic buffer.

A limitation of the present review is that courtyard identification relied primarily on morphological interpretation from published documentation rather than standardised quantitative criteria. The development of robust morphology-based classification frameworks and associated acoustic parameters endorses further investigation in future studies.

4. Concluding Remarks

Preliminary findings from a scoping review offer remarkable insights into creating urban courtyard soundscape design structured around the four elements of the established soundscape description framework:

Sound characteristics exhibit two key findings. First, the substantial proportion of SPL (49.15–59.07 dBA) falls below a relatively high threshold. Therefore, soundscape design should pivot towards designing of sound types that amplify vibrant urban environments. Complementarily, the distinct SPL difference from the external environment substantially shapes the urban courtyard into a compact restorative acoustic environment.

Acoustic effects of urban courtyard spaces exhibit high variability in reverberation. This is driven not only by typical boundary conditions but also by courtyards' identity, specifically its degree of openness, the integration of adjunct building elements, and the surrounding urban morphology.

Social and demographic aspects of the users remain critical, well-recognised factors. Interpreting the specific acoustic conditions of users directly shapes the design narrative, dictating whether an urban courtyard should be grounded in a domestic-public realm or a contextually sensitive soundscape framework.

Physical and environmental conditions, particularly mesothermal microclimates and visually dominant environments, fundamentally dictate auditory perception. Regulating these multi-environmental conditions facilitate highly feasible, cross-modal soundscape strategies.

Ultimately, optimising the interplay among these four elements while addressing the underexplored designable factors identified in this review will pave the way for comprehensive, highly effective urban-soundscape design solutions.

5. Acknowledgments

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6. References

[1] D. A. Thadani, The language of towns & cities: a visual dictionary. in Language of towns and cities. New York: Rizzoli, 2010.
[2] B. Edwards, Ed., Courtyard housing: past, present, and future. Abingdon: Taylor & Francis, 2006. doi: 10.4324/9780203646724.
[3] D. J. Oldham and E. A. Mohsen, 'A Technique for Predicting the Performance of Self-Protecting Buildings with Respect to Traffic Noise', Noise Control Eng., vol. 15, no. 1, pp. 11–19, Jul. 1980, doi: 10.3397/1.2832152.
[4] M. Masullo, F. Castanò, R. A. Toma, and L. Maffei, 'Historical Cloisters and Courtyards as Quiet Areas', Sustainability, vol. 12, no. 7, 2020, doi: 10.3390/su12072887.
[5] ISO, BS ISO 12913-1:2014 Acoustics. Soundscape: Definition and conceptual framework, British Standards Institute., 2014.
[6] R. Pisani, P. Onali, M. Giovannini, A. Astolfi, and M. Masoero, 'Spatial impression for very different spaces. The influence of the space features on the acoustic parameters recommended by ISO 3382', in Proceeding Forum Acusticum 2005, Budapest, Hungary, 2005.
[7] M. Berghauser Pont and P. Haupt, Spacematrix: Space, Density and Urban Form, Revised. TU Delft OPEN Publishing, 2023. doi: 10.59490/mg.38.
[8] R. Krier, Urban space. New York: Rizzoli, 1988.
[9] V. Eawpanich, 'Systematic search results in urban courtyard soundscapes'. University College

