



Report on **REAL TIME AMBIENT NOISE MEASUREMENT AND NOISE MAPPING FOR CHENNAI CITY**



Department of Civil Engineering, IIT Madras, Chennai

DISCLAIMER

This report presents the findings of the project titled “Real-time Ambient Noise Measurement and Noise Mapping for Chennai City”, commissioned by the Tamil Nadu Pollution Control Board (TNPCB), Government of Tamil Nadu as per the Government Order G.O. (Ms) No. 144, Environment, Climate Change and Forest (EC2(2)) Department, dated 22.08.2024. The study has been carried out by the Department of Civil Engineering, Indian Institute of Technology Madras (IIT Madras), Chennai, in accordance with the approved scope of work.

The analyses, interpretations, and conclusions presented in this report are based on ambient noise data collected using a network of low-cost sensors deployed across Chennai city during the study period. Appropriate data validation and quality control measures have been implemented to ensure the reliability and accuracy of the results within the limitations of the monitoring methodology.

The findings and recommendations contained herein are intended solely for the purposes of this study and should be interpreted in the context of the study scope, data availability, and underlying assumptions. No part of this report may be reproduced, republished, or redistributed in any form or by any means, electronic or otherwise, in whole or in part, without prior written permission from the competent authority.

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GLOSSARY

The following are some of the commonly used terms in this report:

Ambient noise	- The background sound in an environment, usually created by a combination of distant or nearby noise sources
Attenuate	- The process of reducing the intensity or level of sound in a device or system
A-weighted decibel (dB(A))	- A decibel measurement adjusted to reflect the frequency sensitivity of the human ear; more accurately represents perceived loudness
Background noise	- Noise originating from sources other than the primary noise source under observation
Continuous Equivalent Noise Level (L_{eq})	- Represents a single constant noise level that would produce the same total sound energy as the varying noise levels over a specified period
Decibel (dB)	- The unit used to measure sound intensity on a logarithmic scale
L_{10}	- The noise level that is exceeded for 10% of the total measurement time; often used to indicate higher noise levels in an environment
L_{50}	- The noise level that is exceeded for 50% of the measurement time; represents the median noise level
L_{90}	- The noise level that is exceeded for 90% of the measurement time; often used to represent background noise levels
Noise	- Unwanted sound that is loud, unpleasant, or unexpected
Noise barrier	- A physical structure designed to block or reduce the propagation of sound waves, commonly used near roads, railways, or industrial areas
Noise level	- The measurable intensity of sound, typically expressed in decibels (dB)
Noise map	- A graphical representation of the distribution of noise levels in a geographic area, used to assess exposure, and inform mitigation planning
Noise pollution	- Unwanted or harmful noise in the environment that can be quantified and assessed, especially in urban or industrial settings
Sound Level Meter	- A device used to measure the intensity of noise pollution
Traffic noise	- Noise produced by road vehicles including cars, trucks, motorcycles, and their interaction with road surfaces

ABBREVIATIONS

ANOVA	-	Analysis of variance
CFD	-	Cumulative Frequency Distribution
CMA	-	Chennai Metropolitan Area
CPCB	-	Central Pollution Control Board
CPCL	-	Chennai Petroleum Corporation Limited
GCC	-	Greater Chennai Corporation
GIS	-	Geographic Information System
GSM	-	Global System for Mobile Communications
IDW	-	Inverse Distance Weighting
IoT	-	Internet of Things
JSON	-	JavaScript Object Notation
LCSNs	-	Low-Cost Sensor Networks
MCU	-	Microcontroller Unit
NANMN	-	National Ambient Noise Monitoring Network
RMS	-	Root Mean Square
SIM	-	Subscriber Identity Module
SLM	-	Sound Level Meter
TNPCB	-	Tamil Nadu Pollution Control Board
UCHC	-	Urban Community Health Centre
UNEP	-	United Nations Environment Programme
UPHC	-	Urban Primary Health Centres
WHO	-	World Health Organization
Wi-Fi	-	Wireless Fidelity

NOTATION

$\bar{x}$	-	Mean of variable x_i
$\bar{y}$	-	Mean of variable y_i
CoD	-	Coefficient of Divergence
dB	-	Decibel
$dB(A)$	-	Decibel (A-weighted)
H_0	-	Null hypothesis
H_a	-	Alternate hypothesis
j, k	-	Two paired monitoring locations
L_{10}	-	Noise level exceeding for 10% of the measurement time
L_{50}	-	Noise level exceeding for 50% of the measurement time
L_{90}	-	Noise level exceeding for 90% of the measurement time
L_{eq}	-	Continuous Equivalent Noise Level
L_i	-	Instantaneous noise measurement
L_{max}	-	Maximum noise level
L_{min}	-	Minimum noise level
L_{np}	-	Noise Pollution Level
n	-	Total number of observations
NC	-	Noise Climate
$^{\circ}C$	-	Degree Celsius
p	-	Probability value
r	-	Pearson Correlation Coefficients
TNI	-	Traffic Noise Index
x_{ik}	-	Value at station i at time k
x_{jk}	-	Value at station j at time k
α	-	Level of significance

EXECUTIVE SUMMARY

Introduction

The study addresses the growing challenge of urban noise pollution in one of India's fastest urbanizing metropolitan regions. Chennai has experienced rapid expansion in population, transport infrastructure, construction activity, and industrial growth, all of which have significantly altered its acoustic environment. Noise pollution has emerged as a critical environmental stressor with direct implications for public health, quality of life, and urban sustainability. Despite the presence of regulatory frameworks such as the Noise Pollution (Regulation and Control) Rules, 2000, the absence of continuous, high-resolution, city-wide noise data has constrained effective enforcement and planning. This project was therefore conceived to generate robust scientific evidence through real-time monitoring and spatial mapping to support informed urban noise management and policy development.

Aim and objectives of the study

The primary aim of the project is to comprehensively characterize the ambient noise environment of Chennai by capturing its spatial, temporal, and seasonal variations using a network of low-cost, real-time noise sensors. The study aims to establish a continuous and representative monitoring framework that reflects the true dynamics of urban noise exposure across different land-use categories, enabling a shift from fragmented measurements to an integrated, data-driven understanding of the city's soundscape.

The specific objectives of the study include:

- Deployment of low-cost noise sensor units across representative urban land-use categories
- Long-term measurement of noise levels across day and night
- Assessment of compliance with CPCB-prescribed noise standards
- Identification of dominant noise sources and their spatiotemporal influence
- Generation of geospatial noise maps to identify hotspots and potential silent zones
- Formulation of targeted noise mitigation and management strategies tailored to Chennai's urban context

Key highlights of the study

A key strength of the project lies in its comprehensive and systematic monitoring design. The study covers all 15 administrative zones of Chennai, with sensors deployed at 60 strategically selected locations, ensuring representation of diverse urban typologies, including sensitive areas in close proximity to medical facilities. Continuous monitoring provides fine temporal resolution and enables the capture of diurnal, weekly, and seasonal variability that is often missed in conventional short-term studies. The development and deployment of validated low-cost sensors demonstrate a scalable and cost-effective monitoring approach suitable for large urban areas. In addition, the custom-made digital dashboard enables real-time data access and user-friendly visualization, enhancing transparency and usability of the data. The generation of GIS-based noise maps further strengthens the project by providing clear visual representation of spatial noise patterns across the city.

Key findings and major outcomes

The project outcomes provide a comprehensive understanding of Chennai's urban noise environment. Analysis of the monitored data reveals that road traffic is the dominant contributor to ambient noise across most zones of the city. Persistent exceedance of permissible noise limits was observed not only in commercial and traffic zones but also in residential and sensitive areas, indicating widespread and chronic noise exposure.

Spatial and temporal analyses further revealed important patterns. Correlation analysis showed that noise levels across most monitoring locations were strongly homogeneous, driven by similar sources, primarily road traffic. However, localized heterogeneity was evident between certain zones, particularly where land use and urban activity differed markedly. Temporal assessments demonstrated strong diurnal cycles, with peak levels during commuting hours. Weekly variations suggested a marginal reduction in noise on Sundays, but not sufficient to bring it within limits.

Comparative and visual analyses, including box plots, cumulative frequency distributions, heat maps, and calendar plots, reinforced these findings by identifying clear noise hotspots and quieter areas. Zone XI (Valasaravakkam) consistently emerged as a high-exposure area, while Zone XIII (Adyar) offered some acoustic

relief. The results confirm that Chennai's urban environment suffers from chronic and pervasive noise pollution, with high public health implications, and they highlight the urgent need for comprehensive noise management policies that combine city-wide measures with site-specific interventions.

Noise mapping insights

Noise mapping emerged as a critical outcome of the study by translating measured data into intuitive spatial representations of noise exposure. Spatial maps illustrated the variation in noise levels across different land-use categories, consistently showing higher daytime values compared to night time. Hotspots such as Zone11_T (Urban Primary Health Centre, Maduravoyal) and Zone5_S (Rajiv Gandhi Government General Hospital) repeatedly exceeded 70 dB(A). These maps effectively highlighted how land-use and traffic intensity shape the city's noise climate. Strategic noise maps, generated through interpolation, offered a more comprehensive view by filling gaps between monitoring stations and revealing city-wide patterns. The consolidated maps confirmed the persistence of elevated noise levels during the day, particularly in central and northern zones such as Zone IV, V, VII, XI, and XV. Night time values were relatively lower but still exceeded thresholds in several hotspots.

Together, spatial and strategic noise maps provide evidence of the scale and distribution of noise pollution in Chennai. They not only confirm the dominance of traffic-related sources but also help distinguish between chronic hotspots and relatively quieter areas. These insights are crucial for urban planning and policy, as they enable targeted mitigation in the most affected zones while ensuring the preservation of existing quiet areas. The mapping outcomes thus serve as an essential tool for evidence-based noise management and sustainable urban development.

Urban noise pollution management framework

Overall, effective noise management in Chennai requires a comprehensive, location-specific strategy that integrates engineering controls, urban design principles, and regulatory enforcement across residential, industrial, commercial, traffic, and sensitive zones. Addressing noise at the source through quieter technologies, improved traffic management, and better industrial practices, while simultaneously mitigating its transmission through building design, barriers, and green buffers, is

essential for protecting public health. Special emphasis on schools and hospitals underscores the need to safeguard vulnerable populations by creating and strictly enforcing quiet zones supported by continuous monitoring and community awareness.

In the long term, strengthening Chennai's noise management practices must go beyond isolated mitigation measures and be embedded within broader urban and transport planning frameworks. The adoption of people-centric urban models offers a sustainable pathway to reduce dependence on private vehicles, reclaim public space, and lower environmental noise levels. Coupled with data-driven policymaking, periodic review of noise reduction targets, and active public participation, these approaches can help Chennai transition towards a healthier, more livable, and acoustically sustainable urban environment.

Implications for policy and urban planning

The findings of this project have significant implications for future policy development and urban governance. The availability of high-resolution, long-term, and spatially explicit noise data provides a strong scientific basis for strengthening enforcement of existing noise regulations and for revising land-use planning and zoning practices. The study supports the integration of noise considerations into traffic planning, infrastructure design, and healthcare and residential zoning. The proposed mitigation framework offers evidence-based, location-specific recommendations that can guide urban local bodies in implementing effective and sustainable noise control measures.

Significance of the study

The project demonstrates the feasibility and effectiveness of a low-cost, sensor-based real-time noise monitoring network for a large Indian metropolitan city. Its methodology and outcomes are scalable and replicable, making them highly relevant for other cities in Tamil Nadu and across India facing similar urbanization pressures. By linking scientific monitoring with GIS-based visualization and policy-oriented analysis, the study bridges the gap between research and practice. Overall, the project makes a significant contribution to improving urban environmental quality, protecting public health, and advancing sustainable and inclusive urban development through informed noise pollution management.

1. INTRODUCTION

1.1 Background of the study

As urban populations expand due to migration for better employment opportunities and living standards, environmental pollution problems, including noise pollution, have become more pronounced in several Indian cities. Metropolitan cities like Mumbai, Delhi, Kolkata, and Chennai are among the noisiest in India, demanding studies on noise characteristics, sources, spatio-temporal variations, health impacts, and control measures. Noise interferes with everyday activities such as work, rest, or sleep, and long-term exposure to noise levels above 55 dB can lead to severe health outcomes, including increased blood pressure, cardiovascular diseases, and damage to the central nervous system (Münzel et al., 2014). It also affects daily activities, reducing efficiency, changing social behavior, and hindering communication (Jamir, Nongkynrih, & Gupta, 2014). According to the World Health Organization, environmental noise is a critical issue affecting human health, with almost 1 billion people worldwide at risk of permanent hearing loss due to noise pollution (WHO, 2021). With 466 million people suffering from hearing loss globally (Davis & Hoffman, 2019), the effects are more severe in sensitive populations such as infants, children, pregnant women, and older adults. Therefore, identifying noise sources and hotspots and formulating mitigation strategies to reduce noise levels to below standards is imperative.

Efficient management of urban noise pollution involves integrating noise monitoring and noise mapping, both of which play crucial roles in creating quieter, healthier urban environments. Noise levels in urban areas exhibit significant spatial and temporal variations, and despite the increase in noise monitoring stations, many locations still lack accurate decibel representation. Conventional sound measurement methods are expensive, time-consuming, and labor-intensive, failing to provide real-time data. Low-cost sensor networks offer an affordable alternative, requiring less maintenance and providing real-time, coherent measurements. These sensors can form a well-connected network, covering larger areas and delivering comprehensive acoustic information.

Results derived from this network can be used to develop maps of an entire city. Noise mapping is a valuable tool for urban planning, helping to assess, manage, and mitigate environmental noise pollution. These maps visually represent noise level distributions across different geographical areas and aid policymakers, urban planners, and environmental agencies in identifying quiet areas and noise hotspots, facilitating targeted noise reduction strategies. Additionally, noise maps guide the design and implementation of reduction measures, such as noise barriers, traffic reduction, and green spaces.

1.2 Scenario of noise pollution in Indian cities

Increasing transportation demands to meet the requirements of the rising population, an increase in the number of vehicles, the condition of the roads, an inefficient and inadequate public transport system, and excessive use of vehicular horns make traffic noise pollution a major issue in Indian cities (Goswami & Swain, 2017). Improper urban planning in Indian cities can be considered a prime reason for acute noise pollution. The roads are congested, but the number of cars, motorbikes, and rickshaws increases daily (Goswami & Swain, 2017). Excessive honking amidst the slow-moving traffic is also another source of noise pollution. Festive noise also contributes to environmental pollution (Goswami & Swain, 2017). In India, any celebration is accompanied by bands, loud music, bursting of crackers, and people shouting, be it marriages, religious processions, social events, or spiritual celebrations. The increasing construction and related activities also contribute to noise generation at high levels in urban areas. Residential noise, noise from loudspeakers and sirens, shouting of street vendors, children playing, bells and prayers from places of worship, and noise from other human activities are also familiar sources in most Indian cities.

Noise from artificial sources has grown tremendously in the past few decades, and cities like Mumbai, Delhi, Kolkata, and Chennai are listed among the noisiest cities in India (Hunashal & Patil, 2012). A review study showed that the road traffic noise exceeds 70 dB(A) in most Indian cities (Goswami & Swain, 2017), and according to the UNEP Annual Frontiers report, Moradabad in Uttar Pradesh is the second most noise-polluted city in the world (UNEP, 2022). 5 out of the 13 most noise polluted cities in South Asia are in India: Moradabad, Asansol, Kolkata, Jaipur, and Delhi

(UNEP, 2022). The Central Pollution Control Board (CPCB) has established the National Ambient Noise Monitoring Network (NANMN), covering 70 locations in 7 metro cities (Delhi, Lucknow, Hyderabad, Kolkata, Mumbai, Chennai, and Bangalore) to monitor the noise scenario throughout the country. Table 1.1 shows the ambient air quality standards with respect to noise as prescribed by CPCB in the Noise Pollution (Regulation and Control) Rules, 2000 (CPCB, 2000).

In Delhi, the national capital, rapid urbanization has decreased the rural population to 2.5%, and the urban population faces serious environmental challenges, including noise pollution. According to a study by Mishra et al. (2021), the noise level in most places of Delhi exceeded the permissible limit set by CPCB. A survey by Singh & Davar (2004) shows that automobiles and loudspeakers are significant sources of noise pollution in Delhi. The number of registered motor vehicles in Delhi doubled over the last decade, reaching almost 12 million in 2020 (Statista, n.d.). The Worldwide Hearing Index ranked Delhi as the second noisiest city in the world in 2017 (Balachandran, 2019). Even the implementation of the Odd-Even rule did not have any effect on controlling the noise pollution level in Delhi (Dass et al., 2017).

Table 1.1 Ambient air quality specification for noise

Area Code	Category of Area/Zone	Limits in dB(A) Leq ¹	
		Day Time	Night Time
(A)	Industrial area	75	70
(B)	Commercial area	65	55
(C)	Residential area	55	45
(D)	Silence Zone	50	40

¹ Note:

- Day time shall mean from 6.00 a.m. to 10.00 p.m.
- Night time shall mean from 10.00 p.m. to 6.00 a.m.
- Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.
- dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing

1.3 Need for the study

Environmental noise is often referred to as a "forgotten pollutant" (King et al., 2016), as its effects are neither immediately visible nor easily recognized. Despite numerous global awareness campaigns, noise pollution continues to be overlooked and insufficiently addressed in policy and planning (Iglesias-Merchan et al., 2021). Urban noise is a growing concern, and its mitigation requires a detailed understanding of its spatio-temporal distribution, which varies depending on infrastructure, land use, traffic patterns, and human activities. A detailed analysis of these variations can help identify the contribution from critical sources and trends of noise pollution.

In dense urban environments, the presence of silent zones (areas where noise levels are stringently controlled) is essential to protect vulnerable populations such as patients, school children, and the elderly. Hospitals, educational institutions, and similar sensitive receptors are meant to be shielded by regulations restricting noise-generating activities. However, in cities like Chennai, the absence of clearly demarcated silent zones, weak enforcement, and a lack of public awareness have increased noise exposure in these critical areas. There is an urgent need to revise existing noise standards and implement spatial zoning policies that are both enforceable and evidence-based.

