Aural Architecture and Sound Mitigation in Urban Parks: The case of Connaught Place

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Abstract Urban parks located within high-density commercial districts are frequently exposed to intrusive acoustic conditions that compromise their restorative function. This study investigates how principles of aural architecture can be strategically applied to mitigate noise and enhance acoustic comfort in Central Park, Connaught Place, New Delhi. The research addresses a significant gap in Indian urban design practice, where noise is typically treated as a pollutant rather than as a designable environmental resource. The study focuses on three key aspects: identifying landscape and built elements that influence the park's aural architecture; examining the relationship between sound sources, spatial configuration, and user perception; and formulating context-specific sound mitigation strategies. A mixed-methods approach was adopted, integrating quantitative sound pressure level measurements, spectrogram analysis, and spatial mapping with qualitative soundwalks and socio-acoustic perception surveys. Findings reveal that persistent low-frequency traffic noise dominates the park's perimeter, while areas with dense vegetation demonstrate comparatively improved perceptual comfort. The inactive central water feature limits effective acoustic masking, resulting in inadequate attenuation within the park core. Survey responses establish a strong correlation between soundscape quality, emotional response, and patterns of spatial use, highlighting demographic differences in acoustic preference and reinforcing the need for zoning.The study concludes that effective sound mitigation in urban parks requires an integrated framework combining physical attenuation, acoustic masking, positive soundmarks, and perceptually informed zoning. By reframing noise management through the lens of aural architecture, the research contributes both theoretical insights and a practical, replicable design framework for soundscape-sensitive interventions in Indian urban public spaces.

Keywords: Aural Architecture, Soundscape, Public Comfort, Sound Mitigation

1 Introduction

The term "aural architecture" is broader in meaning than "acoustics." Acoustics is the science of sound the physics of sound waves, reflection, absorption, etc. Aural architecture, on the other hand, is the human experience of sound in a space which includes psychological, emotional, and cultural aspects of how we perceive and interact with sound.

A. K. Singh et al. (eds.), *Proceedings of the International Seminar on Designing the Future (ISDF 2026)*, Atlantis Advances in Applied Sciences 4,
https://doi.org/10.2991/978-94-6239-747-7_8

The acoustic quality of parks is often compromised, in cities like Delhi which are dominated by traffic, construction, and commercial activity. Central Park, Connaught Place, situated in New Delhi's busiest commercial hub, exemplifies this challenge. The continuous acoustic pressure is increased day by day due to being surrounded by traffic corridors, metro stations, and retail activity. To assess how central park's landscape and built elements affect the soundscape is crucial to enhancing its role as a restorative public space.

Recent advancements in environmental acoustics call for a major shift from traditional noise abatement which treats sound purely as a pollutant to a soundscape approach that manages sound as a perceptual and environmental resource (Kang, 2023). Conventional physical metrics, such as the equivalent continuous sound pressure level (LAeq), are often inadequate for highly trafficked urban centers; research indicates that up to 60-80% of noise annoyance is driven by non-acoustic, psychoacoustic factors (Kang, 2023). For spaces like Connaught Place, where acoustic comfort correlates poorly with actual decibel levels once they drop below 65-70 dBA (Yang & Kang, 2005), relying solely on physical noise mapping is insufficient. Instead, an aural architecture framework must be adopted. This approach recognizes that the way we hear sound is emotional, constantly changing, and all around us. Therefore, we need to design spaces with dynamic sound features rather than just building static noise walls (Kang, 2019).

Empirical evidence highlights that mitigating mechanical urban noise is most effectively achieved through a combination of spatial geometry modification and the intentional introduction of soundmarks. Mature vegetation acts passively to scatter undesirable traffic annoyance, while dynamic water features act actively to mask undesirable sounds and prevent psychological adaptation (Chitra et al., 2020; Harvie-Clark et al., 2023). Furthermore, people of different ages prefer different soundscapes where older demographics require tranquil, nature-only restorative zones, and younger demographics tolerate a vibrant mixture of active human and mechanical sounds which allows intentional acoustic zoning within public spaces (Yang & Kang, 2005; Margaritis et al., 2020). By bridging the critical gap between conceptual soundscape research and practical, effective design application, this study provides a replicable, data-driven framework. It shifts the paradigm of Indian urban park design from passive noise tolerance to active acoustic modulation, equipping planners with context-specific mitigation strategies that can be directly scaled to other high-density commercial districts.

This study, grounded in aural architecture, analyzes the relationship between sound sources, spatial form, and user experience in Central Park. Through literature review, soundwalks, and comparative case studies, it develops context-specific sound mitigation strategies which contribute to the integration of acoustic comfort in sustainable urban design.

Although previous studies concluded on soundscape and urban acoustics and allowed us to understand how people perceive acoustic environments through soundwalks and decibel collections; and there remains a clear gap in the practical application of these principles in real urban settings like connaught place. Much of the existing research focuses either on technical acoustic measurements such as sound pressure levels or on conceptual discussions of soundscape perception, but relatively few studies integrate these approaches to guide practical urban design interventions, particularly in dense urban areas. Furthermore, many soundscape studies have been conducted in European or Western urban contexts, leaving limited empirical research addressing high-density urban environments in Indian cities, where traffic congestion and mixed land use create complex acoustic conditions. There is also a lack of studies that combine spectrogram-based acoustic analysis with user perception and spatial design strategies in urban public spaces. This study is necessary to bridge the gap between theoretical soundscape research and practical design approaches for improving acoustic comfort in urban public spaces.

