QUIETCORRIDORS: INTELLIGENT NOISE ANALYTICS FOR HEALTHIER URBAN MOBILITY

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Introduction:

Noise pollution has become a pressing environmental issue in modern societies, particularly in urban areas where rapid urbanization, population growth, and increasing vehicular traffic have significantly worsened the sound environment. The World Health Organization has identified noise as the third most harmful form of pollution after air and water, attributing millions of healthy life years lost to noise-related illnesses worldwide. Among the various sources, road traffic is the most dominant contributor to noise in urban centers, posing severe risks to public health, social well-being, and environmental quality. Studies across different regions consistently highlight that road traffic noise frequently exceeds permissible limits, creating conditions that compromise both community health and quality of life.

Recent studies show that in Ondo Central Business District (CBD), noise levels ranged from 68 to 76 dB, surpassing the WHO threshold of 70 9 in nearly 90% of monitored locations. Predictive modeling using CoRTN and Multiple Linear Regression (MLR) demonstrated high accuracy, with R^2 values of 0.943 and 0.963 respectively, underscoring the utility of such tools in managing noise pollution. Key predictors included traffic volume, vehicle speed, and heavy vehicle proportion, all of which strongly influence noise intensity ([1] Ibili et al., 2022). Comparable observations in other regions confirm that noise levels consistently exceed recommended limits, with vehicular traffic volume, particularly heavy goods vehicles, being the primary contributor. Predictive models like CoRTN and MLR performed reliably in these studies as well, with MLR showing slight superiority in accounting for local conditions ([2] Kallankandy & Deswal, 2022).

Urban areas such as Kalaburagi have also reported significant noise variations, with average levels around 55.76 dB but peaks reaching 72.56 dB. While these values sometimes remain within regulatory thresholds, the persistence of elevated readings during peak hours emphasizes the risk of long-term exposure and its impact on public health. Moreover, awareness of noise hazards remains low among residents, further exacerbating the problem ([3] Guttedar et al., 2025). In Surat, a tier-II city in India, daytime noise levels were observed in the range of 71.7–76.6 dB, while nighttime levels ranged from 65.7–73.3 dB, both exceeding national permissible limits. Even during early morning hours, the minimum recorded noise was above standards, demonstrating how urban traffic sustains high noise levels around the clock ([4] Sonaviya & Tandel, 2020).

Delhi, one of the largest metropolitan cities, provides another striking example where noise levels across 100 monitored sites ranged between 66.5 and 84.7 dB, consistently above CPCB and WHO standards. Honking alone was found to increase noise by 2–5 dB, while silence zones such as hospitals and universities failed to comply with safe limits. Health risks reported included stress, hypertension, and sleep disturbances, reinforcing the urgent need for policy interventions ([5] Chauhan et al., 2023). Similar patterns were observed in Patna, where noise levels from 77.7 to 92.5 dB were recorded at all locations, far beyond permissible limits. Contributing factors included narrow roads, dense population, unregulated private vehicles, and ongoing construction. Noise indices such as TNI and NPL were also significantly above thresholds, confirming the severity of the problem ([6] Ranjan et al., 2023).

Noise is not restricted to road traffic alone; construction zones and mixed land-use areas exacerbate the problem. For example, in Malaysia, residential and construction sites both exceeded permissible limits, with construction zones consistently noisier due to heavy vehicles and machinery. Motorcycles and frequent honking were additional contributors, underscoring how multiple sources compound noise pollution in developing regions ([7] Faisal et al., 2023). In Konya, Turkey, traffic noise was linked to stress, hypertension, hearing loss, and psychological effects, while weak enforcement of standards and low public awareness worsened the issue ([8] Ozen et al., 2021).

In Raipur, India, traditional models failed to accurately predict noise in heterogeneous traffic conditions. Six models were evaluated, with the Fagotti-Poggi model performing best, though still showing limitations. A locally developed regression-based model provided better accuracy, with errors within ±2 dB, highlighting the importance of developing context-specific approaches ([9] Kumar et al., 2025). In Doha, Qatar, intersections recorded noise levels between 67.6 and 77.5 dB, significantly above both WHO and national standards. Intersections with higher traffic flow, multi-lane structures, and frequent congestion showed the worst results, reflecting the direct influence of road geometry and traffic control systems on noise levels ([10] Abdur-Rouf & Shaaban, 2022).