Despite the increasing concern, several research gaps persist. Many past studies have focused narrowly on specific noise sources or isolated regions, providing only fragmented insights. There is a lack of integrated frameworks considering urban morphology, meteorological factors, socioeconomic conditions, and population density, which influence noise generation and propagation. To bridge these gaps, the present study focuses on real-time characterization and mapping of urban noise using a sensor-based monitoring approach that supports both data-driven planning and targeted mitigation.

This study focuses on Chennai city, where rapid urbanization has significantly altered the acoustic environment. There is a critical need to improve the urban soundscape by understanding the sources, intensities, and temporal dynamics of noise. The primary objectives of this study are to (i) design, develop, and validate low-cost noise sensor units; (ii) conduct real-time field measurements across representative locations; and

(iii) generate noise maps to identify hotspots and potential silent zones. The findings will inform practical mitigation strategies tailored to the urban context of Chennai.

1.4 Scope of work

The urban areas of India experience rapid urbanization accompanied by extensive infrastructure development in transportation, housing, and utilities. The increasing population density, rise in vehicular usage and honking, industrial operations, construction and demolition activities, and infrastructure projects such as roads, bridges, and drainage systems have significantly contributed to elevated noise levels. These urban noise sources pose serious threats to public health and psychological well-being. To address this growing concern and to ensure compliance with ambient noise quality standards, the present study aims to deploy a low-cost sensor-based noise monitoring system across 60 locations in Chennai. These locations represent key land use categories – residential, industrial, commercial, traffic, and sensitive areas. The study involves continuous day and night monitoring over a period of one year to comprehensively characterize the noise environment of the city, analyze its spatial and temporal variations, and generate noise maps for identifying hotspots and potential quiet zones. Ultimately, the findings will support a data-driven framework for effective noise mitigation and urban noise management.

Cities in Tamil Nadu are rapidly urbanizing, and infrastructure facilities like roads, railways, and airways are continuously improved for better connectivity. The increase in population migration to the cities has resulted in increased vehicular transport, use of vehicular horns, industrial activities, building construction, demolition, and infrastructure development (roads, bridges, drainage, and underground drainage) activities by urban local bodies. Noise emitted from the above activities has detrimental effects on people's health and psychological well-being. Hence, it is necessary to regulate and control noise-producing sources with the objective of maintaining ambient air quality standards with respect to noise.

The study proposes to set up a low-cost noise sensor system at 60 locations in Chennai city, covering the major residential, industrial, commercial, traffic, and sensitive zones, and carry out continuous monitoring day and night for one year. The study's main aim is to characterize the noise scenario of the city along with its spatial

and temporal variations. The study also proposes to carry out noise mapping in the city to identify quiet areas and hotspots.

The scope of this study encompasses the deployment, and application of a real-time noise monitoring system in Chennai city, with the ultimate goal of characterizing and mitigating urban noise pollution through a data-driven framework.

Key components of the scope include:

- **Sensor-based stationary monitoring and analysis**
 - Develop, calibrate and validate low-cost custom-made noise sensor units capable of continuously measuring noise levels in dB.
 - Deploy the developed sensors at strategically chosen fixed locations across Chennai to cover diverse land use types: residential, industrial, commercial, traffic, and sensitive areas.
 - Conduct long-term monitoring to capture diurnal, weekly, and monthly patterns and trends in urban noise.
 - Identify spatial and temporal variations of noise levels and characterize urban noise at different categories of locations.
 - Evaluate compliance with CPCB-prescribed noise limits for different categories.
- **Development of noise maps**
 - Generate noise maps using spatial interpolation techniques, integrated within a GIS environment.
 - Identify hotspots of excessive noise and potential silent zones that need protection or regulatory enforcement.
- **Recommendations for urban noise management**
 - Propose location-specific control measures, including zoning revisions, installation of noise barriers, traffic regulation, or green buffer zones.
 - Provide technical and policy recommendations for strengthening Chennai's noise management practices.

1.5 Objectives

The specific objectives of the study are as follows:

- Noise measurement at selected representative monitoring locations in Chennai city, covering different land use categories, using a network of custom-made low-cost sensor units.
- Study the spatial, temporal, and seasonal variations of noise levels in Chennai city by analyzing patterns over different times of day and across diverse urban typologies.
- Check for compliance of obtained noise level values with the standard values of noise regulations as per the Noise Pollution (Regulation and Control) Rules, 2000.
- Identification of the various sources of noise pollution and also their spatiotemporal impact on the surrounding environment in Chennai city.
- Geospatial noise mapping of Chennai city using a GIS system to identify noise hotspots of the city.
- Suggest noise control measures and strategies to develop a mitigation framework for effective urban noise control, tailored to Chennai's specific challenges and conditions.

2. DESCRIPTION OF THE STUDY AREAS

2.1 Chennai

Chennai (13.1° N, 80.3° E), located on the south-eastern coast of India, is the capital city of Tamil Nadu and one of India's major metropolitan areas (Figure 2.1). The city lies on a flat coastal plain called the Eastern Coastal Plains, with an average elevation of 6.7 m above sea level. Covering an area of 426 km², Chennai ranks as the fourth largest city in India by area and the sixth most populous city, with a population of 4.68 million as per the 2011 census. The city has a vulnerable demographic profile with around 13.6 lakh children below the age of 18 years and 4.6 lakh elderly above 60 years (Census Digital Library, 2021). Three rivers – Kosasthalaiyar, Cooum, and Adyar – traverse the city along with the man-made Buckingham Canal. Three large lakes, namely Sholavaram Lake, Red Hills Lake, and Chembarambakkam Lake, are also present in the city. Chennai experiences a tropical wet and dry climate, with temperatures ranging from 20°C to 40°C. It receives most of its annual rainfall during the northeast monsoon from October to December (Government of Tamil Nadu, 2022a).

Chennai is a major hub for culture, commerce, education, and industry in South India, often referred to as the "Gateway to South India". Formerly known as Madras, the city was renamed Chennai in 1996. It serves as the epicenter of urban expansion in the region, spilling over into the neighboring districts of Kanchipuram and Thiruvallur. The city holds political significance as the administrative center of Tamil Nadu, housing the state government, secretariat, and the Madras High Court. Its economic profile is defined by a strong industrial base, especially in the automobile and software sectors, earning it the title "Automobile Capital of India" and a leading IT destination. Chennai is also a health and education hub, with numerous institutions of national importance. The Chennai Metropolitan Area (CMA) spans 1189 km², with 428.5 km² falling under the Greater Chennai Corporation (GCC). The CMA had a population of 8.9 million in 2011, with rapid growth in suburban municipalities and village panchayats (Government of Tamil Nadu, 2022a).

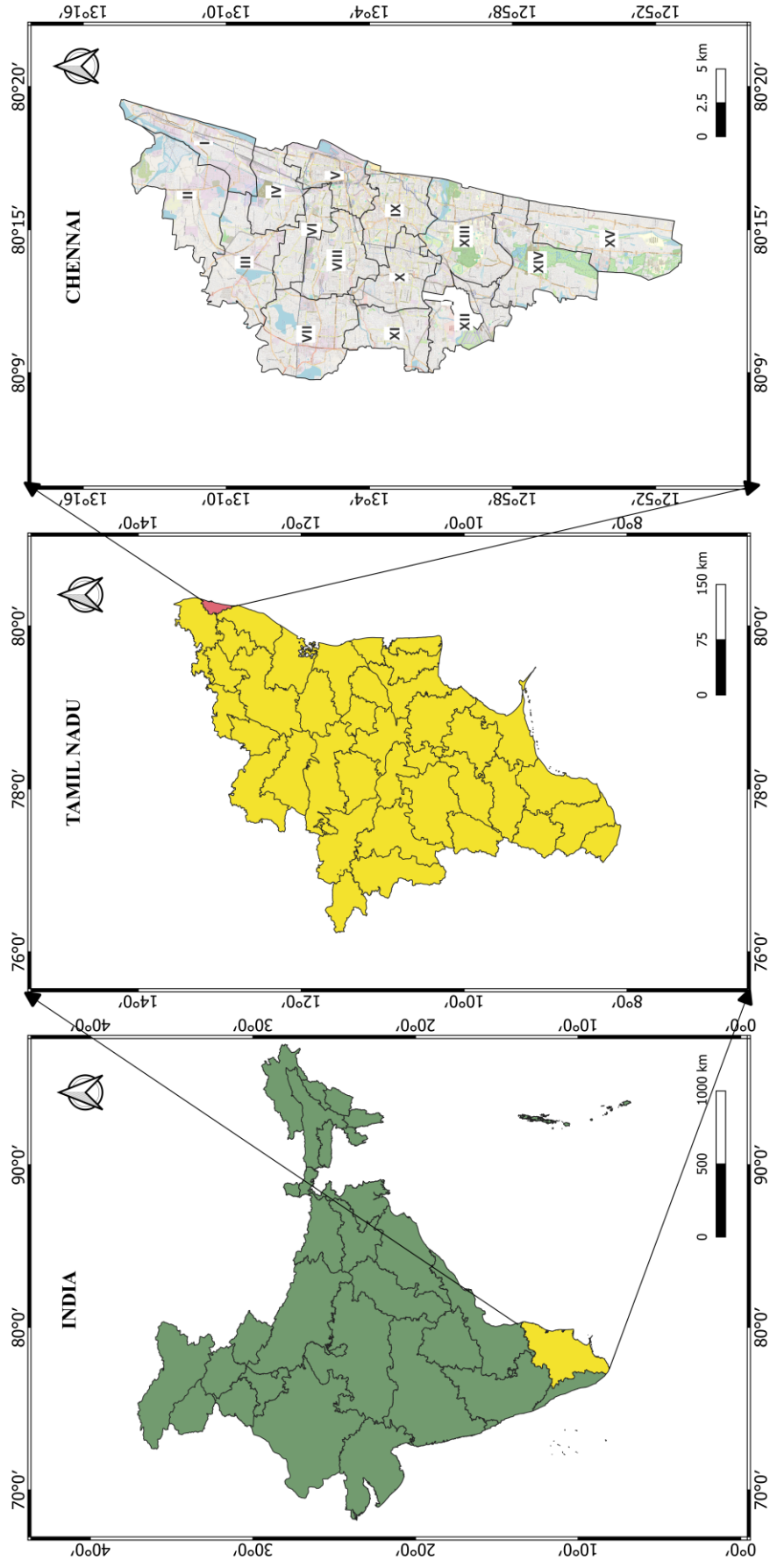


Figure 2.1 Study area

The city has seen significant urban expansion, particularly after the administrative boundaries were extended in October 2011, increasing its area from 176 km² to 426 km² and its population to 6.6 million. However, population growth within the original city limits has slowed, registering only an 8% increase from 2001 to 2011, while newly added areas grew by 54% in the same period. Chennai remains the most densely populated city in Tamil Nadu, with a density of 26,903 persons per km² and about 13.4 lakh people living in slums. As of 2019, approximately 40% of the urban population lived below the poverty line. The city is divided into 15 zones and 200 wards, reflecting its administrative complexity and spatial diversity (Table 2.1) (Government of Tamil Nadu, 2022b; Pradeep & Nagendra, 2024).

Table 2.1 Characteristics of different zones in Chennai city²

Zone Number	Zone name (Ward numbers)	Characteristics	Major noise sources
Zone I	Thiruvotriyur (1 to 14)	Residential & industrial area (contains various industries, power plants, refineries, the fishing harbor, and docks) Includes 6 UPHC & 1 UCHC	Movement of heavy vehicles, Industries
Zone II	Manali (15 to 21)	Residential & industrial area (Chennai Petroleum Corporation Limited (CPCL) and Madras Fertilizers Limited (MFL)) Includes 2 UPHC & 1 UCHC	Movement of heavy vehicles, Industries
Zone III	Madhavaram (22 to 33)	Contains Madhavaram Milk Colony Includes 4 UPHC & 1 UCHC	Road traffic, Congested roads
Zone IV	Tondiarpet (34 to 48)	Industrial area (contains Hindustan Petroleum Corporation Limited, Bharat Petroleum Corporation Limited & Indian Oil Corporation Limited) Houses Kodungaiyur Corporation landfill Includes 46 schools, 15 UPHC & 1 UCHC	Road traffic, Congested roads, Industries

² UPHC – Urban Primary Health Centre, UCHC – Urban Community Health Centre

Zone V	Royapuram (49 to 63)	Contains Tamil Nadu State Legislature and Secretariat, Rajiv Gandhi Government General Hospital & Madras Medical College Includes 43 schools, 13 UPHC & 1 UCHC	Road traffic, Congested roads
Zone VI	Thiru-vi-ka nagar (64 to 78)	Residential area Named after the Tamil scholar Thiru. V. Kalyanasundaram Contains various entertainment venues such as cinemas and parks Includes 51 schools, 14 UPHC & 1 UCHC	Road traffic, Congested roads
Zone VII	Ambattur (79 to 93)	Industrial area (contains around 1800 units) Includes 9 UPHC & 1 UCHC	Road traffic, Industries
Zone VIII	Anna Nagar (94 to 108)	Residential area Contains several schools & colleges, places of worship, shopping areas, and numerous restaurants, hospitals, and nursing homes. Includes 28 schools, 15 UPHC & 1 UCHC	Road traffic
Zone IX	Teynampet (109 to 126)	Commercial area Teynampet Signal – busy intersection with the worst traffic during peak hours Includes 84 schools, 16 UPHC & 1 UCHC	Road traffic, Busy intersections, Congested roads
Zone X	Kodambakkam (127 to 142)	Residential area The hub of the Tamil film industry Includes 5 schools, 15 UPHC & 1 UCHC	Road traffic, Metro rail construction activities
Zone XI	Valasaravakkam (143 to 155)	Residential area Includes 5 UPHC & 1 UCHC	Road traffic, Metro rail construction

Zone XII	Alandur (156 to 167)	Residential area Includes the Chennai International Airport Includes 5 UPHC & 1 UCHC	Road traffic, Air traffic, Metro rail construction activities
Zone XIII	Adyar (170 to 182)	Residential area Contains Guindy National Park, IIT Madras, and SIDCO Industrial Estate Includes 24 schools, 11 UPHC & 1 UCHC	Road traffic, Educational institutions, Industries
Zone XIV	Perungudi (168 & 169, 183 to 191)	Residential area IT Corridor of Chennai Contains the Perungudi dump site and the Pallikaranai water treatment plant Includes 5 UPHC & 1 UCHC	Road traffic, Residential area
Zone XV	Sholinganallur (192 to 200)	Residential area (One of the most densely populated places in Tamil Nadu) Includes 5 UPHC & 2 UCHC	Road traffic, Educational institutions

Transport and mobility have seen rapid transformation in recent decades due to growing urbanization and industrialization. The city has a road network spanning approximately 2,847 km, with about 150 km maintained by state highways and the rest by the Chennai Corporation. The vehicle population in the city has surged to nearly 48 lakh, creating significant pressure on road infrastructure and contributing heavily to air and noise pollution. Public transport accounts for around 70% of commuter movement. There has been a noticeable shift from non-motorised modes like walking and cycling to private motor vehicles, particularly two-wheelers. This transition has led to chronic traffic congestion and increased noise levels, especially around major junctions and arterial roads (Government of Tamil Nadu, 2022a).

Land use and land cover mapping reveal that about 85% of the city's area is developed, including residential, industrial, institutional, and transportation infrastructure. The remaining 15% comprises vegetation, scrubs, and water bodies. Of the developed area, 60% is residential, including formal and informal settlements. The

most densely populated localities include Thiru-vi-ka nagar, Madhavaram, Tondiarpet, Teynampet, and Alandur. The northern zones are heavily industrialised, hosting petrochemical units like CPCL (Chennai Petroleum Corporation Limited) in Manali, power plants in Ennore, and small-scale industries in Ambattur. The western corridor around Sriperumbudur, along the Bangalore highway, is a growing industrial cluster with several automobile manufacturing units. Chennai's connectivity through the Golden Quadrilateral and multiple national highways facilitates the movement of heavy commercial vehicles, further contributing to noise and air pollution levels in the city, making it a critical site for real-time environmental monitoring (Government of Tamil Nadu, 2022a).

2.2 Major sources of urban noise in Chennai city

Noise pollution in urban areas can arise from a variety of sources, each contributing to the overall urban soundscape that affects human health and well-being. The activities and sources contributing to noise levels may be stationary or mobile and vary from place to place. These spatial and temporal changes influence variations in noise levels in pollution sources. Other external factors alter the noise reaching the receiver even when the sources remain constant. Several studies (Jamir, Nongkynrih, & Gupta, 2014; Garg et al., 2016; Kalaiselvi & Ramachandraiah, 2016; Yadav et al., 2022) have documented that the primary contributors to noise pollution in Indian cities include road traffic, loudspeakers, construction activities, honking from automobiles, festivals, and celebrations, household noise generated by electrical appliances and entertainment systems, as well as hawks.

Noise pollution in Chennai, like other urban environments, arises from a range of anthropogenic activities that contribute to a complex and often harmful urban soundscape.

2.2.1 Traffic noise pollution

Among all the sources, traffic is the primary and most significant source of noise pollution (Shalini & Kumar, 2018; Grubesa & Suhanek, 2020), contributing to about 55% of the total noise (Banerjee et al., 2008; Chowdhury, Debsarkar, & Chakrabarty, 2015). In Chennai, traffic noise mainly arises from cars, buses, trucks, motorcycles, and auto-rickshaws. Chennai's growing population, vehicle ownership, congested and

narrow roads, poor traffic management, and widespread honking exacerbate the noise problem. The city's transport network also includes railway lines and metro routes, which add to ambient noise levels, especially in densely populated or commercial areas. Areas like Guindy, T. Nagar, and Anna Nagar have been reported to exhibit the highest traffic-related noise levels.