2 Study Area: Central Park, Connaught Place

The research focuses on Central Park, located within the Inner Circle of Connaught Place (CP), New Delhi, India. This site was specifically chosen as a representative and high-contrast case study for investigating urban soundscapes and the effectiveness of integrated sound mitigation strategies in a dense, commercial metro city.

2.1 Criteria for Selection of Study Area

The selection of Central Park is justified by the following critical criteria, which aligned directly with the core objectives of this study:

Fig. 1. Plan of Connaught Place
(Source: Google Earth)

1. **Acoustic Contrast and High Noise Gradient:** Central Park is situated at the epicenter of one of Delhi's busiest commercial and transportation hubs. It is entirely enveloped by the high-decibel, continuous vehicular traffic of the Inner Circle road, resulting in an extreme acoustic pressure. This provides an ideal public place for quantifying and analyzing the transition of the sound environment from "noise-dominated" to "soundscape-dominated" conditions.

2. **Defined Architectural and Spatial Form:** The park features a distinct, concentric, and highly formalized spatial layout typical of colonial-era planning. This clear geometry allows for the systematic selection of measurement points along a controlled gradient—from high-exposure edges to low-exposure core—which is crucial for establishing reliable spatial sound distribution maps.

3. **Diversity of Users and Social Function:** Central Park serves as a crucial urban lung and respite zone for a highly diverse population, including local office workers on lunch breaks, students, tourists, senior citizens, and vendors. This rich demographic mix is essential for the qualitative research phase, ensuring that the collected perceptual data is representative of varied emotional responses, sound preferences, and functional needs within the park.

A systematic selection of six measurement sites, shown in the Fig. 1, was employed to capture the full acoustic gradient across the park. Sites were selected based on the park's distinct concentric spatial layout, ranging from high-exposure perimeter zones (Acoustic Overload) to intermediate setback areas (Cool Spot) and the geometric core.

Data Collection and Analysis: Sound pressure levels were measured at the selected nodes and time intervals using a mobile application Sound Meter. Measurements were taken at selected nodes and time intervals. One drawback is that the data may not account for irregular events like public celebrations or severe weather patterns.

Spectral Analysis: Spectrograms were generated from sound samples using software Audacity. This visualization of frequency distribution is essential for identifying the dominant sound sources.

2.2 Data Collection Schedule

Acoustic measurements and sound recordings were conducted over a period of 7 days during **September 2025**. Data were collected at six selected sites within Central Park during three representative time periods to capture varying activity conditions: morning (8:00–9:00 AM), afternoon (1:00–2:00 PM), and evening (5:00–7:00 PM).

Each recording lasted approximately 1–2 minutes, and equivalent sound pressure levels (LAeq) were measured using the Sound Meter mobile application. In addition to the recordings, a structured perception survey was conducted during the same time period. The collected acoustic data and survey responses were analysed separately. The analysis revealed a strong correlation between the characteristics of the sound environment and human perception and behaviour, indicating that variations in soundscapes directly influenced users' subjective experiences and responses.

3 Secondary Case Study

3.1 Nauener Platz, Berlin - A Soundscape Design Intervention

This case study examines the soundscape design approach and interventions implemented at Nauener Platz, a 500sqm urban park in Berlin's Mitte neighborhood. The project aimed to improve the environmental quality for its diverse community, which includes high proportions of children, seniors, and international residents. Nauener Platz is situated near main roads with high traffic volume. The soundscape design approach involved acousticians conducting soundwalks and involving local residents (referred to as "local experts") in the planning process.

The redesign focused on both physical mitigation of unwanted noise and the introduction of positive soundmarks. Gabion walls and Audio islands were introduced in the form of benches and "ring seats". These elements play natural sounds (like birdsong and ocean waves).

Fig. 2. Gabion wall dividing street
(Source: When soundscape meets architecture)

In the Fig. 2, the 1.4m high gabion wall as a boundary wall was constructed along the playground to mitigate traffic noise.

Fig. 3. Ear Bench
(Source: When soundscape meets architecture)

The benches, specifically called Ear Benches shown in Fig. 3, were designed based on a psychoacoustic concept. This strategy provided a pleasant acoustic environment to counter perception of the surrounding mechanical noise.

Fig. 4. Ring seats
(Source: When soundscape meets architecture)

Circular ring seating integrated as an audio island, designed to create a pleasant acoustic environment that masks urban noises in the human perception, based on psychoacoustic principles as shown in Fig. 4.

3.2 Urban Squares in Sheffield - Comparative Soundscape Analysis

This case study compares the soundscapes of two urban squares in Sheffield-the **Peace Gardens and Barkers Pool** to understand the impact of design on acoustic perception and use. Urban squares are considered vital focal points for relaxation and social life, where sound conditions are crucial for attracting users.

Natural sounds were overwhelmingly preferred, while mechanical sounds were widely rejected. Demographic factors showed significant differences, especially by age. Over 75% of interviewees favored water sounds and birdsong than urban noises like Construction noise, car music, and vehicle sounds. Natural sounds are perceived as tranquil and less invasive. Age Differences plays a significant role for acoustics and human behavior. Older people prefer quiet natural sounds (favored birdsong). Younger people are more tolerant of music and mechanical sounds. In addition, females showed slightly higher favorability toward emotional sounds like church bells, water, and children's shouting, but sound type differences exceeded gender differences.