London, p. 402539 Bytes, Apr. 21, 2026. doi: 10.5522/04/31878394.
[10] M. Zhang and J. Kang, 'Towards the Evaluation, Description, and Creation of Soundscapes in Urban Open Spaces', Environ. Plan. B Plan. Des., vol. 34, no. 1, pp. 68–86, Feb. 2007, doi: 10.1068/b31162.
[11] M. Masullo, A. Ozcevik Bilen, R. A. Toma, G. Akin Guler, and L. Maffei, 'The Restorativeness of Outdoor Historical Sites in Urban Areas: Physical and Perceptual Correlations', Sustainability, vol. 13, no. 10, 2021, doi: 10.3390/su13105603.
[12] B. Berglund, T. Lindvall, D. H. Schwela, and World Health Organization, 'Guidelines for community noise', 1999.
[13] J. Kang, Urban sound environment. London: Taylor & Francis, 2007.
[14] K. Persson Waye, J. Bengtsson, A. Agge, and M. Björkman, 'A descriptive cross-sectional study of annoyance from low frequency noise installations in an urban environment.', Noise Health, vol. 5, no. 20, pp. 35–46, Sep. 2003.
[15] M. Lugten, G. Wuite, Z. Peng, and M. Tenpierik, 'Assessing the influence of street canyon shape on aircraft noise: Results from measurements in courtyards near Amsterdam Schiphol Airport', Build. Environ., vol. 255, p. 111400, May 2024, doi: 10.1016/j.buildenv.2024.111400.
[16] D. Zhang, M. Zhang, D. Liu, and J. Kang, 'Sounds and sound preferences in Han Buddhist temples', Build. Environ., vol. 142, pp. 58–69, Sep. 2018, doi: 10.1016/j.buildenv.2018.06.012.
[17] M. Yang et al., 'Impact of spatial factors of environmental sounds on psychological and physiological responses: A virtual reality study on direction and distance', Build. Environ., vol. 287, p. 113777, Jan. 2026, doi: 10.1016/j.buildenv.2025.113777.
[18] C.-Y. Chen, 'A Study of Acoustical Arrangements in Relation to Subjective Preference of Traditional Opera Performer on the Stage-Example of Nanguan Melody', presented at the ICSV2018: the 28th International Congress on Sound and Vibration, Singapore, 2022.
[19] D. Zhang, Y. Feng, M. Zhang, and J. Kang, 'Sound field of a traditional Chinese Palace courtyard theatre', Build. Environ., vol. 230, p. 109741, Feb. 2023, doi: 10.1016/j.buildenv.2022.109741.
[20] A. Taghipour, S. Athari, A. Gisladottir, T. Sievers, and K. Eggenschwiler, 'Room Acoustical Parameters as Predictors of Acoustic Comfort in Outdoor Spaces of Housing Complexes', Front. Psychol., vol. Volume 11-2020, 2020, doi: 10.3389/fpsyg.2020.00344.
[21] A. Gidlof-Gunnarsson, E. Ohstrom, T. Kihlman, and J. Forssen, 'Noise responses before and after noise abatement measures in a residential intervention project', Noise Control Eng. J., vol. 63, no. 3, pp. 249–265, May 2015, doi: 10.3397/1/376323.
[22] N. Kim, M. Lee, K. Lee, S. Jung, and M. Kim, 'Acoustical conditions of the Korean traditional royal palace, Gyeongbokgung', presented at the Inter-Noise 2009: 38th International Congress and Exposition on Noise Control Engineering 2009, Ottawa, Canada, 2009, pp. 4854–4862.
[23] K. Veisten, Y. Smyrnova, R. Klæboe, M. Hornikx, M. Mosslemi, and J. Kang, 'Valuation of Green Walls and Green Roofs as Soundscape Measures: Including Monetised Amenity Values Together with Noise-attenuation Values in a Cost-benefit Analysis of a Green Wall Affecting Courtyards', Int. J. Environ. Res. Public. Health, vol. 9, no. 11, pp. 3770–3788, 2012, doi: 10.3390/ijerph9113770.
[24] D. Zhang, C. Kong, M. Zhang, and Q. Meng, 'Courtyard Sound Field Characteristics by Bell Sounds in Han Chinese Buddhist Temples', Appl. Sci., vol. 10, no. 4, 2020, doi: 10.3390/app10041279.
[25] G. Iannace, 'The use of historical courtyards for musical performances', Build. Acoust., vol. 23, no. 3–4, pp. 207–222, Sep. 2016, doi: 10.1177/1351010X16678219.
[26] T. Van Renterghem, M. Hornikx, J. Forssen, and D. Botteldooren, 'The potential of building envelope greening to achieve quietness', Build. Environ., vol. 61, pp. 34–44, Mar. 2013, doi: 10.1016/j.buildenv.2012.12.001.
[27] D. Berkouk et al., 'Exploring the Multisensory Interaction between Luminous, Thermal and Auditory Environments through the Spatial Promenade Experience: A Case Study of a University Campus in an Oasis Settlement', Sustainability, vol. 14, no. 7, 2022, doi: 10.3390/su14074013.
[28] Y. Geng, B. Hong, M. Du, T. Yuan, and Y. Wang, 'Combined effects of visual-acoustic-thermal comfort in campus open spaces: A pilot study in China's cold region', Build. Environ., vol. 209, p. 108658, Feb. 2022, doi: 10.1016/j.buildenv.2021.108658.
[29] J. Y. Jeon, I. H. Hwang, and J. Y. Hong, 'Soundscape evaluation in a Catholic cathedral and Buddhist temple precincts through social surveys and soundwalks', J. Acoust. Soc. Am., vol. 135, no. 4, pp. 1863–1874, Apr. 2014, doi: 10.1121/1.4866239.
[30] N. G. Yilmaz, P.-J. Lee, Y. Soeta, A. Ariki, and A. Heimes, 'Effects of Audio-Visual Interaction on Urban Courtyard Perception', in Proceedings of the 10th Convention of the European Acoustics Association Forum Acusticum 2023, Turin, Italy: European Acoustics Association, 2023, pp. 4299–4306.
[31] A. Gidlöf-Gunnarsson and E. Öhrström, 'Attractive "Quiet" Courtyards: A Potential Modifier of Urban Residents' Responses to Road Traffic Noise?', Int. J. Environ. Res. Public. Health, vol. 7, no. 9, pp. 3359–3375, 2010, doi: 10.3390/ijerph7093359.