2.2.2 Industrial noise pollution

Industrial noise is produced due to processes like rotation and reciprocation, or may emerge from other machinery or equipment used for manufacturing processes. The nature and intensity of noise produced depend mainly on the type of industry, the equipment used, the methods adopted, and the manufacturing scale. Traffic pollution is also high in industrial sites where trucks and other heavy vehicles operate frequently (Silva et al., 2021). In Chennai, industrial activities dominate particularly in the northern and western industrial belts like Manali, Ennore, Ambattur, and Sriperumbudur. These areas host several large and small-scale industries, including petrochemical, textile, and automotive manufacturing units. Heavy machinery, compressors, and trucks within and around these industries generate high-intensity noise. Industrial noise pollution affects not only the people working in the industries but also the population in the surrounding residential areas (Silva et al., 2021).

2.2.3 Domestic noise pollution

Domestic and community noise includes everyday household sounds from appliances, loudspeakers, music systems, television sets, radios, air conditioners, and neighborhood activities. In Chennai, dense housing and mixed land use patterns mean that noise from celebrations, religious events, and neighborhood functions often propagates into adjacent areas. Structure-borne noise, such as the movement of furniture and airborne noise from conversations and entertainment systems, further degrades the acoustic comfort in residential areas, affecting people's health and well-being.

2.2.4 Construction noise pollution

Construction noise is ubiquitous in developing urban areas and is characterized by sudden, loud, intermittent sounds arising from various construction and demolition activities. Using cranes, cement mixers, air compressors, bulldozers, loaders,

jackhammers, dump trucks, and pavement breakers contributes to construction noise. Activities like drilling, welding, hammering, boring, excavation, and heavy machinery operations contribute to intense noise levels at construction sites. Rapid urban expansion and infrastructural development have led to significantly high construction noise in Chennai. Ongoing construction of roads, metro lines, high-rise buildings, and commercial complexes generates continuous and intermittent noise from drilling, hammering, and the movement of heavy equipment. Since construction activities vary with time, the noise levels exhibit significant fluctuations, increasing the annoyance and distress caused to the residents. This type of noise, though temporary, has high intensity and severely affects both the nearby residents and the construction workers.

2.2.5 Noise pollution from other miscellaneous sources

Miscellaneous sources such as noise from commercial establishments (shopping malls, markets, and food courts), public utilities (water pumps, garbage collection), and festivals and celebrations play a significant role. Being culturally vibrant, Chennai witnesses high noise levels during events like Diwali and temple festivals due to fireworks, loud music, and public gatherings, often crossing permissible limits and impacting human and animal well-being.

2.3 Scenario of noise pollution in Chennai

Chennai has witnessed consistently high levels of environmental noise, significantly exceeding permissible limits across various parts of the city. Multiple studies have documented these patterns, identifying traffic congestion, densely populated neighbourhoods, and inadequate urban noise control as the primary contributors. All the studies show a consistent trend, where the city's noise environment is dominated by levels well above the regulating agencies' limits.

An early investigation by Dike (2009), based on data from CPCB, revealed that noise levels in 75% of monitoring locations across Chennai exceeded the permissible limit by 12 – 20 dB(A). Noise levels at residential, industrial, and silent zones were found to exceed the CPCB limits. Specific high-traffic areas such as Guindy, Parry's Corner, Adyar, T. Nagar, Velachery, Porur, and Anna Nagar have been identified as hotspots with noise levels ranging from 65 – 86 dB(A) during both peak and non-peak hours, as documented by Akiladevi et al. (2015). The diurnal variation in noise was studied

in detail at the Thiruvannamiyur Junction by Karthik & Partheeban (2015). They observed that noise levels gradually rise from 6:00 am, peaking between 10:00 – 11:00 am and again between 4:00 – 6:00 pm, corresponding with typical traffic peak hours. Levels then gradually decreased in the late evening.

Gajalakshmi et al. (2019) reported alarmingly high noise levels at St. Thomas Mount, with all four measurement points surpassing 80 dB(A), and peaking at 112 dB(A). Further emphasizing the role of traffic, Mahesh (2021) measured sound levels at six major bus stops and found that they consistently exceeded the prescribed limits, averaging 76.8 dB(A). Partheeban et al. (2022) presented a spatial assessment showing that 18.4% of Chennai's area is exposed to noise levels above 60 dB(A), confirming the widespread impact of road traffic noise across the city.

Using CPCB monitoring data from 10 city locations, Rajamanickam & Nagan (2022) reported a broad range of daily L_{eq} (Continuous Equivalent Noise Level) from 30.38 – 92.50 dB(A), indicating both extreme variability and frequent exceedance of limits. A detailed time-based noise survey by Ramachandran, Devadas, & Pillai (2023) at 40 locations recorded mean levels ranging from 58 – 83 dB(A) in the morning, 55 – 84 dB(A) in the afternoon, and 64 – 91 dB(A) in the evening. Lower values were typically observed in park areas, while intersections near traffic signals registered the highest values. Pradeep & Nagendra (2024) noted that urban commuters regularly experience equivalent noise levels ranging between 74 – 85 dB(A), further affirming the intensity of noise exposure during daily commutes.

3. METHODOLOGY

To address the specific study objectives, the methodology has been divided into five stages, namely, (i) Design, development, and validation of sensor-based noise measuring device, (ii) Sensor-based stationary field monitoring, (iii) Characterization of noise levels, (iv) Noise mapping, and (v) Urban noise pollution management framework. Figure 3.1 shows the detailed flowchart representing the research methodology adopted in the present study.

3.1 Design, development, and validation of sensor-based noise measuring device

The first stage of the study focuses on the conceptualization and development of a low-cost, modular noise sensor capable of continuous noise monitoring in urban environments. The design architecture includes four major modules:

1. Sensing module – to measure ambient noise levels in real-time
2. Communication module – to transmit real-time data to a central server
3. Data storage module – to enable storage of data in the central cloud server
4. Visualization module – to enable user-friendly data interpretation through a custom-made dashboard

Following the design, laboratory calibration is carried out for each sensor using a Type 1 Sound Level Meter (SLM) as a reference standard to ensure measurement accuracy. Calibration is performed under controlled acoustic conditions to fine-tune the sensor response. After calibration, the performance of the sensor is validated by comparing its output with both Type 1 and Type 2 SLMs. If the output values fall within acceptable tolerance levels, the sensor is considered validated for field deployment. Otherwise, the sensor undergoes recalibration until the desired level of accuracy is achieved.

The design, development, and validation of sensor-based noise measuring device is described in APPENDIX A.

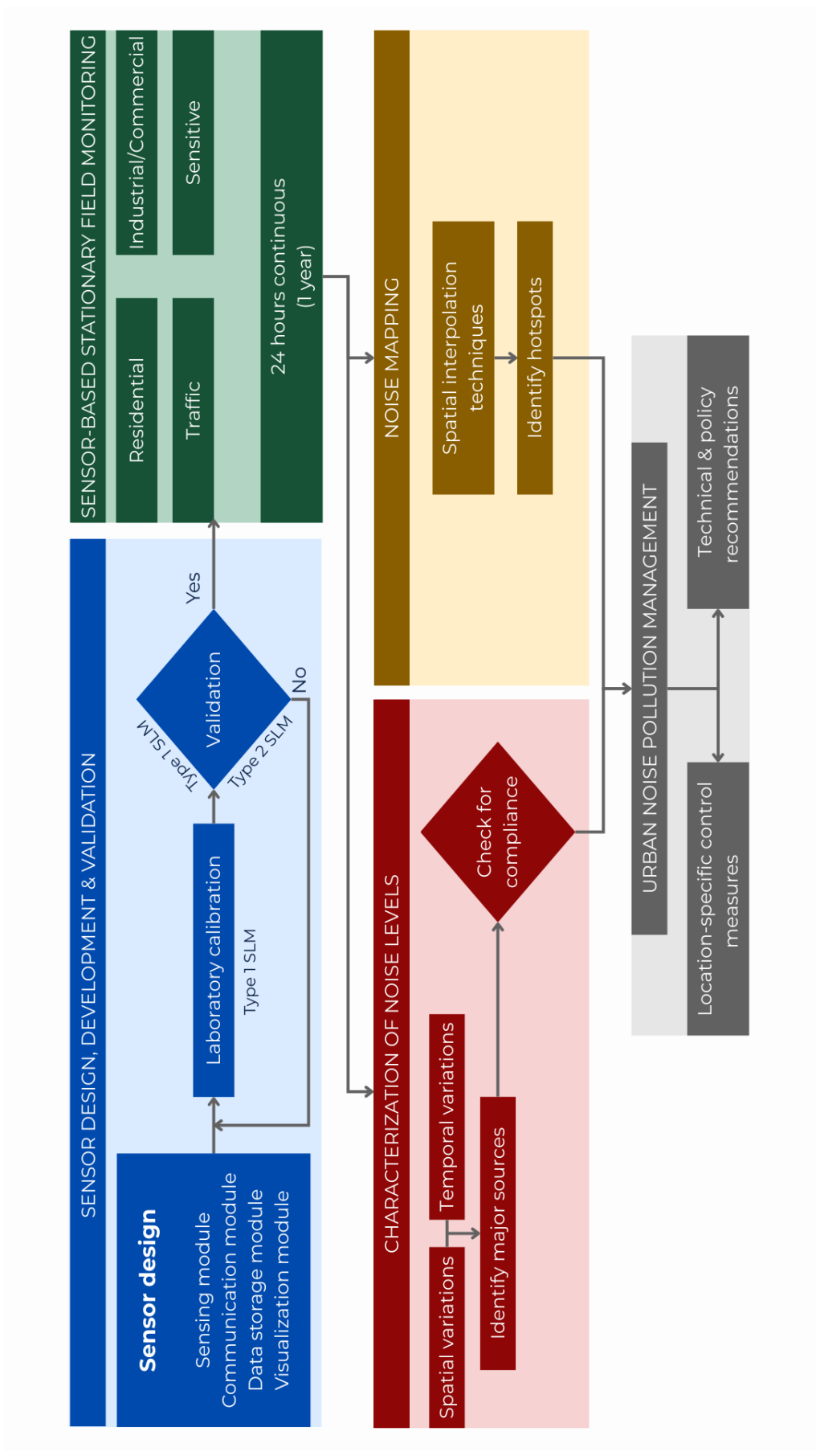


Figure 3.1 Overview of the methodology adopted in the study

3.2 Sensor-based stationary field monitoring

Once validated, the sensors are deployed for stationary, long-term field monitoring across multiple urban land use categories. The study area, Chennai city, is divided into 15 administrative zones. For comprehensive coverage, four representative locations are selected within each zone. These represent the residential, industrial/commercial, traffic, and sensitive areas, resulting in a total of 60 monitoring sites. The monitoring locations were selected based on the availability of a continuous power supply, physical security of the sensors, and accessibility, leading to a preference for locations within government buildings. The sensors installed at these fixed locations operate continuously 24 hours a day for over 1 year, capturing diurnal, weekly, and seasonal noise trends. This phase generates a rich and high-resolution dataset for all subsequent analyses.

3.3 Characterization of noise levels

The third stage involves the characterization of ambient noise in terms of both spatial and temporal variations. Spatial variation analysis helps identify differences in noise exposure across various zones of the city, while temporal analysis reveals patterns based on daily, weekly, and seasonal fluctuations. Such analysis is critical in understanding the dynamics of urban soundscapes. Major noise sources are identified from the variation patterns, which may include vehicular traffic, construction activity, industrial operations, or social events. This is followed by a compliance check, where the observed noise levels are compared with the permissible limits specified by CPCB for each land use category. Locations found to be non-compliant are designated for targeted intervention.

3.4 Noise mapping

In this stage, the noise data is transformed into spatial noise maps using spatial interpolation techniques, specifically the Inverse Distance Weighting (IDW) method, to estimate noise levels at unsampled locations. This approach creates a continuous spatial representation of noise distribution based on the measured data, providing a comprehensive spatial overview of noise exposure levels across the city.

3.5 Urban noise pollution management framework

The final stage of the methodology includes the proposal of noise mitigation measures to reduce the noise levels in urban areas under different scenarios to ensure the least effect on human health. The goal is to formulate evidence-based, location-specific mitigation strategies to minimize noise exposure and protect public health. Based on the spatial and temporal characteristics of noise and the results from mapping and compliance checks, the study proposes a set of technical and policy recommendations. These recommendations aim to ensure that proposed interventions are technically feasible, economically viable, and environmentally sustainable, ultimately minimizing adverse health effects on urban populations. The final stage of the study translates scientific findings into practical solutions by developing an urban noise pollution management framework.

4. SENSOR-BASED STATIONARY FIELD MONITORING

This chapter presents the deployment and operational framework of the sensor-based stationary noise monitoring network established for continuous environmental noise assessment across urban areas. Following the successful design, development, and validation of the low-cost noise sensors, the next step involved their strategic installation at fixed locations to enable uninterrupted, long-term noise data collection. The primary aim of this phase is to generate high-resolution spatiotemporal datasets that reflect real-world urban noise conditions across different land use categories. The data collected in this phase forms the foundation for subsequent noise characterization, mapping, and management interventions, which are discussed further in this report.

4.1 Selection of noise monitoring locations

The Corporation of Chennai divides the city into 15 administrative zones. To ensure comprehensive representation of the city's acoustic environment, a total of 60 monitoring locations were carefully selected (four locations per zone) for deploying custom-made low-cost noise sensor units. Each location falls under one of the following land use categories:

1. Residential
2. Commercial/Industrial
3. Traffic
4. Sensitive

These sites were monitored continuously for one year, capturing both daytime (06:00 to 22:00 hours) and nighttime (22:00 to 06:00 hours) noise levels. Table 4.1 shows the noise monitoring location details in each zone.

Table 4.1 Noise monitoring locations

Zone No.	Zone name	Category	Location	Latitude	Longitude
Zone I	Thiruvotriyur	Residential	Division Office - 1, Ennore	13.22274	80.32473
		Industrial	Corporation Ward Office - 4 - Thiruvotriyur (Jothi Nagar)	13.18173	80.29882
		Traffic	Corporation Office - Zone 1 - Thiruvotriyur	13.15635	80.30193
		Sensitive	Urban Primary Health Center, Sathangadu	13.15318	80.29522
Zone II	Manali	Residential	Urban Primary Health Center, Edayanchavadi	13.20799	80.27426
		Industrial	Division Office - 17 - Vadaperumbakkam	13.17718	80.21780
		Traffic	Urban Primary Health Center, Manali	13.16865	80.25783
		Sensitive	Govt. HSS, Periya Thoppu, Manali	13.16589	80.25732
Zone III	Madhavaram	Residential	Sanitary Inspector Office, Surapet	13.14275	80.19113
		Industrial	Urban Primary Health Center, Kannabiran	13.14257	80.23254
		Traffic	Corporation Ward Office - 25 - Madhavaram (MRH road)	13.15254	80.22812
		Sensitive	Urban Primary Health Center, Puzhal	13.16497	80.20479
Zone IV	Tondiarpet	Residential	Corporation Ward Office - 34	13.14458	80.24309
		Industrial	Manual AQM station, Kodungaiyur	13.12787	80.26245
		Traffic	Corporation Office - Zone 4 - Tondiarpet	13.12095	80.28618
		Sensitive	Urban Primary Health Center, Vyasarpadi	13.12296	80.25174
Zone V	Royapuram	Residential	Division Office - 63 - Egmore	13.07054	80.26502
		Industrial	Manual AQM station, Old Washermanpet	13.10438	80.29074
		Traffic	Chennai Metropolitan Transport Corporation Limited, Park Town	13.07404	80.27598
		Sensitive	Rajiv Gandhi Government General Hospital	13.08175	80.27808

Zone No.	Zone name	Category	Location	Latitude	Longitude
Zone VI	Thiru-vi-ka nagar	Residential	Govt. E-service Centre (Ward 64), Kolathur	13.12216	80.22060
		Commercial	Corporation Office - Zone 6 - Thiru-vi-ka nagar	13.09824	80.25683
		Traffic	Division Office -71 - Perambur	13.11113	80.24802
		Sensitive	Urban Primary Health Centre, Kolathur	13.11943	80.20646
Zone VII	Ambattur	Residential	TNPCB, Ambattur DE Office	13.08867	80.17526
		Industrial	Corporation Office - Zone 7 - Ambattur	13.10648	80.15295
		Traffic	Division Office - 79	13.12349	80.14708
		Sensitive	Urban Primary Health Centre, TMP Nagar, Padi	13.09503	80.17834
Zone VIII	Anna Nagar	Residential	Corporation Zonal Office, Kilpauk	13.08026	80.23491
		Commercial	Government E-service center, Anna Nagar	13.09391	80.19990
		Traffic	Division Office - 94 - E-Sevai Maiyam, Villivakkam	13.10472	80.20082
		Sensitive	Urban Primary Health Center, Ayanavaram	13.09880	80.23028
Zone IX	Teynampet	Residential	Corporation Office - Zone 9 - Teynampet	13.05508	80.23928
		Commercial	Corporation Ward Office - 125 - Mylapore	13.03480	80.27201
		Traffic	Division Office - 111 - Thousand Lights	13.05489	80.25277
		Sensitive	Urban Primary Health Center, Llyold's colony, Triplicane	13.05083	80.27235
Zone X	Kodambakkam	Residential	Division Office - 137 - K K Nagar	13.04286	80.19547
		Commercial	Corporation Office (Division 136), T Nagar	13.03956	80.23817
		Traffic	Corporation Office - Zone 10 - Kodambakkam	13.05181	80.21954
		Sensitive	Urban Primary Health Center, Vadapalani	13.05384	80.20921