The Peace Gardens, despite being in a noisier location, successfully used water as a "primary soundscape quality" to acoustically mask traffic noise. Barkers Pool, being naturally quieter, hosted a soundscape centered on human activity and music. The Sheffield study highlights the need to intentionally introduce 'colourful' soundscapes into the 'brownfield' of city noise. This can be done through the introduction of pleasant sounds which creates an acoustic friendly environment.

Fig. 5. Water Wall Installation act as a sound barrier
(Source: https://soundscape-intervention.org/examples/)

Water wall installation functioning as a passive soundmark or a sonic sculpture. Water dramatically improves sound quality (Fig. 5.).

Fig. 6. Cutting Edge in Sheffield
(Source: https://soundscape-intervention.org/examples/)

Public open space at Cutting Edge in Sheffield, designed to encourage social interaction and active soundmarks through community activities and live performances (Fig. 6.).

Fig. 7. Sound Installation
(Source: https://soundscape-intervention.org/examples/)

Interactive sound installation designed to create a positive acoustic experience by encouraging user engagement and generating pleasant sounds within the public space (Fig. 7.).

Fig. 8. Water Cascade Feature
(Source: https://soundscape-intervention.org/examples/)

Water cascade features serve as a passive soundmark, using the sound of flowing water to enhance the acoustic environment and reduce the perception of urban noise (Fig. 8.).

4 Analysis

4.1 Quantitative Analysis

Spectral Analysis: Spectrograms were generated from sound samples using software Audacity. This visualization of frequency distribution is essential for identifying the dominant sound sources.

4.1.1 Site 1: Spectrogram Analysis and Interpretation

Site 1 is located on a busy paved walkway connecting the outer ring to the central circle (Rajiv Chowk). Although it is set back from the inner road and sits behind large trees, it remains a high-traffic area. The hard surfaces around it, such as the paved paths and low walls, likely bounce sound around rather than absorbing it.

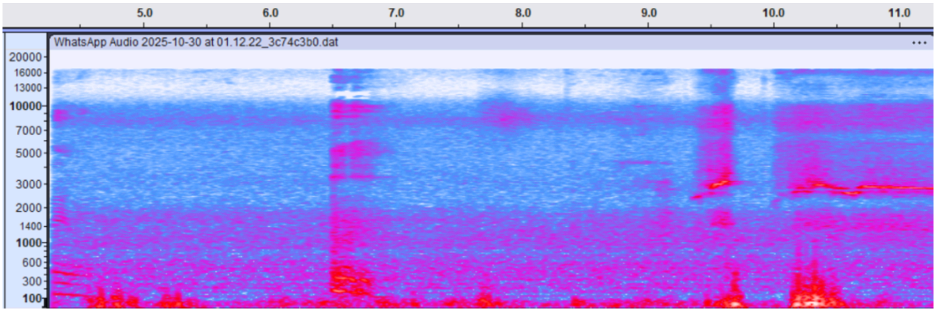

Fig. 9. Spectrogram analysis of Site 1
(Source: Author)

The graph for Site 1 (Fig. 9.) reveals two main acoustic issues:

1. **A Constant Urban Rumble:** As per figure 9, there is a steady, loud band of low-frequency noise (under 1000Hz) lasting the entire recording. This constant background hum comes from distant city traffic and the steady flow of park visitors.
2. **Sudden, Sharp Noises:** The graph also shows brief, intense spikes that reach high pitches (up to 13,000Hz). These represent sudden, loud sounds, such as aggressive and impulsive car horns.

The most significant problem at this site is the constant low-frequency rumble, which ruins the natural feel of the park and is known to be highly irritating. Because low-frequency sound waves are long, they easily pass through standard barriers.

This proves that the existing trees and distance from the road are not enough to block the noise. Ultimately, instead of a peaceful park environment, the space is dominated by the constant heavy "hum" of Connaught Place traffic, interrupted by sharp, loud honking.

4.1.2 Site 2: Spectrogram Analysis and Interpretation

Located at the exact center of the park (Rajiv Chowk), Site 2 is theoretically the "acoustic core." Because it is the furthest point from the outer roads and is screened by vegetation, it should be the quietest area. However, the water features designed to help mask urban noise are currently dry and non-operational.

Instead of acting as a peaceful space, the center is overwhelmed by sound, making it an "Acoustic Core Saturation Zone." While the distance and trees successfully block most of the distant traffic hum, the immediate area is heavily polluted by internal park activities. During the measurement, temporary construction at the open-air theater and a nearby garbage truck—which also introduced unpleasant odours—dominated the environment.

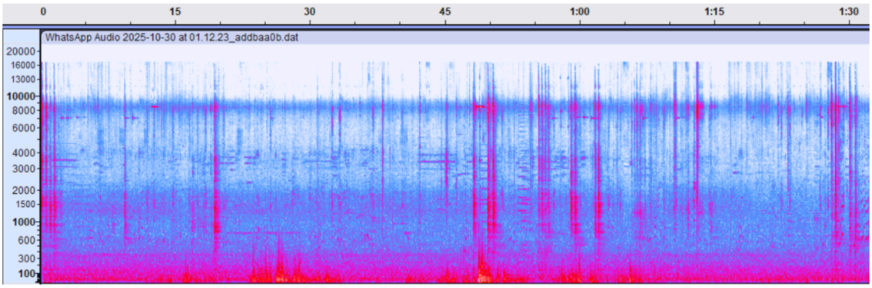

Fig. 10. Spectrogram analysis of Site 2
(Source: Author)