Several studies have focused on corridor-specific noise modeling. Research along Bus Rapid Transit corridors in India showed persistent exceedance of safe levels, reinforcing that even controlled transit systems do not eliminate noise risks ([11] Mishra et al., 2010). Similar findings emerged in Chennai, where busy corridors experienced consistent violations of limits due to congestion, honking, and mixed traffic composition ([12] Karthik & Partheeban, 2013). In Amman, Jordan, modeling of urban traffic noise demonstrated widespread non-compliance with standards and emphasized the urgent need for planning and mitigation strategies ([13] Younes et al., 2021).

The issue is further compounded when urban form and pedestrian exposure are considered. In Hong Kong, spatial analysis revealed how urban design and building structures affect the propagation of traffic noise and increase pedestrian exposure. The study underscored the role of city planning in either mitigating or exacerbating noise pollution ([14] Sheng & Tang, 2011). Advanced modeling techniques have also been tested, with spectrum analysis and dynamic modeling offering more refined predictions compared to traditional experimental approaches ([15] Can et al., 2010).

In India, the application of geospatial tools has gained momentum. Studies in Chennai highlighted how GIS can effectively map noise exposure, identify hotspots such as intersections, and quantify population-level impacts. Approximately 450,000 people were found to be affected by traffic noise, with 83,000 severely impacted, underscoring the public health significance of noise in dense cities ([16] Partheeban et al., 2021). Similarly, GIS-based noise mapping in Bahadurpur revealed dangerously high levels approaching 100 dB, exposing roadside vendors and residents to severe auditory and non-auditory health risks. Short-term sampling proved sufficient to generate accurate noise maps, offering a cost-effective method for urban monitoring ([17] Zafar et al., 2023).

The role of honking in traffic noise has also been highlighted in Indian studies. Between 2012 and 2019, significant increases in noise levels were observed due to rising vehicle counts and honking incidents, which rose four to six times during peak hours. Including honking in noise models substantially improved prediction accuracy, demonstrating the necessity of capturing local behavioral factors ([18] Thakre et al., 2020). The COVID-19 lockdown provided further insights, showing reductions of 4–6 dB in France, equivalent to 60–75% reductions in sound energy. Residents reported greater awareness of natural sounds, suggesting that reductions in traffic noise could lead to improved perceptions of urban soundscapes and associated health benefits ([19] Munoz et al., 2020).

Surat again exemplifies the complexity of heterogeneous traffic conditions. Morning peak measurements across arterial roads recorded values between 66.8 and 78.9 dB, far above CPCB limits. Two-wheelers were identified as the primary contributors, accounting for more than 60% of traffic volume. Variations across sites highlighted the influence of road geometry, traffic flow patterns, and urban activities. The study called for stricter enforcement, improved traffic management, and public awareness campaigns to reduce honking and encourage public transport ([20] Ranpise & Tandel, 2022).

Taken together, these studies from across the globe demonstrate the universality of traffic noise as an environmental hazard. Whether in Nigeria, India, Turkey, Qatar, France, or Malaysia, road traffic noise consistently surpasses safe limits, contributing to a spectrum of health and environmental problems. The use of predictive models, whether empirical frameworks like CoRTN or regression-based approaches tailored to local conditions, has proven essential in understanding and managing this challenge. At the same time, public awareness, strict regulatory enforcement, and integration of noise management into urban planning remain crucial. For Nigerian cities such as Ondo, where mixed traffic conditions, poor infrastructure, and unregulated vehicle imports aggravate the situation, adopting these strategies is particularly urgent. The evidence underscores the necessity of multi-pronged interventions combining monitoring, modeling, planning, and education to safeguard public health and ensure sustainable urban development.

Objectives:

1. To systematically monitor and record traffic-induced noise levels at selected high-traffic urban corridors.
2. To benchmark observed noise levels against CPCB standards for urban zones.
3. To examine correlations between traffic density, noise intensity, and dominant contributing sources.
4. To compare and analyze the spatial patterns of noise levels and traffic density using distinct GIS mapping.

Methodology:

This chapter presents the comprehensive methodology adopted to systematically monitor, quantify, benchmark, and spatially analyse traffic-induced noise levels across selected high-traffic urban corridors in Bengaluru, Karnataka, India. The research design integrates multi-source data acquisition, standardised field instrumentation, and geographic information system (GIS)-based spatial analysis to achieve the four objectives delineated in Chapter I. The methodology is structured across four interconnected phases: (i) study design and site preparation, (ii) multi-source data collection, (iii) statistical and comparative data analysis, and (iv) GIS-based spatial mapping and pattern analysis.