Zone No.	Zone name	Category	Location	Latitude	Longitude
Zone XI	Valasaravakkam	Residential	Urban Primary Health Centre, Ramapuram	13.03018	80.17945
		Commercial	Corporation Office - Zone 11 - Valasaravakkam	13.04096	80.17225
		Traffic	Urban Primary Health Centre, Maduravoyal	13.06306	80.16644
		Sensitive	Urban Primary Health Centre, Nerkundram	13.05510	80.18471
Zone XII	Alandur	Residential	Corporation Ward Office - 167 - Nanganallur	12.97843	80.18592
		Commercial	Corporation Ward Office - 156 - Mugalivakkam	13.02099	80.16707
		Traffic	Urban Primary Health Centre (160), Alandur	13.00178	80.20316
		Sensitive	Urban Primary Health Centre (159), Pazhavanthangal	12.98819	80.18944
Zone XIII	Adyar	Residential	Division Office - 176 - Shastri Nagar, Besant Nagar	12.99784	80.26142
		Industrial	Tamil Nadu Pollution Control Board, Anna Salai, Guindy	13.01194	80.21910
		Traffic	Velachery Gate, IIT Madras	12.98790	80.22314
		Sensitive	B.M. Birla Planetarium, Kotturpuram	13.01203	80.24402
Zone XIV	Perungudi	Residential	Corporation Office - Zone 14 - Perungudi	12.97233	80.19366
		Commercial	Apollo Speciality Hospital, OMR, Perungudi	12.96314	80.24600
		Traffic	Corporation Ward Office - 190 - Pallikaranai	12.93103	80.20265
		Sensitive	National Institute of Wind Energy, Pallikaranai	12.95656	80.21521
Zone XV	Sholinganallur	Residential	CAAQM station, Perungudi	12.95336	80.23579
		Commercial	Govt. E-service Centre (Ward 194), Thoraipakkam	12.93422	80.23328
		Traffic	Corporation Office - Zone 15 - Sholinganallur	12.89608	80.22735
		Sensitive	Urban Primary Health Centre, Semmancheri	12.87529	80.21047

4.2 Criteria for selection of location

The selection of these locations followed a multi-criteria approach with the objective of ensuring spatial representativeness, sensor security, and data quality. The site selection criteria are described below:

- **Land use categories:** The monitoring locations were chosen to capture each zone's dominant land use types. Locations were categorized into five major types: residential, commercial, industrial, traffic, and sensitive areas (such as hospitals, public health centers, schools, and other educational institutions). The primary objective was to ensure that the chosen sites adequately represented the variety of land use patterns across the city and reflected the diverse sources of noise pollution typical of each zone.
- **Spatial coverage:** To ensure equitable distribution and comprehensive coverage, each of the 15 zones of Chennai Corporation was represented by four sites. These were distributed geographically to cover different parts of the city, enabling spatial analysis of noise trends.
- **Safety of the instrument:** Considering the need for long-term deployment and continuous data acquisition, sensor units were installed in secure public buildings. These included government offices, corporation buildings, urban primary health centers (UPHCs), educational institutions, and scientific facilities such as the planetarium. These locations were chosen to minimize the risk of vandalism or tampering, ensure regular power supply, and facilitate maintenance access.
- **Suitable infrastructure:** Selected sites had to meet practical requirements like access to uninterrupted electricity supply, availability of open space for mounting sensors at appropriate heights, and minimal obstruction from nearby reflective or noise-absorbing structures. This ensured the accuracy and consistency of recorded data.
- **Inclusion of vulnerable population:** Approximately 32% of the selected monitoring locations are in close proximity to medical facilities, including 17 Urban Primary Health Centers (UPHCs), one medical college, and one private hospital. This is crucial for evaluating the impact of urban noise on sensitive populations and identifying necessary interventions in designated silent zones.

Further, many selected sites are located in high-traffic and densely populated areas, identified as urban noise hotspots due to increasing population, vehicular congestion, commercial activities, and infrastructure development. These areas are prone to severe noise pollution, making them critical for monitoring.

A map showing the spatial distribution of all 60 monitoring locations across Chennai is provided in Figure 4.1. The location details in each zone along with geo-tagged photographs, are given in APPENDIX B. The description of the noise monitoring locations are given in APPENDIX C.

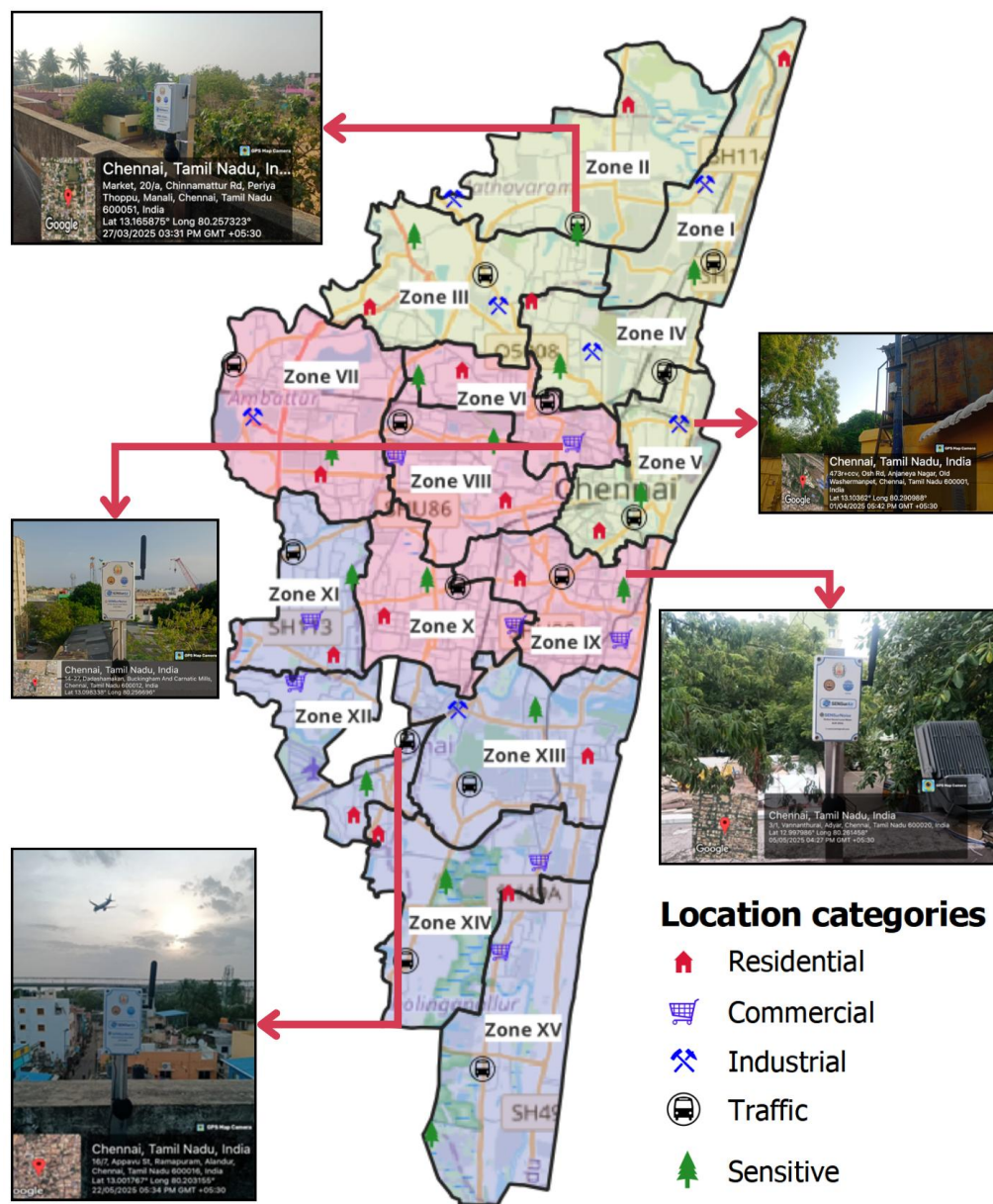


Figure 4.1 Noise monitoring locations

5. CHARACTERIZATION OF NOISE LEVELS

Effective noise management begins with a thorough understanding of the existing soundscape across space and time. The data collected from field monitoring using the low-cost sensor network is used to characterize spatial and temporal variations in urban noise. Characterization is essential to identify patterns, quantify variability, evaluate compliance with regulatory standards, and determine the impact of environmental noise on public health and urban livability. The analysis provides crucial insights into the spatial and temporal behaviour of noise pollution, enabling targeted mitigation strategies and effective policy interventions.

Spatial variation analysis involves assessing the differences in noise levels across various monitoring locations representing residential, industrial/commercial, traffic, and sensitive land use types. By comparing noise levels from multiple zones and locations, it becomes possible to identify high-exposure areas or hotspots, such as zones near major roads, construction sites, or high-traffic intersections. Spatial characterization helps link noise levels to surrounding land uses, activities, and population densities, laying the groundwork for location-specific interventions. Spatial fluctuations are assessed based on the following parameters.

Temporal characterization evaluates how noise levels change over time, providing insights into usage patterns, behavioural trends, and event-specific fluctuations. Analyzing hourly and weekly variations helps identify critical time windows and trends that reveal links between noise levels and human activity patterns. To visualize temporal trends clearly, heat maps are generated showing daytime versus nighttime noise levels across monitoring locations. Heat maps use colour gradients to represent intensity, helping quickly identify high-noise periods or anomalies. These maps provide a clear spatio-temporal understanding of how noise patterns evolve through the day and across the study area. Calendar plots are used to display month-wise noise level trends in a visually intuitive format. Each day is color-coded based on the average L_{eq} level, allowing detection of long-term trends, seasonal effects, and irregular events. Month-wise analysis reveals how noise levels evolve over time, potentially influenced by climate, festivals, traffic variations, or construction cycles.

5.1 Statistical summary

A statistical summary of the noise data is used to evaluate the overall quality and reliability of the dataset. Parameters such as percentage of missing data, L_{eq} (Continuous Equivalent Noise Level), maximum, and minimum values are computed for each location. The percentage of missing data reflects the completeness of the dataset, which is important for robust analysis. The L_{eq} represents the average energy-equivalent sound level over a specified measurement period and serves as a fundamental metric for noise impact assessment. It may be defined as the constant noise level that contains the same total energy as the actual fluctuating noise over a given time period. It simplifies complex noise environments into a single representative value, making it useful for environmental assessments, health impact studies, and regulatory comparisons. Table 5.1 and Table 5.2 provide a description of the noise pollution parameters and indices used to describe the characteristics of noise pollution at a particular location. These indices offer deeper insight into noise behaviour to assess how fluctuations and extremes influence the overall perception and impact of noise.

Table 5.1 Description of noise pollution parameters

Noise pollution parameters	
Percentile noise levels are used to capture the fluctuating nature of environmental noise. These include L_{10} , L_{50} , and L_{90} , which represent the noise levels exceeded for 10%, 50%, and 90% of the measurement time, respectively.	
L_{10}	It indicates the higher end of noise levels and is generally associated with peak events, such as passing vehicles, honking, or industrial blasts. It is often used to represent noise-dominated environments.
L_{50}	It represents the median noise level or the midpoint value in a fluctuating noise environment. It provides a balanced representation of general conditions.
L_{90}	It reflects the background or ambient noise level, which is exceeded 90% of the time. It is helpful in identifying background noise and understanding the baseline quietness of an area.
In general, in any ambient environment, $L_{10} > L_{50} > L_{90}$, demonstrating the presence of frequent high-noise events amidst quieter periods.	

Table 5.2 Description of noise pollution indices (Swain & Goswami, 2013)

Noise pollution indices	
Noise Climate (NC)	NC is defined as the difference between L₁₀ and L₉₀. It represents the range of fluctuations in noise levels over time. Higher NC values indicate greater variability and more unpredictable noise environments. It is given as: $NC = L_{10} - L_{90} \quad (5.1)$
Noise Pollution Level (L_{np})	L_{np} combines L_{eq} and NC using the formula: $L_{np} = L_{eq} + NC \quad (5.2)$ This index reflects both the energy content and the degree of fluctuation, making it a comprehensive indicator of physiological and psychological noise impacts.
Traffic Noise Index (TNI)	TNI is designed to represent annoyance due to traffic noise and is calculated as: $TNI = 4NC + L_{90} - 30 \quad (5.3)$ It is beneficial for evaluating traffic-intensive environments and understanding public dissatisfaction thresholds. 74 dB(A) is considered the threshold limit and causes less than 3% dissatisfaction.

The statistical summary of noise measurements revealed substantial spatial and temporal variability across the monitoring network. Table 5.3 and Table 5.4 provide the statistical summary of measurements for day (6.00 a.m. to 10.00 p.m.) and night (10.00 p.m. to 6.00 a.m.) time, respectively.

All stations have less than 30% missing data, except three: Zone7_I, Zone13_I and Zone13_T, for day and night. The equivalent noise levels (L_{eq}) consistently exceeded the CPCB-prescribed limits in several residential and sensitive zones. Traffic location recorded the highest levels, with 75.10 dB(A) during day and 73.67 dB(A) during night at Zone11_T. These results confirm that road traffic is the dominant noise source shaping Chennai's urban soundscape. The lowest levels during day was recorded in Zone14_R (59.73 dB(A)) and during night, the lowest levels were recorded in Zone12_C (54.49 dB(A)).

Statistical noise parameters like L_{10} , and L_{50} were maximum at Zone11_T during day and night. L_{90} which represents the background noise level was found to be maximum at Zone7_I during day and Zone5_S during night. During both day and night, the lowest value for L_{10} was observed at Zone10_C, while L_{50} had lowest values at Zone13_S. The lowest value for L_{90} was observed at Zone13_S during day and Zone2_R during night.

Parameters such as NC and TNI further reinforce the presence of unstable, traffic-dominated noise environments. NC, which represents the fluctuations in noise levels varies from 2.43 dB(A) (Zone10_C) to 22.22 dB(A) (Zone14_C) during day and from 1.52 dB(A) (Zone10_C) to 21.13 dB(A) (Zone1_S) during night. NC values frequently exceeded 10 dB(A) during night, indicating highly unstable environments with large fluctuations between background and peak levels during these times. During day, TNI values exceeded the threshold limit of 74 dB(A) in 7 monitoring sites including silence, commercial and industrial areas. During night, the threshold was exceeded at 13 locations majorly in residential and silence areas, emphasizing the effect of traffic related noise on these locations even during night.

The monthwise statistical summary of noise levels and other noise pollution parameters and indices are given in APPENDIX D.

Table 5.3 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices – Day

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Residential	Zone1_R	7.65	63.44	109.30	30.00	62.11	59.06	56.95	5.16	68.60	47.59
	Industrial	Zone1_I	11.29	64.60	106.50	33.00	65.75	64.29	62.49	3.26	67.86	45.53
	Traffic	Zone1_T	11.49	60.69	99.60	44.60	62.64	59.64	55.59	7.05	67.74	53.79
	Sensitive	Zone1_S	8.05	68.24	114.60	39.40	70.33	64.63	58.56	11.77	80.01	75.63
Zone II	Residential	Zone2_R	8.03	61.09	107.60	38.80	62.26	58.80	54.72	7.54	68.63	54.89
	Industrial	Zone2_I	8.25	69.47	114.40	39.40	65.24	62.48	59.14	6.10	75.57	53.54
	Traffic	Zone2_T	13.39	68.31	116.50	30.00	70.23	65.92	63.26	6.97	75.28	61.15
	Sensitive	Zone2_S	21.37	67.28	101.85	48.22	71.05	56.84	50.36	20.69	87.97	103.12
Zone III	Residential	Zone3_R	7.46	72.56	112.80	39.80	70.09	64.02	61.48	8.61	81.17	65.90
	Industrial	Zone3_I	8.69	68.24	116.00	39.50	69.71	64.85	60.21	9.50	77.74	68.21
	Traffic	Zone3_T	7.11	72.23	118.20	49.10	72.76	70.36	67.91	4.85	77.09	57.32
	Sensitive	Zone3_S	0.07	61.22	107.10	40.30	62.25	60.09	57.82	4.43	65.65	45.54
Zone IV	Residential	Zone4_R	7.70	61.59	113.10	35.10	61.82	59.23	56.51	5.31	66.90	47.75
	Industrial	Zone4_I	29.25	66.89	100.93	30.03	63.78	53.37	47.97	15.81	82.69	81.21
	Traffic	Zone4_T	7.69	70.45	112.70	44.80	71.79	70.09	67.63	4.16	74.61	54.26
	Sensitive	Zone4_S	14.14	69.47	115.40	42.70	71.19	64.45	61.70	9.49	78.96	69.66
Zone V	Residential	Zone5_R	7.44	63.74	105.30	40.10	67.46	59.42	56.48	10.98	74.72	70.39
	Industrial	Zone5_I	10.61	65.30	100.98	44.65	68.08	64.34	59.32	8.76	74.06	64.37
	Traffic	Zone5_T	8.07	68.25	103.60	30.50	69.51	68.32	65.92	3.59	71.84	50.28
	Sensitive	Zone5_S	6.22	71.03	101.10	58.40	72.64	70.83	68.69	3.95	74.98	54.49