The graph shown in the Fig. 10 for Site 2 reveals three distinct acoustic layers:

1. **Constant Construction Rumble:** There is a steady, highly intense band of low-frequency noise (deep red/pink) that lasts the entire recording. Unlike Site 1, this constant baseline isn't from traffic; it is driven primarily by the ongoing temporary construction and the idling garbage truck nearby.
2. **Frequent, Sharp Noises:** The most striking feature of this longer recording is the intense vertical spikes happening roughly every 3 seconds. These loud, high-frequency bursts strongly suggest sudden mechanical clanking, sirens, or loud vehicle horns cutting through the park.
3. **Human Activity:** Between the 40-second and 1-minute-20-second marks, there are clear, sustained mid-frequency sounds. These align with pedestrian activity and human voices, showing active use of the central core.

Ideally, noise levels should naturally fade as you move toward the center of a park. Instead, Site 2 suffers from a persistent low-pitched rumble mixed with repetitive and high-energy noises. Because of this, the continuous sound level (Leq) remains high.

4.1.3 Site 3: Spectrogram Analysis and Interpretation

Site 3 is located on the eastern inner edge of the park. It sits at a moderate distance from the inner circular road and is shielded by a thick band of trees and plants. While this dense greenery helps block some specific sound disturbances, the area still deals with a mix of constant background noise and distinct mid-level sounds.

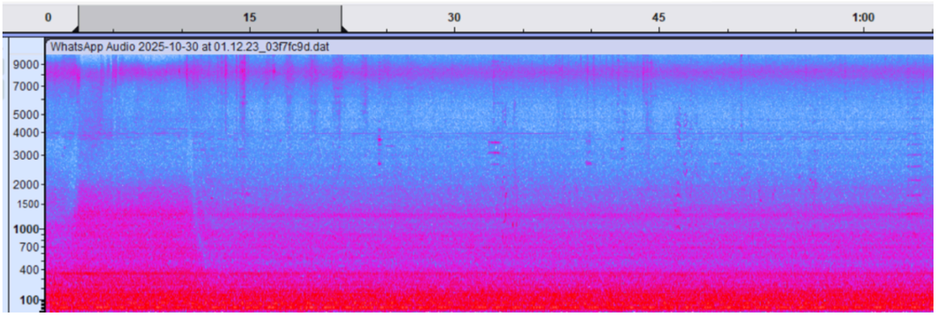

Fig. 11. Spectrogram analysis of Site 3
(Source: Author)

The graph for Site 3 in the Fig. 11 shows a "hybrid" acoustic environment, marked by the following layers:

1. **The Constant Low Hum:** A steady, intense band of low-frequency noise (deep red/pink) runs through the entire recording. While this usually points to distant city traffic, the primary source of this constant, disruptive hum during the measurement was actually a nearby water pump.
2. **Heavy Mid-Range Noise:** There is a strong, uniform presence of mid-frequency sound (shown in pink/magenta). This is a critical issue because noise in this specific range interferes with human speech and is a major cause of acoustic annoyance.
3. **High-Frequency Drop-Off:** Above 4000Hz, the sound energy drops away rapidly into a low-intensity blue. This indicates that higher-pitched sounds are either absent from the area or are being successfully blocked.

This site clearly shows the limits of using greenery for sound control. The thick planting effectively absorbs and scatters high-frequency sounds, but it is completely useless against the deep, low-frequency drone of the water pump and residual traffic.

As a result, Site 3 is not a relaxing aural environment. However, because it lacks the sudden, piercing spikes of noise found at Site 2, the overall fluctuation in sound is lower. This makes the space feel slightly less chaotic than the park's center, even if the constant background hum remains high.

4.1.4 Site 4: Spectrogram Analysis and Interpretation

Site 4 is located on the southeastern edge of the park, right next to the inner circular road. Because it serves as the main entrance and has almost no plant cover, it is completely exposed to urban traffic. This lack of protection turns the area into an "Acoustic Overload Zone."

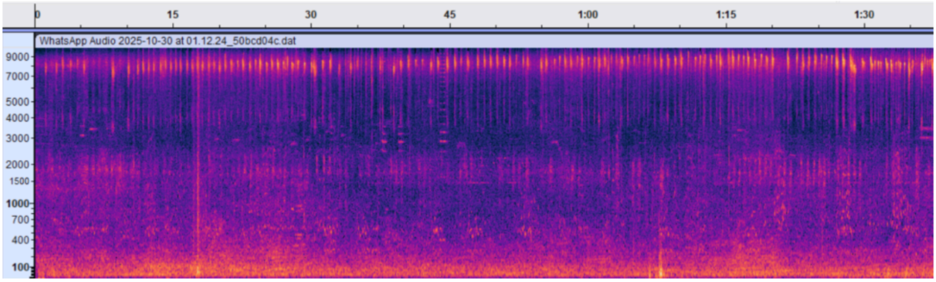

Fig. 12. Spectrogram analysis of Site 4
(Source: Author)

The graph given in Fig. 12 for Site 4 shows a chaotic soundscape, overwhelmed by a constant rumble and sharp, loud interruptions:

1. **Heavy Traffic Rumble:** There is a continuous, intense band of noise between 100Hz and 600Hz (deep orange/red). This is the clear, unmistakable signature of high-volume traffic flowing constantly on the adjacent road.