Rapid urban expansion in Bengaluru has exacerbated noise pollution, particularly in commercial and arterial zones characterised by high passenger car unit (PCU) volumes and mixed land-use patterns. Prior studies have established that the equivalent continuous sound level (Leq) at urban road junctions in Indian cities consistently exceeds permissible limits prescribed by the Central Pollution Control

Board (CPCB) [7], [8], [9]. The methodology adopted herein is specifically calibrated to address local conditions at monitored stations such as Yeshwanthpur Police Junction, where road type (flexible pavement), land-use classification (commercial area), and green shade density (low) are documented as contextual variables influencing noise propagation and receptor exposure [2], [3].

The methodological framework draws on established protocols for urban noise monitoring as recommended by the International Electrotechnical Commission (IEC 61672-1) and procedural guidelines from the CPCB, ensuring that measured parameters — including LA10, LA50, LA90, Leq, Noise Climate (NC), Traffic Noise Index (TNI), and Noise Pollution Level (NPL) — are compliant with national and international standards [1], [6]. Meteorological covariates including PM2.5, PM10, relative humidity (RH), wind speed (WS), and barometric pressure (BP) are co-recorded to account for atmospheric influences on sound propagation [4], [5].

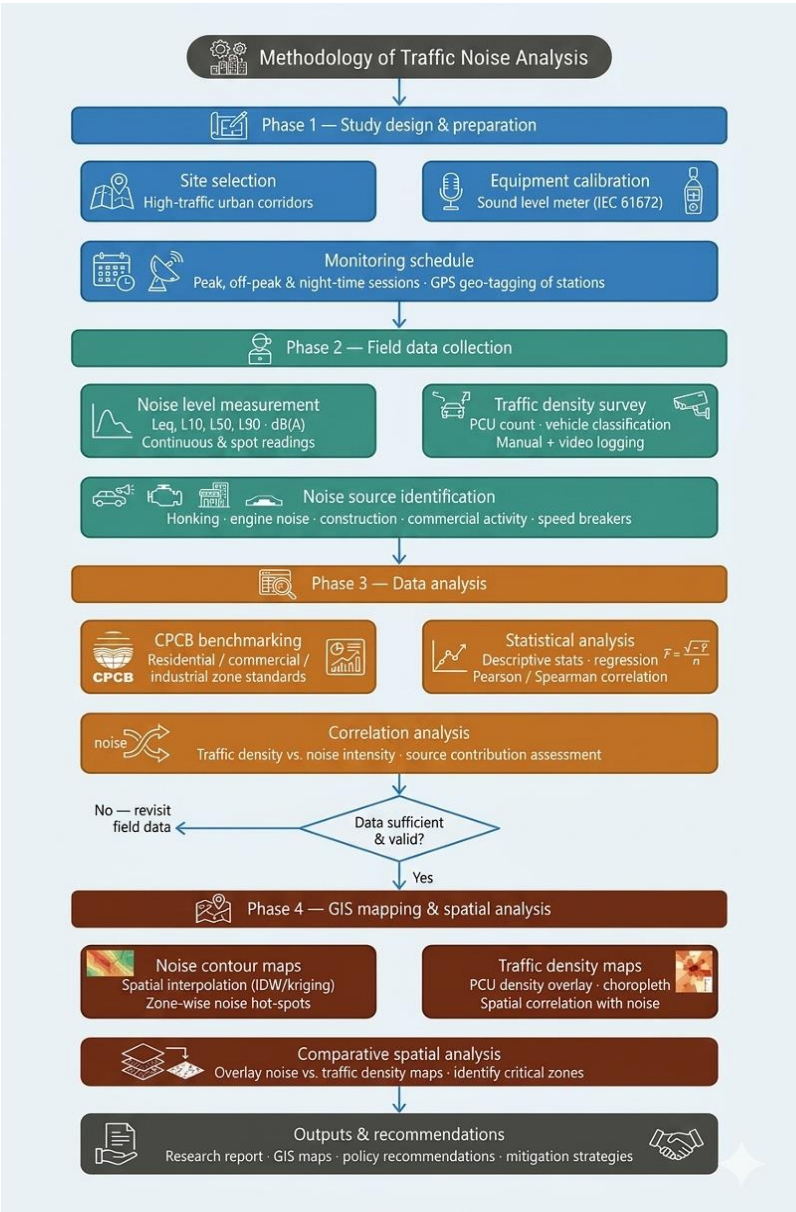

Figure 1-Methodology Flowchart

Results and Conclusions

In summary, this study establishes a rigorous, multi-parametric characterisation of urban noise pollution across representative zones of Bengaluru's metropolitan area. The convergent evidence from GIS spatial analysis, statistical indices, correlation assessment, and extreme value modelling demonstrates that the city's acoustic environment is in severe and persistent non-compliance with national standards, that the causal mechanisms are site-specific and require differentiated engineering responses, and that the emerging spatial dynamics of noise pollution — particularly in the IT corridors of eastern Bengaluru — demand proactive planning and enforcement action to prevent the acoustic degradation trajectory already observed in the western industrial zones.

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Future Scope:

The QUIETCORRIDORS project, in its current phase, has established a foundational monitoring and analysis framework for Bengaluru's urban traffic noise environment. Several significant extensions and research directions are envisaged for future phases to expand the scope, depth, and applied impact of this work.

1. Expansion of the Monitoring Network

The present study is based on six monitoring stations selected to represent major land-use categories. Future phases should expand the network to a minimum of 20–25 stations across all Bengaluru BBMP zones, including peri-urban transitional areas, metro corridor alignments (Namma Metro Phase-II), and newly developed peripheral townships. A denser spatial network would improve IDW and Kriging interpolation accuracy and enable more reliable identification of emerging acoustic hotspots.

2. IoT-Based Real-Time Noise Monitoring System