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VI	Residential	Zone6_R	8.57	69.84	115.10	38.90	72.10	67.96	64.96	7.14	76.97	63.50
	Commercial	Zone6_C	7.71	61.63	105.90	41.30	63.82	59.87	55.50	8.32	69.95	58.78
	Traffic	Zone6_T	20.31	63.41	106.80	38.90	63.61	61.64	60.10	3.51	66.92	44.14
	Sensitive	Zone6_S	13.74	60.10	104.20	40.90	60.76	56.71	53.07	7.69	67.79	53.85
Zone VII	Residential	Zone7_R	15.67	66.49	102.20	30.00	67.57	66.16	64.44	3.13	69.62	46.97
	Industrial	Zone7_I	33.14	71.16	105.00	49.20	72.80	70.75	68.71	4.08	75.24	55.04
	Traffic	Zone7_T	8.12	61.47	110.70	38.60	62.32	60.24	58.39	3.93	65.40	44.11
	Sensitive	Zone7_S	11.06	67.54	104.10	39.60	69.98	66.20	62.20	7.78	75.31	63.31
Zone VIII	Residential	Zone8_R	10.83	61.49	96.70	31.50	64.61	59.20	55.92	8.69	70.18	60.68
	Commercial	Zone8_C	20.08	61.71	98.20	30.60	63.83	56.64	52.68	11.15	72.86	67.28
	Traffic	Zone8_T	8.85	72.68	117.20	47.20	72.89	70.16	67.90	4.99	77.66	57.85
	Sensitive	Zone8_S	9.05	69.20	114.60	30.00	71.45	68.27	64.78	6.67	75.87	61.46
Zone IX	Residential	Zone9_R	9.46	63.60	105.60	43.50	66.37	62.08	57.82	8.55	72.16	62.03
	Commercial	Zone9_C	15.35	66.37	115.70	35.30	66.80	64.64	61.33	5.47	71.84	53.21
	Traffic	Zone9_T	6.54	69.04	112.80	47.80	70.48	68.89	65.85	4.63	73.67	54.37
	Sensitive	Zone9_S	15.83	63.09	112.20	41.90	62.89	60.62	58.62	4.27	67.36	45.71
Zone X	Residential	Zone10_R	8.46	66.83	97.20	38.70	67.48	61.98	57.88	9.60	76.43	66.28
	Commercial	Zone10_C	16.45	64.52	101.24	44.97	51.12	49.25	48.69	2.43	66.95	28.41
	Traffic	Zone10_T	14.83	70.32	105.50	36.50	72.23	69.63	67.10	5.13	75.46	57.63
	Sensitive	Zone10_S	17.45	70.21	116.10	40.60	69.49	64.45	61.20	8.29	78.50	64.36

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XI	Residential	Zone11_R	12.29	70.38	110.00	46.80	70.54	68.04	64.73	5.81	76.18	57.96
	Commercial	Zone11_C	6.68	69.78	108.40	30.00	71.13	68.31	65.85	5.28	75.06	56.97
	Traffic	Zone11_T	8.77	75.10	115.50	37.20	76.97	75.31	64.33	12.64	87.74	84.88
	Sensitive	Zone11_S	9.67	64.25	113.00	38.20	65.90	62.02	58.94	6.96	71.21	56.77
Zone XII	Residential	Zone12_R	5.94	67.19	109.00	31.60	68.78	66.09	62.88	5.90	73.09	56.49
	Commercial	Zone12_C	19.59	60.02	107.50	39.50	60.63	56.85	53.91	6.72	66.74	50.81
	Traffic	Zone12_T	7.12	65.43	107.20	31.70	67.33	64.86	61.50	5.83	71.26	54.83
	Sensitive	Zone12_S	14.05	63.68	107.60	40.80	63.02	57.77	54.62	8.40	72.07	58.20
Zone XIII	Residential	Zone13_R	17.48	62.97	99.70	44.90	65.47	61.53	57.13	8.34	71.31	60.49
	Industrial	Zone13_I	42.11	61.36	99.09	30.03	63.96	60.42	56.27	7.69	69.05	57.04
	Traffic	Zone13_T	43.75	66.63	100.20	30.03	69.23	65.76	62.04	7.19	73.82	60.80
	Sensitive	Zone13_S	22.09	60.90	101.26	30.03	53.88	48.19	46.57	7.31	68.21	45.81
Zone XIV	Residential	Zone14_R	7.02	59.73	105.80	31.00	60.22	55.43	52.04	8.18	67.91	54.75
	Commercial	Zone14_C	11.77	68.11	100.09	47.92	70.91	60.24	48.69	22.22	90.33	107.57
	Traffic	Zone14_T	7.80	66.07	109.00	50.60	67.02	65.49	64.37	2.64	68.71	44.94
	Sensitive	Zone14_S	9.78	67.27	102.22	42.62	71.35	59.84	50.51	20.84	88.11	103.87
Zone XV	Residential	Zone15_R	5.89	66.87	101.18	48.97	68.16	58.17	51.82	16.34	83.21	87.18
	Commercial	Zone15_C	9.43	67.88	109.90	48.60	69.08	67.48	66.12	2.96	70.84	47.96
	Traffic	Zone15_T	17.12	68.56	107.30	47.90	70.41	67.52	65.80	4.61	73.17	54.23
	Sensitive	Zone15_S	6.54	61.53	112.00	30.00	62.44	59.74	57.96	4.48	66.01	45.88

Table 5.4 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices – Night

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Residential	Zone1_R	7.74	57.08	101.30	30.00	58.54	53.45	48.90	9.64	66.72	57.45
	Industrial	Zone1_I	11.57	61.91	102.60	33.00	63.47	61.62	59.23	4.24	66.15	46.19
	Traffic	Zone1_T	11.20	55.48	103.90	38.70	58.13	52.35	48.31	9.83	65.30	57.61
	Sensitive	Zone1_S	7.77	68.97	114.50	35.80	72.26	60.20	51.13	21.13	90.10	105.64
Zone II	Residential	Zone2_R	7.74	56.43	105.70	32.90	57.00	50.21	45.48	11.52	67.96	61.57
	Industrial	Zone2_I	8.31	59.24	105.60	34.10	57.79	53.54	49.78	8.02	67.26	51.84
	Traffic	Zone2_T	13.20	61.41	100.50	30.00	63.91	56.36	51.20	12.71	74.12	72.03
	Sensitive	Zone2_S	21.11	64.27	102.33	48.18	64.31	50.52	49.20	15.11	79.38	79.64
Zone III	Residential	Zone3_R	8.08	62.23	110.90	34.20	59.80	54.91	49.81	9.99	72.22	59.75
	Industrial	Zone3_I	8.54	65.62	113.60	37.10	64.13	56.67	50.22	13.90	79.52	75.84
	Traffic	Zone3_T	6.95	67.56	107.60	36.50	68.49	62.15	57.44	11.05	78.62	71.65
	Sensitive	Zone3_S	0.00	56.15	106.90	32.60	58.42	53.66	48.80	9.62	65.77	57.27
Zone IV	Residential	Zone4_R	7.53	59.20	109.10	30.40	59.20	53.59	47.98	11.22	70.42	62.88
	Industrial	Zone4_I	31.22	69.50	99.94	30.28	58.58	49.01	47.54	11.04	80.55	61.71
	Traffic	Zone4_T	7.67	63.38	105.70	35.60	67.01	60.80	56.90	10.11	73.49	67.34
	Sensitive	Zone4_S	13.79	62.04	105.90	36.10	61.94	55.39	48.38	13.56	75.60	72.62
Zone V	Residential	Zone5_R	6.94	60.22	103.60	34.80	65.48	53.10	47.34	18.14	78.35	89.89
	Industrial	Zone5_I	9.67	57.84	98.21	43.53	61.75	55.15	51.65	10.10	67.94	62.05
	Traffic	Zone5_T	8.37	63.82	100.50	30.00	66.59	62.78	59.87	6.71	70.53	56.72
	Sensitive	Zone5_S	5.87	65.29	91.60	46.10	67.88	64.34	61.22	6.66	71.94	57.86

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VI	Residential	Zone6_R	8.27	69.56	107.00	34.70	73.60	63.45	54.24	19.36	88.92	101.68
	Commercial	Zone6_C	8.04	59.77	106.70	37.70	61.57	57.10	50.68	10.88	70.65	64.21
	Traffic	Zone6_T	19.95	56.95	98.30	34.40	59.79	54.75	49.22	10.57	67.52	61.49
	Sensitive	Zone6_S	13.89	54.93	99.50	35.60	55.38	50.34	46.24	9.14	64.07	52.80
Zone VII	Residential	Zone7_R	14.90	62.36	91.60	42.70	64.45	61.56	59.30	5.15	67.51	49.91
	Industrial	Zone7_I	32.50	65.33	103.90	36.90	67.81	64.42	61.17	6.64	71.97	57.73
	Traffic	Zone7_T	7.97	57.01	106.30	33.20	59.53	54.62	49.69	9.84	66.85	59.05
	Sensitive	Zone7_S	11.46	63.03	105.10	36.60	64.02	57.93	52.63	11.39	74.42	68.18
Zone VIII	Residential	Zone8_R	11.42	60.31	93.10	30.80	64.42	55.29	48.13	16.29	76.60	83.29
	Commercial	Zone8_C	22.00	56.15	96.00	31.30	59.48	51.58	48.35	11.13	67.28	62.87
	Traffic	Zone8_T	8.46	67.26	115.80	42.40	69.23	62.46	58.35	10.88	78.14	71.87
	Sensitive	Zone8_S	8.48	64.13	108.30	30.00	67.59	59.49	52.96	14.63	78.76	81.48
Zone IX	Residential	Zone9_R	8.77	59.84	93.40	37.00	63.72	54.09	47.84	15.87	75.71	81.34
	Commercial	Zone9_C	14.61	59.75	97.70	35.20	61.75	57.85	52.72	9.03	68.78	58.84
	Traffic	Zone9_T	6.54	62.57	100.10	42.20	65.96	60.63	56.88	9.08	71.65	63.19
	Sensitive	Zone9_S	15.65	56.83	104.40	37.00	58.88	54.48	49.50	9.38	66.20	57.01
Zone X	Residential	Zone10_R	8.46	58.43	97.90	37.80	59.03	51.54	47.48	11.55	69.98	63.66
	Commercial	Zone10_C	16.40	59.43	101.26	44.93	49.92	48.76	48.40	1.52	60.95	24.48
	Traffic	Zone10_T	14.80	64.94	109.90	43.40	67.68	62.73	58.15	9.53	74.47	66.26
	Sensitive	Zone10_S	17.10	64.36	110.70	35.80	64.72	57.27	50.22	14.50	78.86	78.22

Zone No.	Category	Station ID	% missing data	L _{req} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XI	Residential	Zone11_R	11.82	61.95	109.90	41.60	63.52	57.88	53.23	10.29	72.24	64.39
	Commercial	Zone11_C	6.67	65.16	109.00	30.00	67.79	64.12	59.28	8.51	73.67	63.32
	Traffic	Zone11_T	7.91	73.67	116.50	37.40	76.31	74.21	55.51	20.80	94.47	108.71
	Sensitive	Zone11_S	9.52	57.36	103.70	33.70	58.77	53.70	48.60	10.17	67.52	59.27
Zone XII	Residential	Zone12_R	5.65	59.02	108.20	31.10	61.39	55.78	50.16	11.23	70.25	65.07
	Commercial	Zone12_C	19.03	54.49	99.80	34.20	57.83	51.48	47.05	10.78	65.27	60.17
	Traffic	Zone12_T	6.34	64.38	124.90	31.20	66.37	63.46	60.16	6.21	70.59	55.00
	Sensitive	Zone12_S	12.66	58.22	107.80	36.10	58.02	52.03	47.23	10.79	69.01	60.37
Zone XIII	Residential	Zone13_R	22.23	56.73	93.10	37.60	58.98	51.24	46.77	12.21	68.94	65.59
	Industrial	Zone13_I	52.52	57.42	97.80	30.03	60.02	54.42	51.07	8.95	66.37	56.88
	Traffic	Zone13_T	93.81	60.42	96.91	30.03	63.85	58.15	48.52	15.33	75.75	79.85
	Sensitive	Zone13_S	22.61	58.60	101.29	30.03	50.25	47.17	46.18	4.07	62.67	32.46
Zone XIV	Residential	Zone14_R	6.58	57.53	101.10	31.20	55.23	50.26	47.05	8.18	65.72	49.79
	Commercial	Zone14_C	11.72	63.13	98.14	47.82	60.48	52.19	48.58	11.90	75.03	66.16
	Traffic	Zone14_T	7.25	63.05	106.10	39.90	64.64	62.27	59.87	4.77	67.82	48.95
	Sensitive	Zone14_S	9.33	63.21	100.66	42.86	61.86	49.71	46.85	15.01	78.22	76.89
Zone XV	Residential	Zone15_R	5.78	67.36	101.28	47.43	67.10	51.13	49.93	17.17	84.53	88.61
	Commercial	Zone15_C	9.35	63.88	97.70	41.90	66.05	63.33	60.86	5.19	69.07	51.62
	Traffic	Zone15_T	16.84	65.64	102.70	40.80	67.75	63.36	60.28	7.47	73.11	60.16
	Sensitive	Zone15_S	6.16	56.42	101.50	30.00	57.97	53.59	48.73	9.25	65.67	55.71

5.2 Comparison among locations

Box plots are employed to compare noise levels across multiple locations and zones. The comparison of noise levels across monitoring locations highlighted clear spatial variability in the city's acoustic environment (Figure 5.1, Figure 5.2 and Figure 5.3). The highest recorded noise level was observed at Zone11_T (Urban Primary Health Centre, Maduravoyal), reflecting the influence of heavy traffic and the frequent presence of heavy-duty vehicles. The lowest level was measured at Zone14_R during day and at Zone12_C during night. Overall, noise levels at 46 locations during day and 52 locations during night exceeded the CPCB permissible limits, with 100% of residential and sensitive locations recording values above their respective threshold limits during day and 100% of residential, traffic and sensitive locations with values above their respective threshold limits during night. Furthermore, 43% of the monitoring sites exhibited noise levels in the range of 65 – 70 dB(A) during day, illustrating that the majority of Chennai's urban areas are persistently exposed to moderate to high noise levels. During night, 40% of the monitoring sites exhibited noise levels in the range of 55 – 60 dB(A). The box plot analysis thus provides a clear visualization of both the extremes and the concentration of noise values across zones.

The monthwise comparison of noise levels across monitoring locations are given in APPENDIX D.