2. **Constant Honking and Revving:** The most extreme feature of this recording is the sheer density of tall, vertical spikes. These happen constantly and represent loud, close-range sounds—primarily aggressive vehicle horns and engines accelerating right next to the park.

3. **Saturated Mid-Range Noise:** The intense noise levels (orange/dark red) stay very high up to the 1500Hz range for almost the entire recording. This means the combination of the low traffic hum and the mid-pitch sounds of passing cars creates a solid wall of noise.

Because the road is so close to the entrance, this is an "active spot" acoustic environment. The sound simply does not have enough physical distance to fade out or be absorbed by the air before it hits the park boundaries.

This data proves that the minimal greenery at the edge completely fails to block high-volume traffic noise. The resulting acoustic chaos at Site 4 highlights a critical need: to protect the peaceful interior of the park, this entrance requires immediate, heavy architectural interventions such as solid, high-mass acoustic walls to actually block the sound waves from entering.

4.1.5 Site 5: Spectrogram Analysis and Interpretation

Site 5 sits on the northern side of the park. Like Site 3, it is set back from the inner road and shielded by a band of trees.

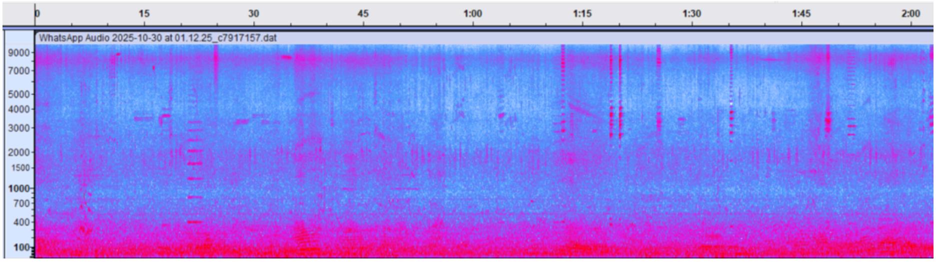

Fig. 13. Spectrogram analysis of Site 5
(Source: Author)

The graph for Site 5 as per the Fig. 13 shows a very high baseline of noise, characterized by two constant layers of sound and occasional loud spikes:

1. **Constant Traffic Rumble:** A steady, intense band of low-frequency noise (between 100Hz and 400Hz) runs through the entire recording (deep red/pink). This confirms that the deep, residual hum of urban traffic is inescapable at this location.
2. **Steady Mid-Range Hum:** The recording shows clear horizontal bands of sound in the mid-frequency range (1000Hz to 4000Hz). This indicates a constant, unbroken layer of mid-pitch background noise.
3. **Fewer Sharp Noises:** While there are some sudden, loud spikes, they happen much less frequently here compared to highly exposed entrances like Site 4.

The aural environment at Site 5 is exhausting because it is so monotonous. Visitors are hit with a double layer of constant noise: the deep traffic rumble and the steady mid-pitch hum. Because the sound level rarely drops or changes, it creates a fatiguing environment with no acoustic relief.

4.1.6 Site 6: Spectrogram Analysis and Interpretation

Site 6 is located on the southwestern edge, right next to the inner circular road outside the park. Because it sits right on the busy road network, it has almost no buffer zone and is heavily exposed to close-range traffic noise.

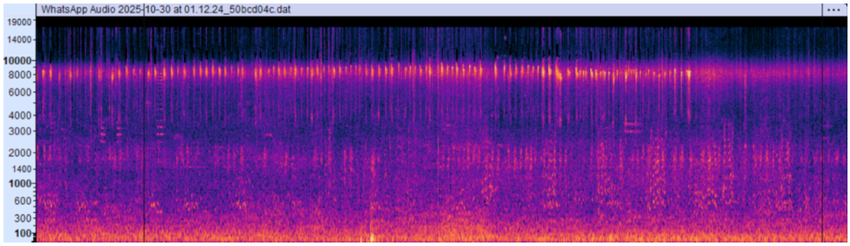

Fig. 14. Spectrogram analysis of Site 6
(Source: Author)

The graph given in Fig. 14 for Site 6 reveals an extreme acoustic environment, displaying the highest levels of continuous noise seen across all the tested locations:

1. **Intense Traffic Rumble:** There is an extremely loud, continuous band of low-frequency noise (between 100Hz and 600Hz). The deep orange/red colors are among the brightest recorded, showing that the heavy traffic noise flows directly into this spot with maximum force.
2. **A Solid "Wall" of Noise:** Unlike the other sites, Site 6 shows constant, intense noise reaching very high pitches (up to 8,000Hz to 10,000Hz). Instead of just occasional loud spikes, there is a dense, vertical wall of sound created by the continuous roar of engines, exhaust, and tires.

Because Site 6 is right on the road and lacks any effective physical barriers to block sound waves, it suffers from maximum noise exposure across all pitches. The combination of a constant background roar and high-pitched events (reaching up to 14,000Hz) creates a highly stressful and annoying environment. It has resulted in a space that is actively uncomfortable and detrimental to anyone trying to use it.

4.2. Inferences

The inferences are illustrated more in Table 1.