A transformative extension would involve deployment of low-cost IoT-enabled acoustic sensors at strategic locations, transmitting real-time Leq, L10, L50, and L90 data to a cloud-based KSPCB data platform. Real-time noise maps updated at 15-minute intervals would enable dynamic hotspot identification, immediate regulatory alert generation upon threshold exceedance, and longitudinal trend analysis. Integration with the Bengaluru Smart City Mission data dashboard would support evidence-based urban planning.

3. Machine Learning-Based Noise Prediction Models

Future work should explore non-linear machine learning models including Random Forest Regression, Gradient Boosting (XGBoost), Artificial Neural Networks (ANN), and Support Vector Regression (SVR) to capture complex interactions among traffic volume, vehicle composition, road geometry, land-use, and meteorological variables. These models have demonstrated superior predictive performance for urban noise in recent international literature and could significantly improve Leq estimation accuracy for Indian heterogeneous traffic conditions.

4. Health Impact Quantification and Epidemiological Study

A dedicated epidemiological component linking measured noise exposure levels to health outcome data (sleep quality surveys, cardiovascular health records, cognitive performance assessments at RVCE) would strengthen the public health case for regulatory intervention. WHO Environmental Noise Guidelines [20] provide dose-response relationships that could be applied to GPD-derived return level estimates, enabling computation of disability-adjusted life years (DALYs) attributable to traffic noise exposure in the study corridors.

5. Noise Barrier Design and Green Infrastructure Evaluation

Recommendations for acoustic barrier installation on NH-48 and around RVCE and NIHMANS should be advanced into detailed engineering design studies using ISO 9613-2 insertion loss methodology and 3D noise propagation modelling software (SoundPLAN, CadnaA). Comparative evaluation of barrier materials for insertion loss performance, cost-effectiveness, and urban aesthetic integration is warranted. A systematic evaluation of optimised tree species selection, planting density, and multi-layer vegetation configurations for noise reduction in Indian urban settings is also recommended.

6. Integration with Urban Traffic Management Systems

Future research should explore bi-directional integration between the QUIETCORRIDORS noise monitoring platform and the Bengaluru Integrated Traffic Management System (BITMS), enabling noise-informed adaptive signal control at acoustically critical intersections and acoustic-optimised route guidance for heavy vehicles during night hours. The correlation data generated in this study provide the empirical basis for acoustic cost functions in such optimisation frameworks.

7. Electric Vehicle Transition and Long-Term Acoustic Trend Analysis

As Bengaluru undergoes a gradual transition to electric vehicles (EVs), longitudinal acoustic monitoring at the established QUIETCORRIDORS stations would provide valuable empirical data on the acoustic co-benefits of electrification. At low speeds (<30 km/hr), EV powertrains eliminate engine and exhaust noise, potentially reducing Leq by 2–4 dB(A) at congested urban intersections. Long-term trend monitoring from 2025 to 2030 would quantify the net acoustic impact of fleet electrification in an Indian urban.