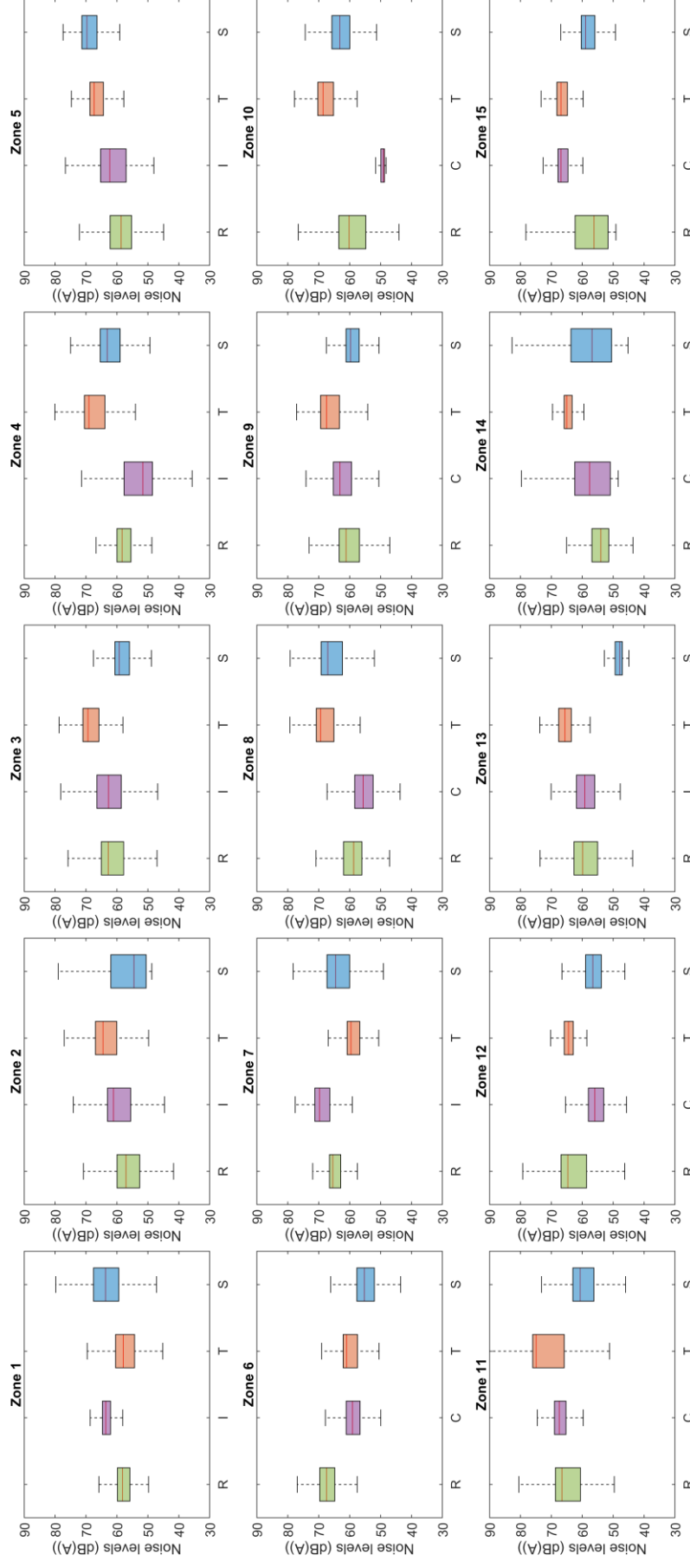


Figure 5.1 Box plot showing variations in noise levels

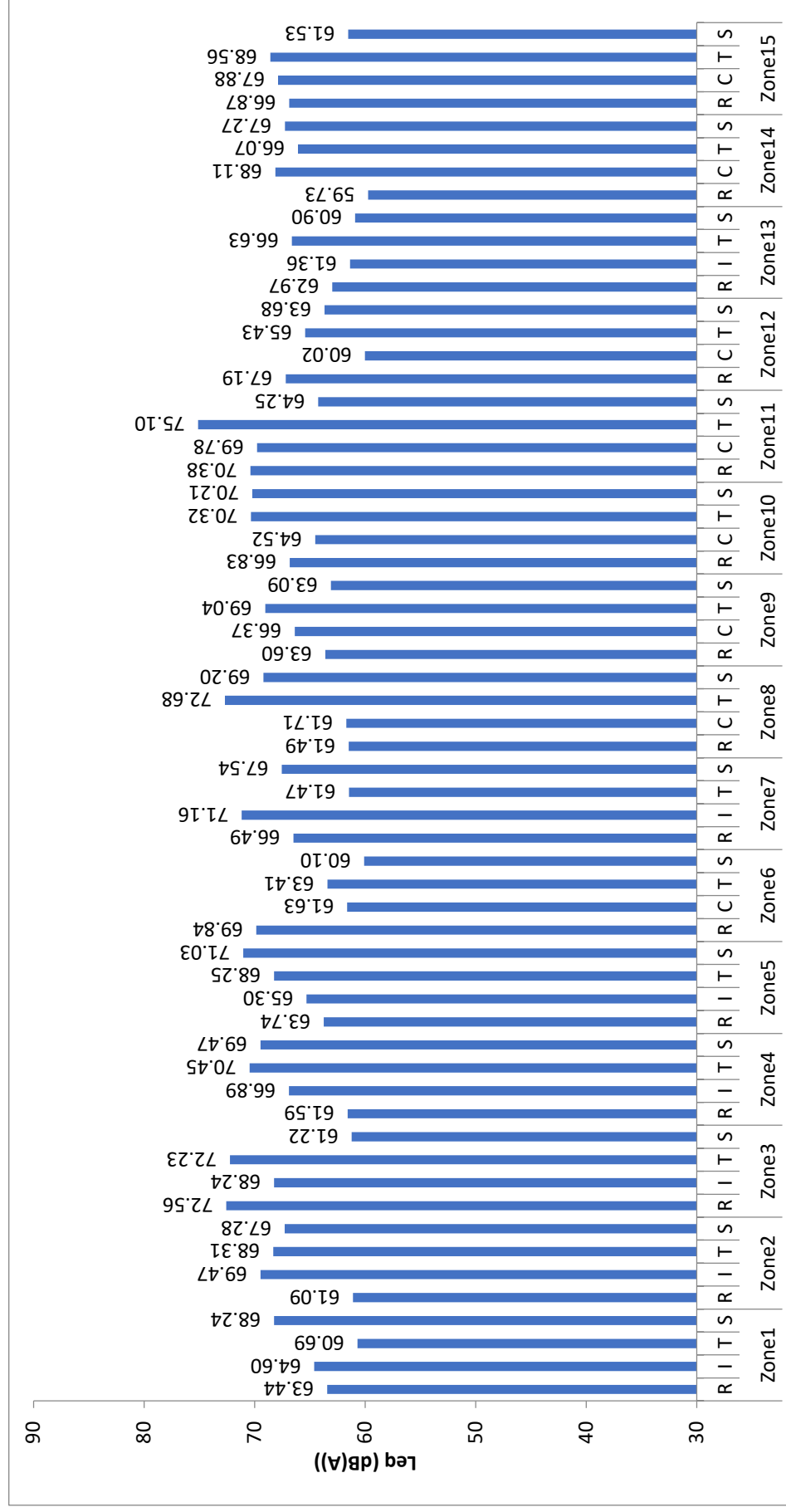


Figure 5.2 Comparison of noise levels across all the zones – Day

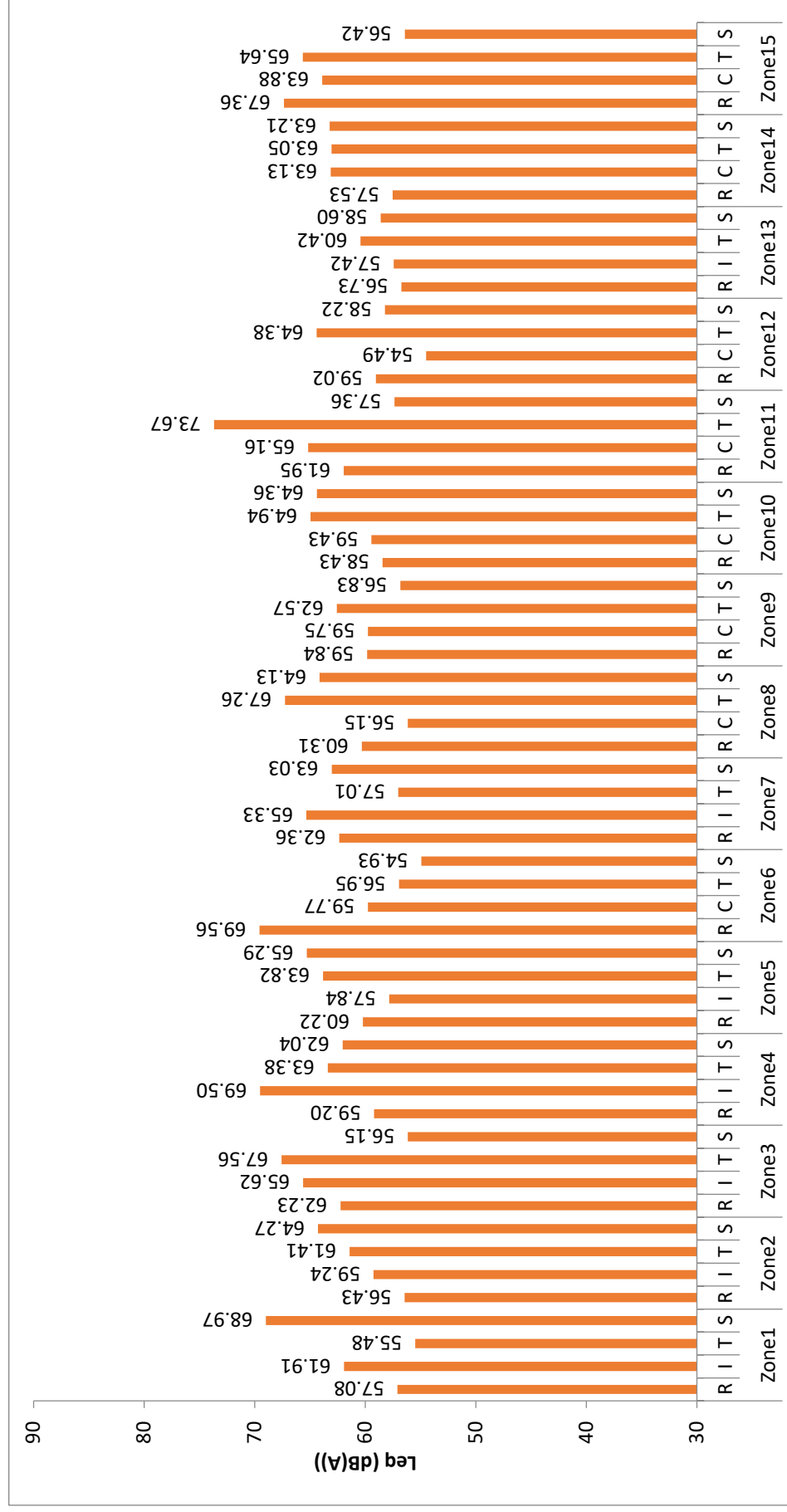


Figure 5.3 Comparison of noise levels across all the zones – Night

5.3 Category-wise analysis

5.3.1 Residential areas

In residential areas, the prescribed day limit of 55 dB(A) was exceeded at all 15 locations, with L_{eq} values ranging between 59.73 dB(A) (Zone 14_R) and 72.56 dB(A) (Zone 3_R). Maximum noise levels (L_{max}) at all sites crossed 90 dB(A), with the highest at Zone 6_R, while minimum levels (L_{min}) were observed at Zone 1_R and Zone 7_R. Statistical descriptors (L_{10} , L_{50} , and L_{90}) indicated higher noise variability, with maximum values recorded at Zones 6_R and 11_R, and minimums at Zone 14_R and Zone 15_R. NC varied from 3.13 to 16.34 dB(A), while TNI crossed the threshold of 74 dB(A) at one location (Zone 15_R). During the night, L_{eq} values still exceeded the night limit, ranging from 56.43 dB(A) to 69.56 dB(A). At night, L_{max} remained above 90 dB(A) across all sites, with NC ranging from 5.15 to 19.36 dB(A) and TNI exceeding the threshold in five locations. The consistently high values in residential areas can be attributed to dense habitation, frequent vehicular movement on interior streets, neighborhood commercial activities, and evening social or cultural gatherings that continue late into the night.

5.3.2 Industrial areas

Industrial zones generally complied with the permissible limits. During the day, none of the seven locations exceeded the 75 dB(A) standard, with L_{eq} values between 61.36 dB(A) and 71.16 dB(A). However, L_{max} levels were significantly high (> 99 dB(A)) at all sites, peaking at Zone 3_I. Noise descriptors showed higher L_{10} , L_{50} , and L_{90} values at Zone 7_I, while the lowest values were at Zone 4_I. NC varied between 3.26 and 15.81 dB(A), and TNI exceeded 74 dB(A) at only one location. At night, all locations were within the 70 dB(A) limit, with L_{eq} ranging from 57.42 dB(A) to 69.50 dB(A), though L_{max} again crossed 97 dB(A) everywhere. NC (4.24 – 13.90 dB(A)) and TNI values confirmed relatively stable noise levels. The pattern reflects typical industrial activity with daytime machinery operations, goods transport, and heavy vehicle movement while reduced activity at night kept noise under control, though occasional high peaks (L_{max}) suggest truck movement or loading/unloading operations during late hours.

5.3.3 Commercial areas

In commercial zones, noise levels frequently surpassed the limits due to high business and market activity. Out of eight locations, four exceeded the 65 dB(A) day limit, with L_{eq} values between 60.02 dB(A) (Zone 12_C) and 69.78 dB(A) (Zone 11_C). L_{max} exceeded 98 dB(A) at all sites, with the highest at Zone 9_C. Noise indices showed elevated values at Zones 11_C and 15_C, with NC ranging from 2.43 to 22.22 dB(A). TNI exceeded the 74 dB(A) threshold at only one site during the day. At night, 7 out of 8 sites crossed the 55 dB(A) limit, with L_{eq} values from 54.49 dB(A) to 65.16 dB(A), and L_{max} exceeding 96 dB(A) across locations. NC was comparatively moderate (1.52 – 11.90 dB(A)), and TNI remained below threshold. Elevated noise in commercial areas arises from customer activity, public gatherings, vehicular traffic around shopping streets, loading/unloading operations, and prolonged business hours, with night-time noise linked to eateries, late-night transport, and movement in mixed use localities.

5.3.4 Traffic areas

Traffic-dominated locations showed some of the highest noise intensities. During the day, 12 of 15 locations surpassed the 65 dB(A) standard, with L_{eq} ranging from 60.69 dB(A) (Zone 1_T) to 75.10 dB(A) (Zone 11_T). All sites recorded L_{max} above 99 dB(A), peaking at Zone 3_T. Statistical parameters showed maximum values at Zone3_T and Zone 11_T, while minimums occurred at Zones 1_T and 7_T. NC ranged between 2.64 and 12.64 dB(A), and TNI stayed below 74 dB(A) except in one location. At night, noise levels were even more concerning with all 15 locations exceeding the 55 dB(A) limit, with L_{eq} between 55.48 dB(A) and 73.67 dB(A), and L_{max} surpassing 96 dB(A) at all sites. The highest peak was at Zone 12_T, while L_{min} values were lowest at Zones 2_T and 5_T. NC values were higher (4.77 – 20.80 dB(A)), and TNI crossed the threshold at two sites. These patterns are directly linked to continuous vehicular movement, honking, high-density intersections, and heavy transport trucks plying through arterial routes even at night.

5.3.5 Sensitive areas

Even in silent zones, where the permissible limit is 50 dB(A), all 15 locations exceeded both day and night limits. During the day, L_{eq} values varied from 60.10 dB(A) (Zone 6_S) to 71.03 dB(A) (Zone 5_S), with L_{max} crossing 100 dB(A)

everywhere and peaking at Zone 10_S. $L_{\min}$ was lowest at Zones 8_S and 15_S, while Zone 5_S registered the highest L_{10} , L_{50} and L_{90} values. NC ranged from 3.95 to 20.84 dB(A), and TNI exceeded the threshold at three locations. At night, L_{eq} values ranged from 54.93 dB(A) (Zone 6_S) to 68.97 dB(A) (Zone 1_S), with all $L_{\max}$ values above 90 dB(A) and NC between 4.07 and 21.13 dB(A). TNI exceeded at five sites. The high noise levels in sensitive areas can be attributed to encroaching urban activities, traffic passing near hospitals, schools, and religious places, construction works, and commercial spillover into sensitive zones which indicates poor enforcement of protective noise regulations.

5.4 Spatial variability analysis

5.4.1 Correlation Coefficients (r)

Correlation analysis was conducted to assess the degree of similarity in noise patterns across different monitoring locations. A correlation coefficient is a statistical measure that describes the strength and direction of the relationship between two variables (Wongphatarakul, Friedlander, & Pinto, 1998; Salleh et al., 2015). Positive correlations indicate that when noise levels increase at one site, they also tend to increase at another, whereas negative correlations suggest an inverse relationship. The Pearson correlation coefficient, the most widely used measure of linear association, was applied in this study. Its values range between -1 and $+1$, where $+1$ denotes a perfect positive relationship, 0 indicates no relationship, and -1 represents a perfect negative relationship. The coefficient is mathematically expressed as (Salleh et al., 2015):

$$r = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2 \sum_{i=1}^n (y_i - \bar{y})^2}} \quad (5.4)$$

Where, x and y are the two variables of interest, $\bar{x}$ and $\bar{y}$ are their respective means, and n is the total number of observations.

Residential areas

In residential locations, the observed correlation values ranged from 0.11 to 0.81, indicating varying degrees of similarity in noise dynamics (Figure 5.4). The strongest correlations were observed between Zone 7 and Zone 11 (0.81), between Zone 7 and

Zone 12 (0.81) and between Zone 11 and Zone 12 (0.81), suggesting that these zones are influenced by similar noise sources, possibly due to comparable urban activities or residential layouts. Conversely, the weakest correlation was noted between Zone 6 and Zone 13, and also between Zone 15 and all the other zones, pointing to distinct local factors affecting noise in these areas.

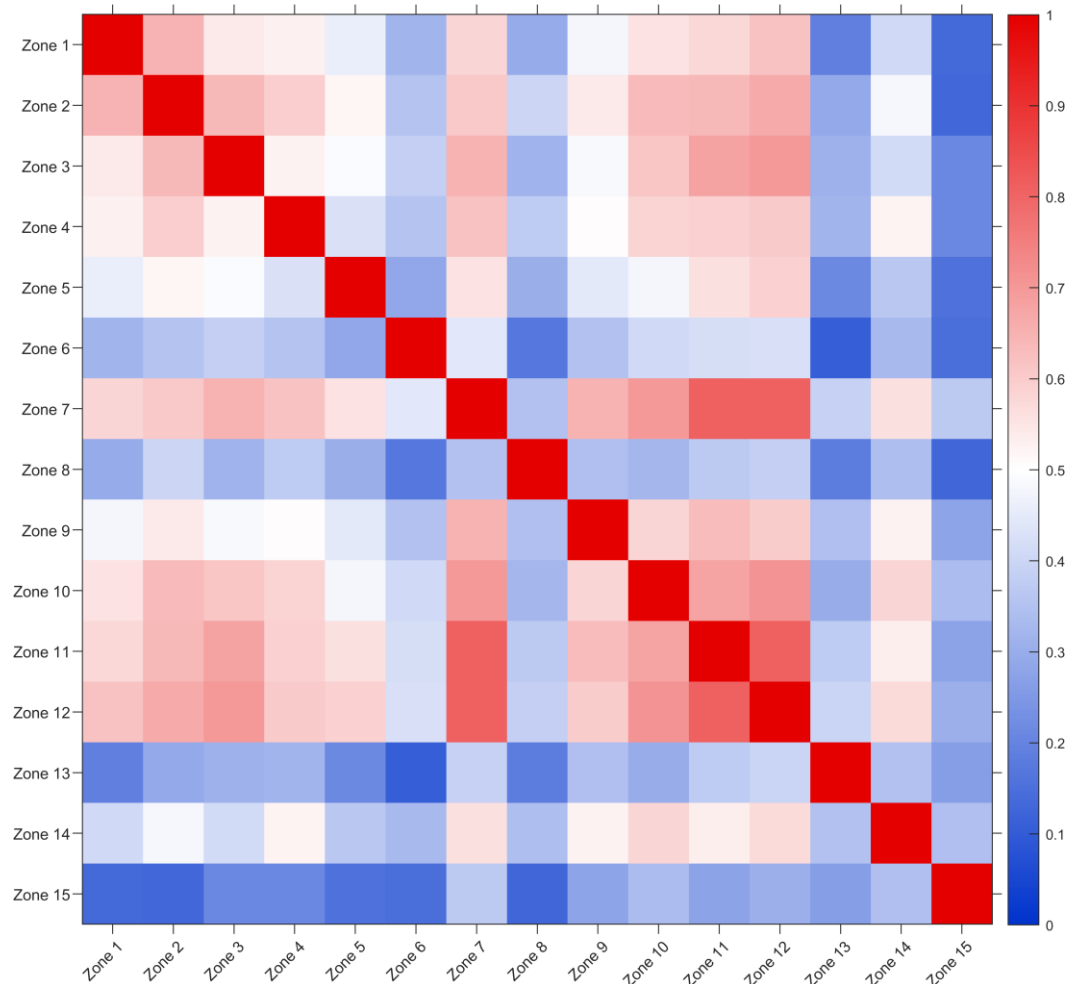


Figure 5.4 Pearson Correlation (r) between pairs of sensors deployed across various residential areas

Industrial areas

Industrial areas showed correlation values ranging from 0.09 to 0.69, reflecting moderate similarity among locations (Figure 5.5). The highest correlations were found between Zone 5 and Zone 13 (0.69), indicating that these zones may experience comparable industrial activities or shared background noise from large-scale operations. In contrast, the weakest correlation was observed between Zone 2 and

Zone 4, highlighting considerable differences in noise dynamics. Notably, Zone 4 consistently displayed weaker correlations with other industrial zones, suggesting unique local characteristics or differing industrial setups.