Table 1. Noise Source Distribution Across Surveyed Sites

Site ID	LAeq (Average) (dBA)	Traffic Noise (Vehicles, Horns)	Human Voices/ Crowd Activity	Music/ Commercial Noise	Characterization
Site 1	64.2	75%	15%	10%	Moderate Urban Noise

Site 2	69.8	90%	5%	5%	Hotspot: Loudest, High Traffic Exposure
Site 3	56.5	20% (Distant Hum)	50%	25%	Cool Spot: Quietest, Acoustically Sheltered
Site 4	67.5	80%	10%	10%	High Commercial/Traffic Noise
Site 5	61	40%	45%	10%	Moderate Transition Zone
Site 6	85	90%	Trace	10%	Traffic Noise/ Announcements

4.3 User Perception and Soundscape Evaluation

A structured perception survey (N = 30) was conducted to examine how users interpret and respond to the park's sound environment. The sample was nearly gender-balanced (53.3% male, 46.7% female), with 80% of respondents between 16–40 years of age (46.7% aged 16–25; 33.3% aged 25–40). Visit frequency varied, with 37% daily users, 22.2% weekly visitors, and 40.7% occasional users, indicating both continuous and intermittent exposure to the park's acoustic conditions.

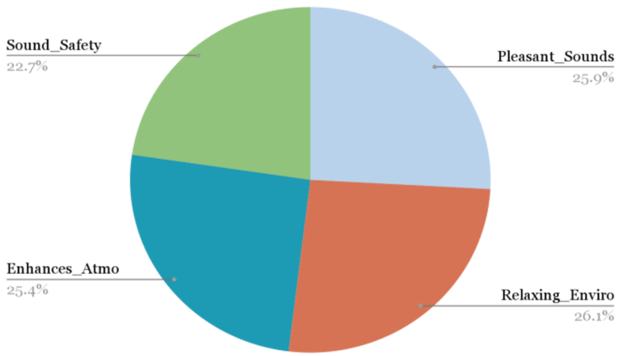

Fig. 15. Soundscape Perception
(Source: Author)

Across four perceptual dimensions assessed on a five-point Likert scale, responses were relatively evenly distributed: Relaxing Environment (26.1%), Pleasant Sounds (25.9%), Enhanced Atmosphere (25.4%), and Sound Safety (22.7%), shown in the

Fig. 15. These balanced results suggest that users experience the soundscape holistically, where relaxation, atmosphere, and safety are interdependent qualities rather than isolated attributes.

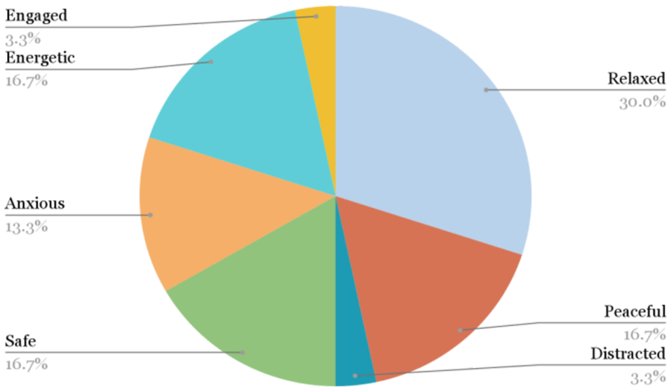

Fig. 16. How do the sounds make people feel
(Source: Author)

As per the Fig. 16, 86.7% of respondents reported noticing changes in the sound environment across different times of day, reflecting sensitivity to fluctuations in traffic intensity and visitor density.30.0% described the environment as Relaxed, 16.7% as Peaceful, and 16.7% as Safe, while 13.3% reported feelings of Anxiety. The coexistence of comfort and stress responses highlights the layered nature of the park's acoustic character.

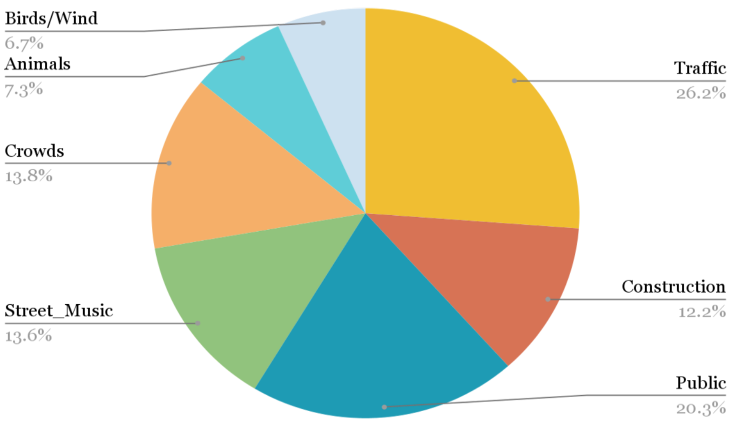

Fig. 17. Noise Sources & Annoyance
(Source: Author)

Despite the generally positive appraisal, traffic noise emerged as the dominant intrusive sound source, consistently rated at higher annoyance levels (4–5 on a five-point scale), as given in Fig. 17. In contrast, natural elements such as birds and wind scored predominantly low annoyance scores (1–2), showing their role as positive acoustic drivers. These findings correspond directly with the spectrogram analysis, which identified persistent low-frequency traffic dominance in perimeter zones.

Importantly, 63.3% of respondents confirmed that sound influences their movement or seating choice within the park, often gravitating toward zones perceived as quieter or vegetatively buffered. People tend to cluster in the transitional and central areas of the park because, the recordings show, these zones offer relief from sudden, sharp traffic noises.

The correlation between distinct acoustic layers and human emotional reactions is well-documented in large-scale urban sensory research, where data-driven sound maps consistently associate traffic and mechanical sounds with responses of fear or anger, while linking human sounds and music with feelings of joy and surprise (Aiello et al., 2016). The presence of both comforting and stressful responses in Central Park validates this layered emotional mapping within dense commercial zones.

Collectively, the findings demonstrate that acoustic comfort in Central Park is shaped not solely by equivalent continuous sound level (LAeq), but by frequency composition, temporal variation, and the presence of positive sound sources. The perceptual data demonstrates the need for sound mitigation strategies, strengthened perimeter buffering, and the introduction of effective acoustic masking elements.

5 Sound Mitigation Strategies and Aural Design Framework for Central Park, Connaught Place

5.1 Introduction

The preceding sections examined the existing acoustic environment of Central Park through both quantitative measurements and perceptual responses. The analysis indicated that although the park contains natural elements that contribute positively to the soundscape, it remains heavily influenced by low-frequency vehicular noise, sudden high-intensity honking, and operational disturbances from its immediate commercial surroundings. These findings highlight a clear gap between the intended role of Central Park as a refuge within the dense urban core of Connaught Place and its actual acoustic performance.

This section presents a comprehensive set of sound mitigation strategies grounded in the principles of aural architecture. Each proposed intervention is directly informed by the site-specific acoustic analysis and is supported by established international existing literature. The aim is to articulate a unified, research-backed framework for the design through which the soundscape of Central Park can be improved to enhance public comfort, restorative quality, and overall environmental experience.

5.2 Conceptual Basis for Aural Architecture Interventions

Aural architecture describes the ways in which spatial form, surface materiality, vegetation density, and the placement of sound sources shape user auditory experience. Its principles guide designers toward environments where sound is not only managed but intentionally curated (Kang, 2019). For urban parks, this involves reducing disruptive noise, introducing desirable soundmarks, and creating zones that align acoustic profile with user expectations and behaviours.

In Central Park, the acoustic measurements revealed a constant, deep traffic rumble at the outer edges and a completely overwhelming amount of noise in the center.. These observations align with broader studies demonstrating that urban parks near traffic corridors often require a combination of physical barriers, vegetative layers, and masking elements for restoring perceptual tranquility (Yang & Kang, 2005; Chitra et al., 2020).

The strategies described in the following sections therefore follow a dual approach: **(1) attenuation of intrusive noise and (2) enhancement of positive sound elements,** consistent with emerging soundscape standards such as ISO 12913.

5.3 Perimeter Noise Control and Edge Reinforcement

The loudest conditions in Central Park occur along the outer edges particularly at Sites 4 and 6 where road-facing boundaries expose users to continuous low-frequency vehicle rumble (125–500 Hz) and high-intensity horn peaks. The literature consistently shows that low-frequency noise, due to its wavelength, cannot be effectively mitigated through vegetation or thin partitions. Instead, substantial mass and physical obstruction are required (Kang, 2023).

High-mass acoustic barriers between 1.8 and 2.4 metres in height have been shown to reduce noise levels by 7–15 dB(A) in comparable urban parks (Harvie-Clark et al., 2023). These findings directly support the introduction of **gabion walls, rammed earth berms, brick or stone composite screens, and green acoustic walls at the periphery of Central Park.** Such barriers not only attenuate incoming traffic noise but also visually separate the park from the highly active commercial loops, reinforcing perceptual tranquillity. Multi-layered greenery can produce significant relative attenuation exceeding 20 dB at higher frequencies (between 10 kHz and 12.5 kHz), it offers virtually zero protection against low-frequency mechanical rumble below 100 Hz (Tyagi et al., 2006; Kalansuriya et al., 2009).

Complementary to these structures, a multilayered vegetative buffer strengthens high-frequency attenuation and increases visual–aural harmony, a phenomenon noted to significantly influence perceived comfort (Kang, 2019). Thus, layered planting with tall grasses, dense shrubs, and evergreen trees is recommended to augment the mass barrier system and create a more buffered transition into the park.

5.4 Revitalisation of the Acoustic Core Through Water-Based Masking

The central zone of the park exhibited a noticeable loss of tranquillity due to the non-functional water feature, which previously served as the primary masking element. Numerous studies confirm that water sounds are among the most preferred natural sound sources and significantly contribute to masking mechanical noise (Yang & Kang, 2005). Their broad spectral content, particularly in the mid-frequency range, effectively moderates perceptual annoyance and improves emotional response scores (Chitra et al., 2020).

Reactivating the central water feature is therefore essential. More importantly, literature recommends the use of dynamic and variable water patterns to prevent perceptual adaptation, ensuring that masking benefits remain effective over longer periods (Kang, 2019).

5.5 Transition Zones and Semi-Quiet Interventions

The intermediate areas of the park (Sites 1, 3, and 5) present opportunities for creating semi-quiet environments that accommodate reading, light conversation, and passive recreation. The measured mid-frequency attenuation in these zones correlates with the presence of dense vegetation, consistent with literature showing that such planting contributes to scattering high-frequency energy and facilitates the presence of desirable biophonic sounds (Chitra et al., 2020). Even where decibel levels remain moderate, the presence of vegetation has been found to significantly enhance perceived tranquillity (Kang, 2019).

By using mounded earth forms, sunken seating courts, and bamboo or cane diffusing screens, these zones can be further refined into tranquil pockets. These interventions reflect international precedents where micro-topography and material screens are used to create acoustic shadows within otherwise noisy urban parks.