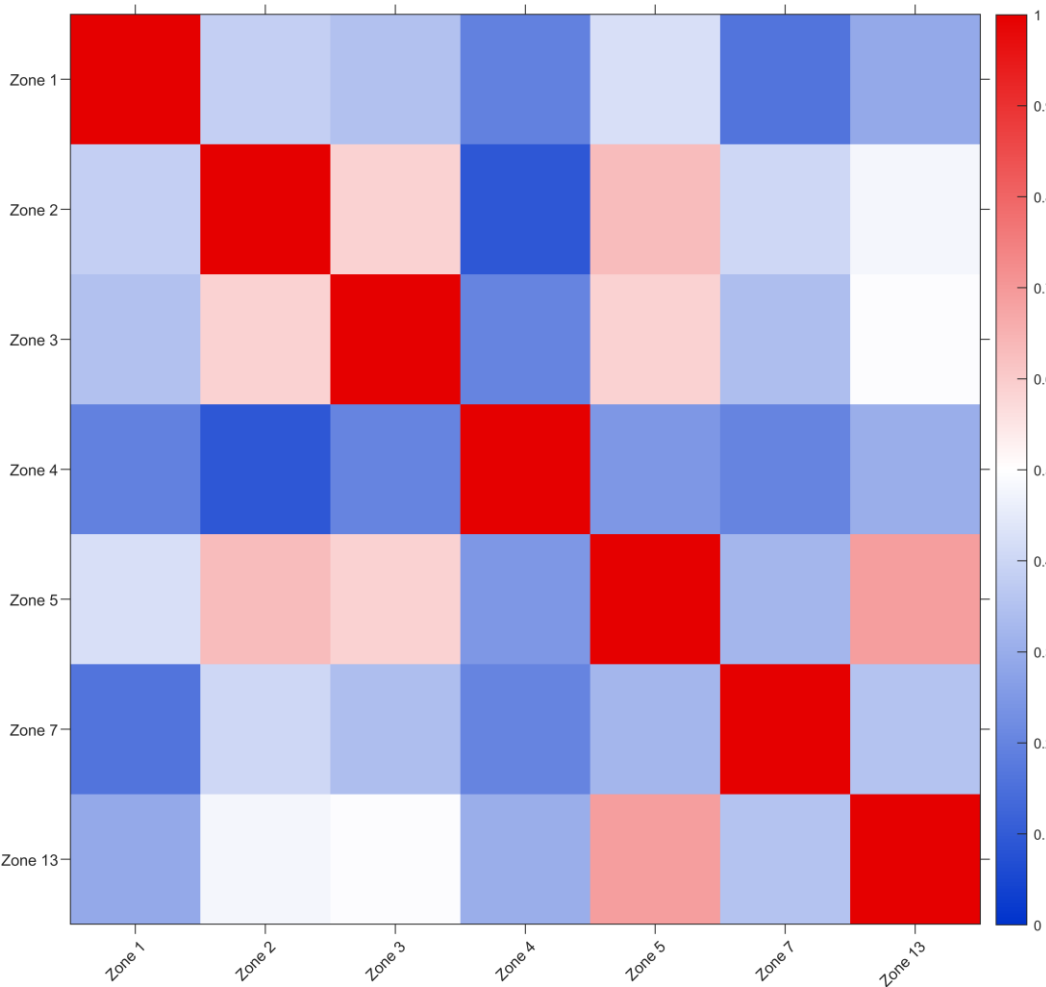


Figure 5.5 Pearson Correlation (r) between pairs of sensors deployed across various industrial areas

Commercial areas

In commercial locations, the correlation values ranged from 0.04 to 0.59, signifying higher variability in noise environments (Figure 5.6). The strongest correlation was observed between Zone 12 and Zone 15 (0.59), likely reflecting common commercial activities or similar levels of urban vibrancy. The weakest correlation occurred between Zone 10 and Zone 11, and overall, Zone 10 exhibited very low correlations with other commercial zones, suggesting distinct local noise influences, possibly due to variations in business density, traffic intensity, or urban form.

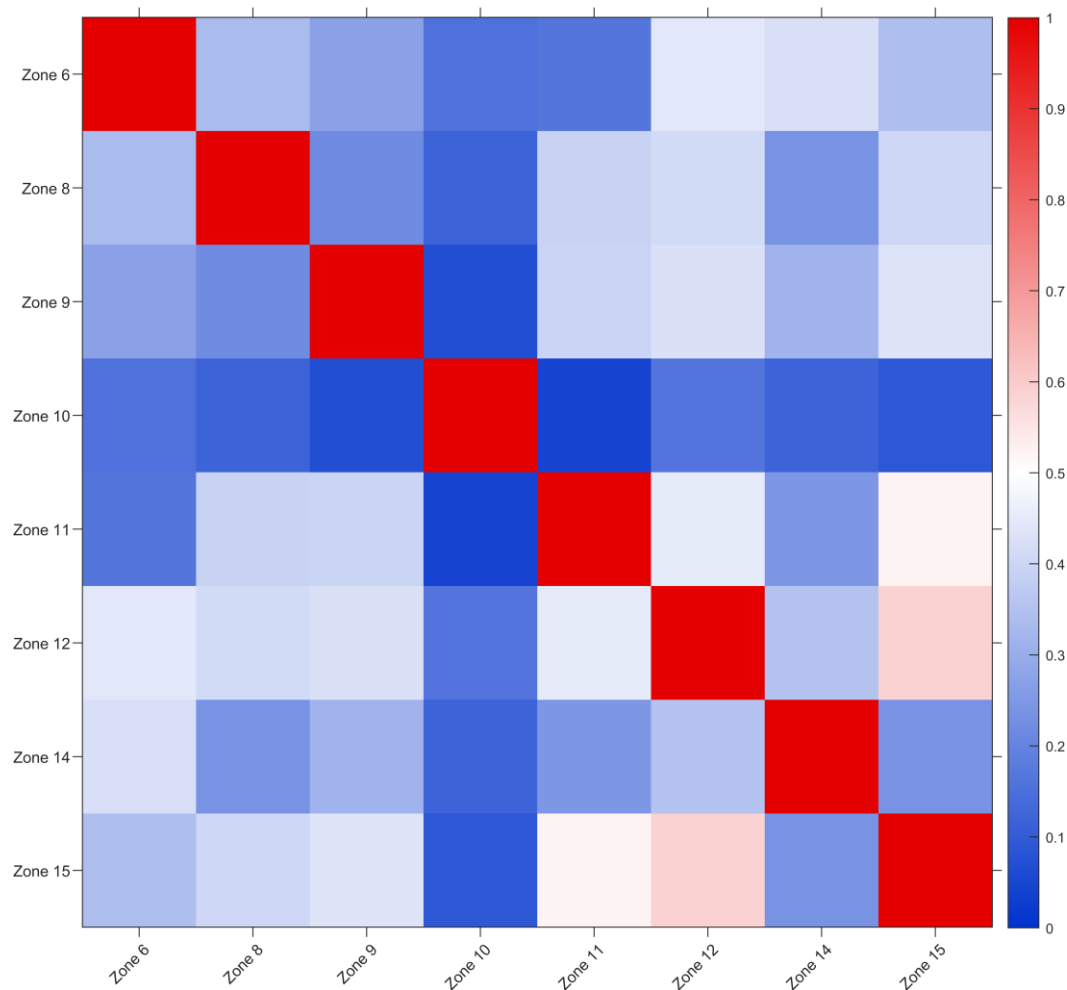


Figure 5.6 Pearson Correlation (r) between pairs of sensors deployed across various commercial areas

Traffic areas

Traffic-dominated areas exhibited correlation values spanning 0.01 to 0.87, indicating both strong and weak similarities in traffic noise dynamics (Figure 5.7). The northern and central zones (Zones 1 to 10) demonstrated strong inter-correlations, suggesting shared traffic patterns, but these zones correlated less with the southern zones, indicating geographic differences in traffic flow. The weakest correlation was observed between Zone 11 and Zone 13, while Zones 11, 12, and 13 overall showed weaker connections with other zones, signifying distinctive traffic noise characteristics in these areas.

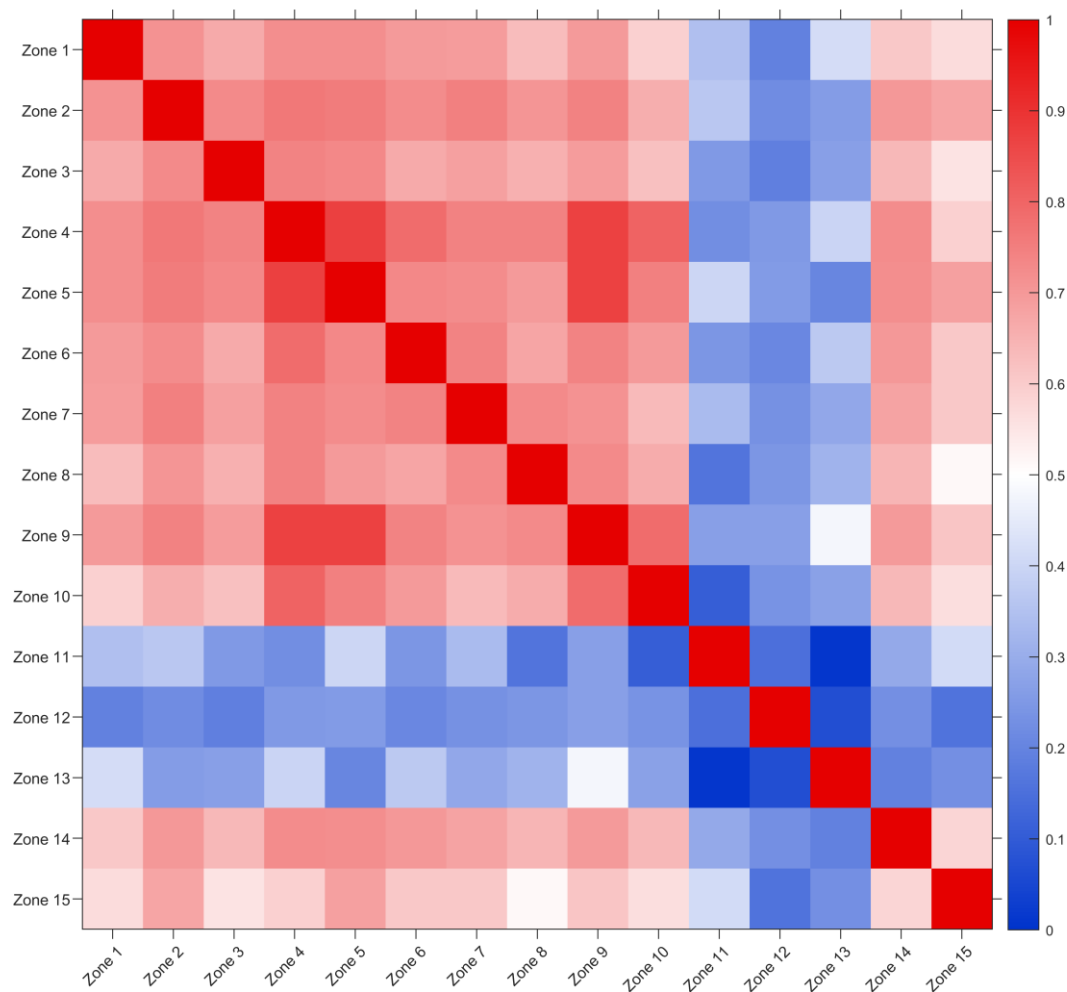


Figure 5.7 Pearson Correlation (r) between pairs of sensors deployed across various traffic areas

Sensitive areas

In sensitive areas, correlation values ranged from 0.16 to 0.78 (Figure 5.8). The strongest correlation was noted between Zone 5 and Zone 11 (0.78), pointing to shared noise influences despite the sensitive nature of these locations. The weakest correlation was observed between Zone 2 and Zone 10, suggesting contrasting noise environments. Importantly, Zones 3 to 11 showed relatively higher correlations with each other compared to the remaining zones, reflecting more uniform noise dynamics across these sensitive locations, which may be attributed to similar land use or protective urban planning measures.

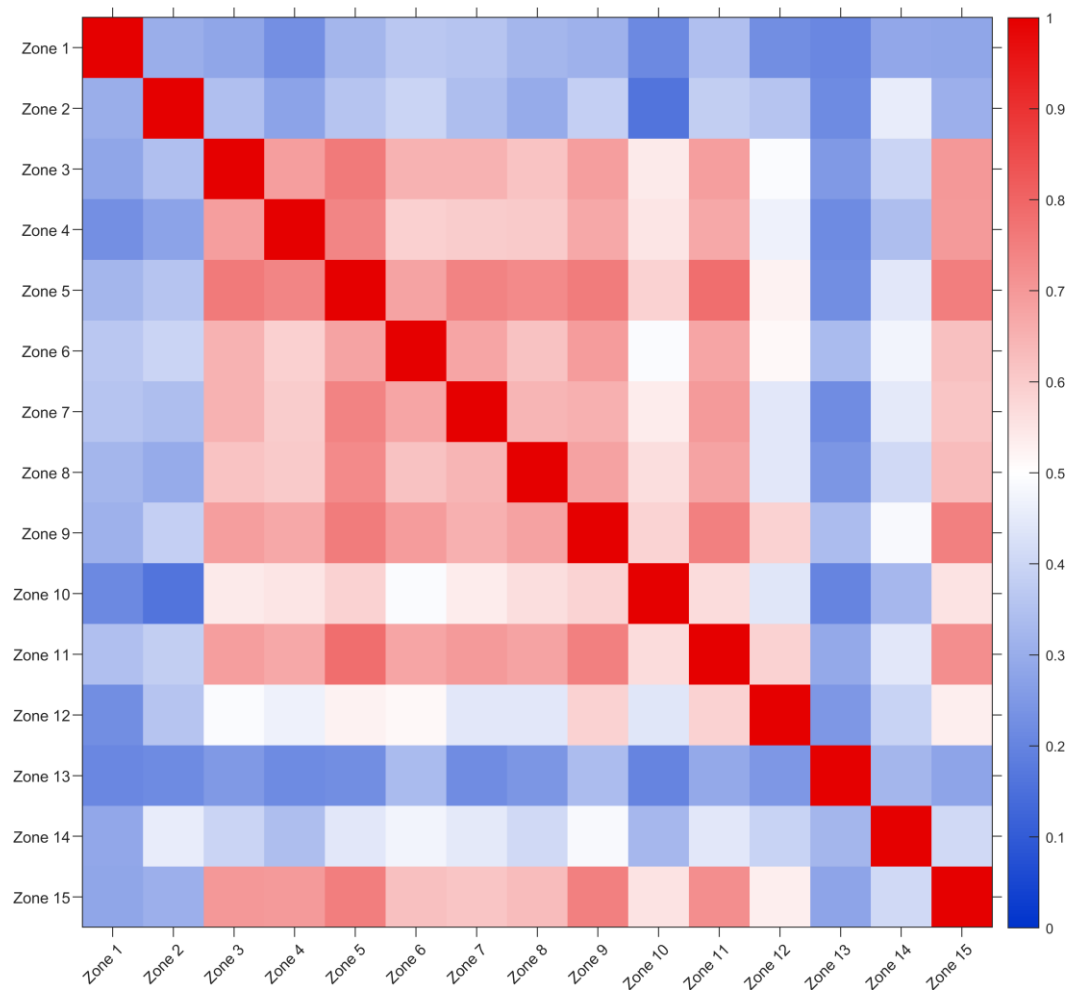


Figure 5.8 Pearson Correlation (r) between pairs of sensors deployed across various sensitive areas

5.4.2 Statistical analysis

A one-way analysis of variance (ANOVA) was conducted to test whether the equivalent continuous noise levels (L_{eq}) differed among the five land-use categories: Residential, Industrial, Commercial, Traffic, and Sensitive locations. The null hypothesis (H_0) assumes that the mean L_{eq} values across all categories are equal:

$$H_0: \mu_1 = \mu_2 = \dots = \mu_k$$

where $k = 5$ categories, while the alternative hypothesis (H_a) assumes that at least one category mean differs from the others:

H_a : The means are not all equal

The significance level was set at $\alpha = 0.05$.

Table 5.5 Results of the ANOVA test

Source	SS	df	MSS	f	P
Between categories	1415509.06	4	353877.27	7813.22	0
Within categories	12892678.46	284656	45.29	-	-
Total	14308187.52	284660	-	-	-

The ANOVA results (Table 5.5) indicate that $p < 0.05$, so the null hypothesis is rejected. This implies that there is a statistically significant difference in noise levels among the five categories at the 5% significance level.

Figure 5.9 shows the distribution of L_{eq} values across the five categories of locations. Among them, traffic areas recorded the highest mean noise level of 64.87 dB(A), while commercial areas exhibited the lowest mean of 58.93 dB(A). The remaining categories showed intermediate mean values ranging approximately between 59 and 60 dB(A).