5.6 Integration of Positive Soundmarks

A crucial aspect of contemporary soundscape design is the intentional introduction of positive soundmarks to enrich environmental experience (ISO 12913-1, 2014). International case studies, such as the redesign of Nauener Platz in Berlin, demonstrate that thoughtfully curated sound elements such as **ear benches, water features, and rustling vegetation** improve social comfort, perceived safety, and place identity (Schulte-Fortkamp, 2016).

In the context of Central Park, passive soundmarks may include bird-attracting vegetation, bamboo clusters, shallow water channels, and soft wind-responsive installations. These sounds subtly animate the environment without overwhelming it. Active soundmarks, such as low-volume sound benches or curated nature-sound playback during early mornings, may be introduced sparingly to maintain the character of the park. These interventions align with the broader consensus that soundscape quality improves not only through noise reduction but through the enrichment of auditory experience (Ali et al., 2021).

5.7 Acoustic Zoning Based on User Perception and Behaviour

Your perceptual analysis revealed that different user groups experience the park's soundscape in distinct ways, with older visitors preferring quiet, natural zones and younger users responding positively to mixed social and natural environments. These findings are consistent with broader research showing significant demographic variations in sound preference (Yang & Kang, 2005) and supporting activity-based sound zoning (Margaritis et al., 2020).

By structuring Central Park into tranquil, social, family, and transit zones, the design responds directly to diverse user expectations. This approach aligns with international best practices in soundscape planning, where zoning has been shown to improve satisfaction and encourage longer park usage.

5.8 Central Park as an Auditory Refuge: Synthesising Evidence and Outcomes

A recurring theme in soundscape literature is the notion that urban parks function as auditory refuges spaces that do not eliminate city noise but transform it through curation and contextual framing (Kang, 2023). This understanding helps bridge the gap between achievable noise mitigation and desired perceptual outcomes. Studies show that even moderate reductions in SPL, when combined with desirable soundmarks, lead to substantial increases in perceived tranquillity (Harvie-Clark et al., 2023).

The proposed interventions for Central Park follow this principle closely. High-mass barriers reduce intrusive traffic noise; vegetative layers diffuse and mask higher frequencies; the central water feature re-establishes a strong natural soundmark; and acoustic zoning aligns the soundscape with user needs. Together, these interventions form a cohesive aural architecture strategy that transforms Central Park into a more comfortable, perceptually restorative urban environment.

An integrated sound mitigation framework for Central Park based on site-specific acoustic analysis and soundscape theory. The proposed strategies perimeter noise control, water-based masking, vegetative buffering, soundmarks, and perceptual zoning address existing acoustic challenges while aligning with established best practices.

The primary contribution of this proposed framework is its practical applicability. Much of the existing literature on soundscape ecology remains theoretical, making it difficult for urban designers to implement. By providing specific, context-tested interventions such as high-mass perimeter walls for low-frequency attenuation and dynamic water features for acoustic masking this study equips designers with a scalable toolkit. It demonstrates that aural architecture is not just an abstract concept, but a crucial, actionable layer of smart city development that can be replicated across other high-density commercial hubs in India.

6 Conclusion

This study examined how the principles of aural architecture can be applied to reduce noise and improve public comfort in Central Park, Connaught Place. Using a combination of sound level measurements, spectrogram analysis, spatial study, user perception surveys, and relevant literature, the research evaluated the current acoustic condition of the park within the busy commercial setting of New Delhi.

The findings show that Central Park is heavily influenced by continuous traffic noise, especially along its outer edges. Persistent low-frequency sounds from surrounding roads create a constant acoustic burden, while sudden high-frequency noises such as horns and construction activity increase auditory stress. Although the park contains vegetation and a central water feature, these elements currently do not provide sufficient acoustic relief. The water feature remains inactive, and vegetation alone is not enough to block low-frequency sound transmission. Spectrogram analysis confirmed the dominance of traffic-related noise, and survey responses reflected similar concerns, with many users identifying traffic as the most disturbing sound source.

User perception data reinforced these observations. User feedback strongly aligned with the physical measurements. Although a majority of respondents described the park as relaxing and pleasant, traffic noise was consistently identified as the most intrusive sound source. Importantly, 63.3% of users reported that sound influenced their behaviour and spatial choice, demonstrating a direct relationship between acoustic conditions and spatial usage patterns. Positive natural sounds such as wind and birds were associated with comfort, while the absence of active water-based masking limited the presence of beneficial broadband acoustic relief within the central zone.

The study confirms that acoustic experience is spatially layered and frequency-dependent, shaped by the interaction between built form, landscape elements, and perceptual interpretation. Vegetation alone provides partial mitigation, particularly for mid- and high-frequency components, but is insufficient for attenuating low-frequency traffic noise.

By reframing noise management through the lens of aural architecture, this research contributes to a design-oriented, sound mitigation framework tailored to the Indian metro cities. The proposed strategies perimeter reinforcement, vegetative buffering, reactivation of water-based masking, soundmark introduction, and perceptual zoning offer a replicable approach for enhancing soundscape quality in urban public spaces.

Ultimately, the most significant contribution of this research is a shift in urban design methodology. It moves the conversation past simply measuring noise pollution, offering instead a data-driven, design-oriented solution. By bridging the gap between theoretical acoustic research and real-world spatial application, this replicable framework gives architects, urban designers, and municipal authorities the practical tools needed to reclaim acoustic comfort and enhance the public realm in India's rapidly growing, high-density urban centers.

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