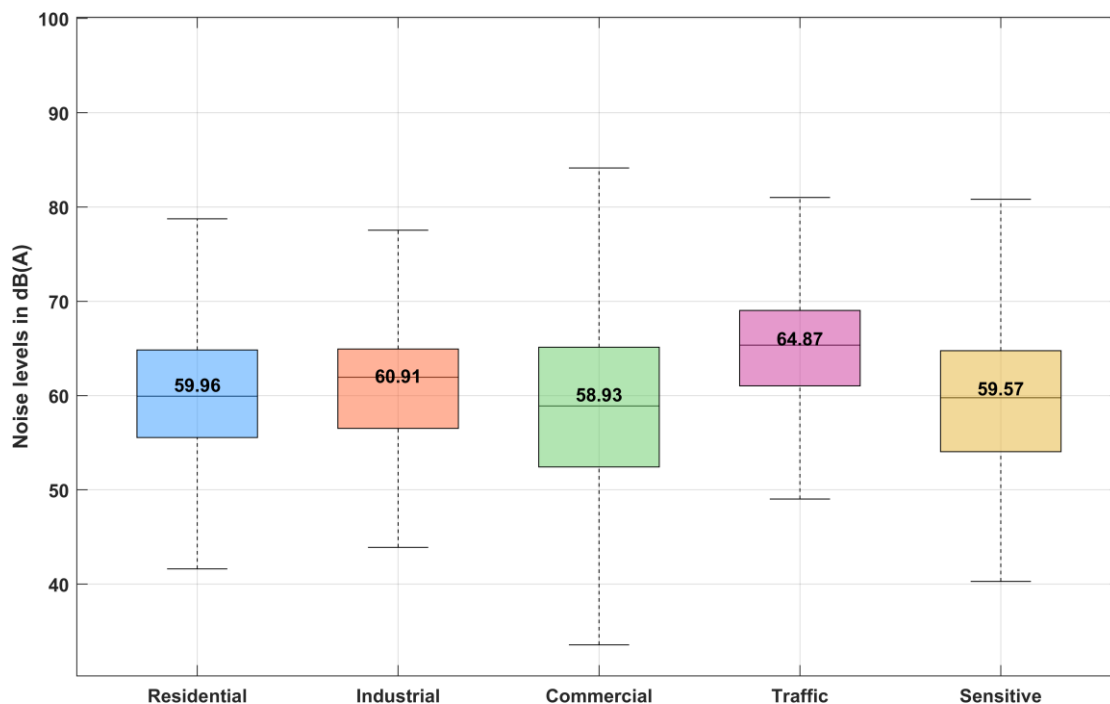


Figure 5.9 Distribution of L_{eq} values across the five categories of locations

The higher noise levels in traffic areas are expected due to the continuous presence of vehicular flow, including heavy vehicles, causing elevated sound emissions. In contrast, commercial areas generally have lower traffic density and less heavy

machinery, leading to lower L_{eq} values. Sensitive areas show intermediate values due to moderate human activity and local traffic patterns. Residential areas, though generally quieter, may occasionally experience localized traffic or construction, resulting in moderate L_{eq} values. Traffic-heavy and industrial areas exhibit elevated noise from vehicles, machinery, and industrial operations, which explains their significant difference from other categories. The analysis confirms that land-use type strongly influences urban noise levels, highlighting the need for targeted noise mitigation strategies in high-noise areas such as traffic and industrial zones.

5.4.3 Coefficients of Divergence (CoD)

The noise levels between locations differ due to differences in activities and emission rates. The coefficients of divergence (CoD) are statistical tests conducted between pairs of sites to examine their relative variation in pollutant levels recorded between similar time gaps. CoD can be used to assess the spatial variability of noise levels, identifying areas with high noise concentrations compared to quieter areas.

This method is used to examine the degree of uniformity (homogeneous or heterogeneous) of pollutant concentration measured concurrently at two sites. A CoD value of zero means both sites are identical, whereas value of one indicates that the two sites differ significantly based on pollutant concentration. CoD values between pairs of sites are calculated using the below equation (Wilson et al. 2005; Krudysz et al. 2008; Xie et al., 2012; Kumar et al., 2025):

$$CoD_{jk} = \sqrt{\frac{1}{n} \sum_{i=1}^n \left(\frac{x_{ij} - x_{ik}}{x_{ij} + x_{ik}} \right)^2} \quad (5.5)$$

Where n is the number of paired measurements between stations, j and k represent two paired monitoring locations, x_{ik} is the value at station i at time k and x_{jk} is the value at station j at the same time k . A CoD value of 0 indicates uniformity between pairs of samples, whereas 1 indicates complete divergence. Values less than 0.2 between two sites typically represent spatial homogeneity, while values greater than 0.2 shows spatial heterogeneity (Wilson et al. 2005; Kumar et al., 2025).

CoD values were computed using L_{eq} levels for all site pairs and the results are summarised in Figure 5.10. The estimated CoD ranged from 0.01 to 0.19, with an average value of 0.07. CoD values below 0.2 suggest spatial homogeneity, while values above 0.2 indicate spatial heterogeneity.

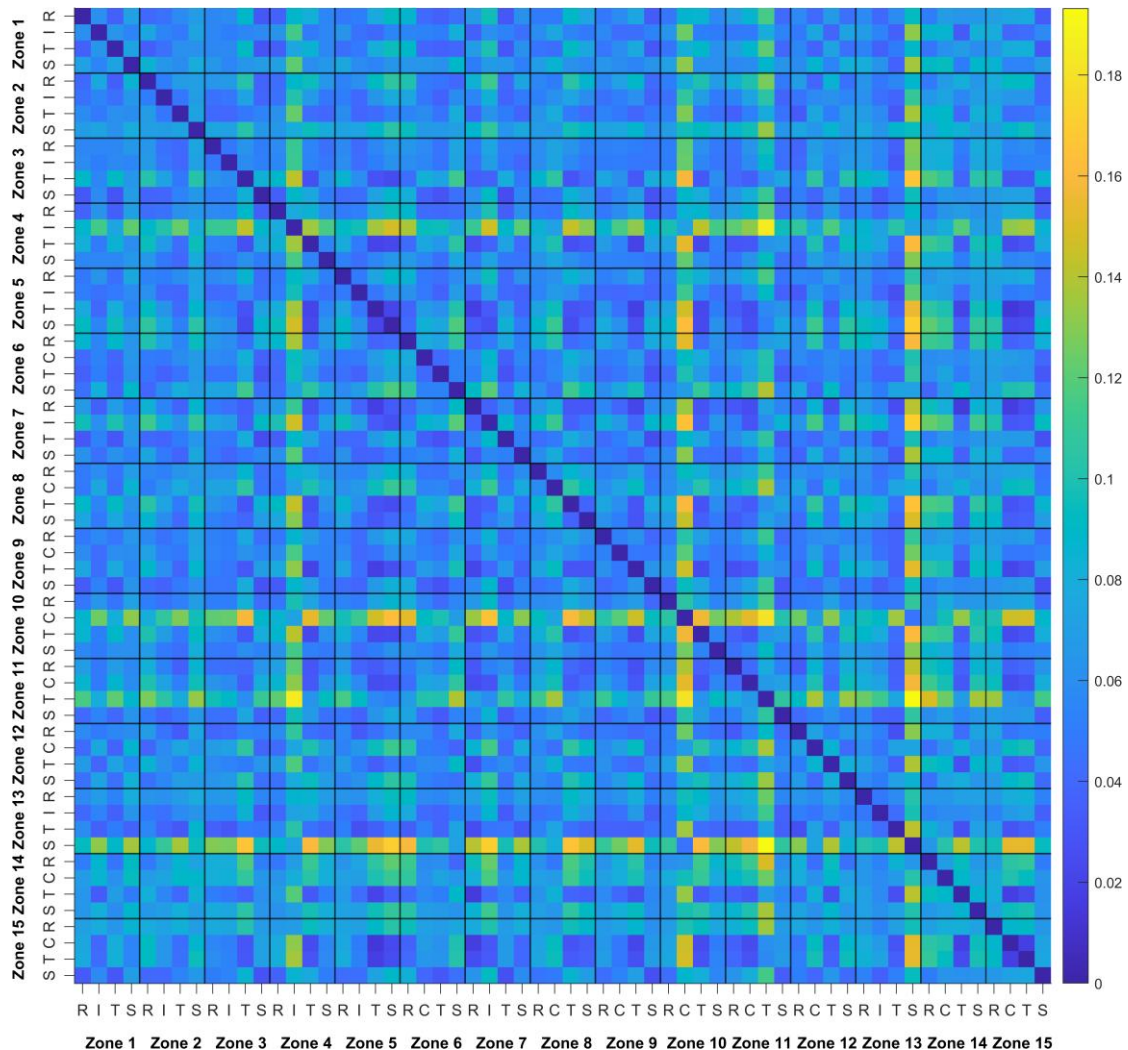


Figure 5.10 Coefficient of Divergence (CoD) values between pairs of sensors deployed across various zones

All site pairs had $CoD < 0.2$, indicating strong spatial homogeneity. Despite the geographical separation between sites, the dominant noise sources were similar across most locations, likely due to the prevalence of road traffic in urban centres, which is a consistent and widespread source of environmental noise in Chennai's urban centres.

The spatial analysis indicates that Chennai's monitored zones exhibit predominantly homogeneous noise profiles, driven largely by urban traffic.

5.5 Assessment of compliance with noise standards

An important step in noise characterization is checking for regulatory compliance with CPCB-prescribed ambient noise standards, which vary across residential, industrial, commercial, and sensitive areas (Table 1.1). The L_{eq} values obtained from monitoring are compared against these thresholds. Locations where observed values exceed permissible limits are designated as non-compliant, requiring further investigation, public awareness, and mitigation interventions. Compliance checks serve as a regulatory benchmark and help prioritize noise management actions.

Assessment against CPCB noise standards revealed widespread non-compliance, particularly in residential, transport, and sensitive zones. Several stations reported 100% exceedance during both day and night (Table 5.6 & Figure 5.11), indicating chronic exposure to hazardous noise levels. Sensitive areas were particularly vulnerable, with hospitals and educational institutions recording total non-compliance. 10 out of 15 sensitive locations showed 100% exceedance during day and all of the 15 sensitive locations showed 100% exceedance during night. Transport hubs and residential areas demonstrated near-100% exceedance. All the industrial locations exhibited near zero exceedance. Commercial zones exhibited more mixed results. While most of the commercial centers showed compliance with standards, locations like Zone11_C and Zone15_C still experienced high exceedance during both day and night, emphasizing the role of mixed land use and market-related activity in shaping urban noise.

The monthwise compliance with noise standards across monitoring locations are given in APPENDIX D.

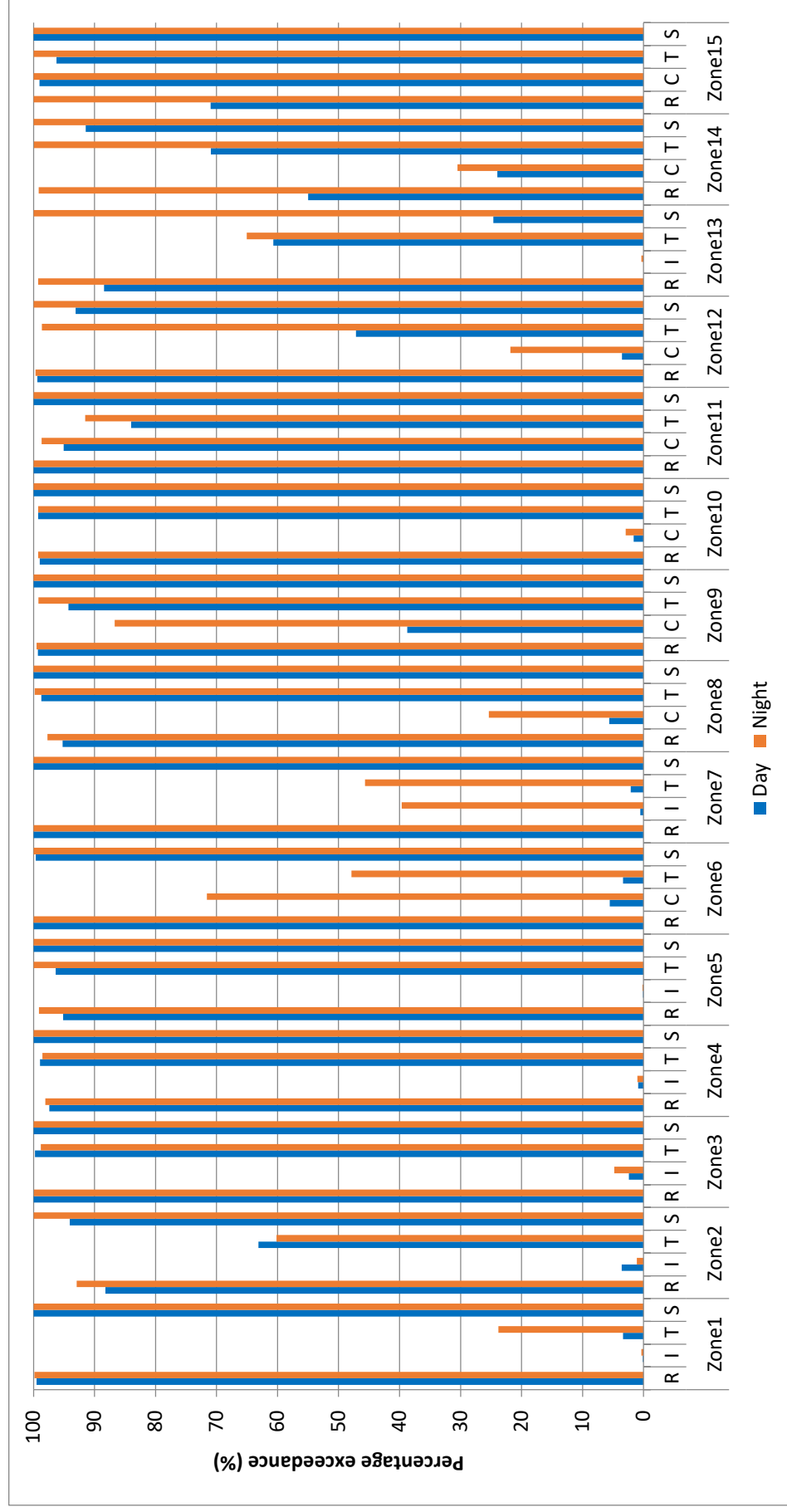


Figure 5.11 Exceedance of noise levels with respect to CPCB standards

Table 5.6 Exceedance of noise levels with respect to CPCB standards³

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone1_R	2911	2897	99.52	1454	1452	99.86
Zone1_I	2853	4	0.14	1422	5	0.35
Zone1_T	3682	124	3.37	1847	440	23.82
Zone1_S	2957	2957	100.00	1483	1483	100.00
Zone2_R	2899	2558	88.24	1454	1351	92.92
Zone2_I	2936	106	3.61	1467	16	1.09
Zone2_T	2730	1723	63.11	1368	823	60.16
Zone2_S	3511	3302	94.05	1760	1760	100.00
Zone3_R	3435	3435	100.00	1706	1705	99.94
Zone3_I	2951	71	2.41	1478	71	4.80
Zone3_T	3448	3440	99.77	1727	1706	98.78
Zone3_S	2872	2872	100.00	1438	1438	100.00
Zone4_R	3308	3222	97.40	1657	1625	98.07
Zone4_I	2826	25	0.88	1376	14	1.02
Zone4_T	3323	3288	98.95	1662	1638	98.56
Zone4_S	2940	2940	100.00	1476	1476	100.00
Zone5_R	3332	3170	95.14	1675	1660	99.10
Zone5_I	3919	5	0.13	1980	4	0.20
Zone5_T	2986	2877	96.35	1488	1488	100.00
Zone5_S	3451	3451	100.00	1732	1732	100.00
Zone6_R	3072	3072	100.00	1541	1541	100.00
Zone6_C	3101	172	5.55	1545	1106	71.59
Zone6_T	2652	90	3.39	1332	638	47.90
Zone6_S	2857	2847	99.65	1426	1426	100.00
Zone7_R	3508	3508	100.00	1770	1770	100.00
Zone7_I	2164	12	0.55	1077	427	39.65
Zone7_T	2999	63	2.10	1502	686	45.67
Zone7_S	2903	2903	100.00	1445	1445	100.00
Zone8_R	3781	3600	95.21	1878	1835	97.71
Zone8_C	3373	190	5.63	1648	418	25.36
Zone8_T	2975	2937	98.72	1494	1491	99.80
Zone8_S	2983	2983	100.00	1501	1501	100.00
Zone9_R	3839	3811	99.27	1934	1924	99.48
Zone9_C	2731	1058	38.74	1390	1205	86.69
Zone9_T	3170	2988	94.26	1585	1572	99.18
Zone9_S	2828	2828	100.00	1417	1417	100.00
Zone10_R	2856	2827	98.98	1428	1417	99.23
Zone10_C	3770	62	1.64	1886	55	2.92
Zone10_T	2889	2867	99.24	1445	1434	99.24
Zone10_S	2800	2800	100.00	1406	1406	100.00
Zone11_R	3354	3354	100.00	1686	1686	100.00
Zone11_C	3298	3135	95.06	1649	1627	98.67
Zone11_T	3183	2674	84.01	1606	1470	91.53
Zone11_S	3093	3093	100.00	1549	1549	100.00
Zone12_R	3597	3575	99.39	1804	1798	99.67
Zone12_C	2856	101	3.54	1438	314	21.84
Zone12_T	3315	1563	47.15	1670	1647	98.62
Zone12_S	3080	2868	93.12	1538	1538	100.00

³ Stations with 100% exceedance are highlighted in red

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone13_R	3100	2742	88.45	1554	1542	99.23
Zone13_I	2639	0	0.00	1083	4	0.37
Zone13_T	2601	1579	60.71	143	93	65.03
Zone13_S	3566	879	24.65	1770	1770	100.00
Zone14_R	3362	1848	54.97	1689	1675	99.17
Zone14_C	4024	965	23.98	2012	614	30.52
Zone14_T	3335	2366	70.94	1676	1675	99.94
Zone14_S	4215	3855	91.46	2118	2118	100.00
Zone15_R	4231	3003	70.98	2118	2118	100.00
Zone15_C	3101	3070	99.00	1552	1552	100.00
Zone15_T	2904	2795	96.25	1457	1457	100.00
Zone15_S	3245	3245	100.00	1629	1629	100.00

5.6 Cumulative frequency distribution

The cumulative frequency distribution is particularly useful in noise studies as it enables a quantitative assessment of noise exposure patterns. It displays the total number of noise measurements that fall below a certain decibel level, providing a clear picture of the noise levels over a specific period or location. In regulatory and planning contexts, cumulative frequency plots are valuable tools for evaluating compliance with standards, communicating results to stakeholders, and supporting evidence-based noise management strategies.

The cumulative frequency distribution (CFD) of noise levels (Figure 5.12, Figure 5.13, and Figure 5.14) revealed that a large proportion of measurements in residential zones consistently lay above the CPCB-prescribed thresholds. The distribution curves for a majority of traffic areas and a few commercial hubs were skewed towards higher decibel levels, reflecting the dominance of traffic and market-related activity as continuous noise sources. Sensitive areas, which are expected to maintain comparatively low acoustic environments, showed steeply rising CFD curves above 50 dB(A), confirming complete non-compliance with standards. In contrast, certain industrial zones exhibited flatter curves with a wider spread of values, indicating localized variability influenced by specific operational schedules.

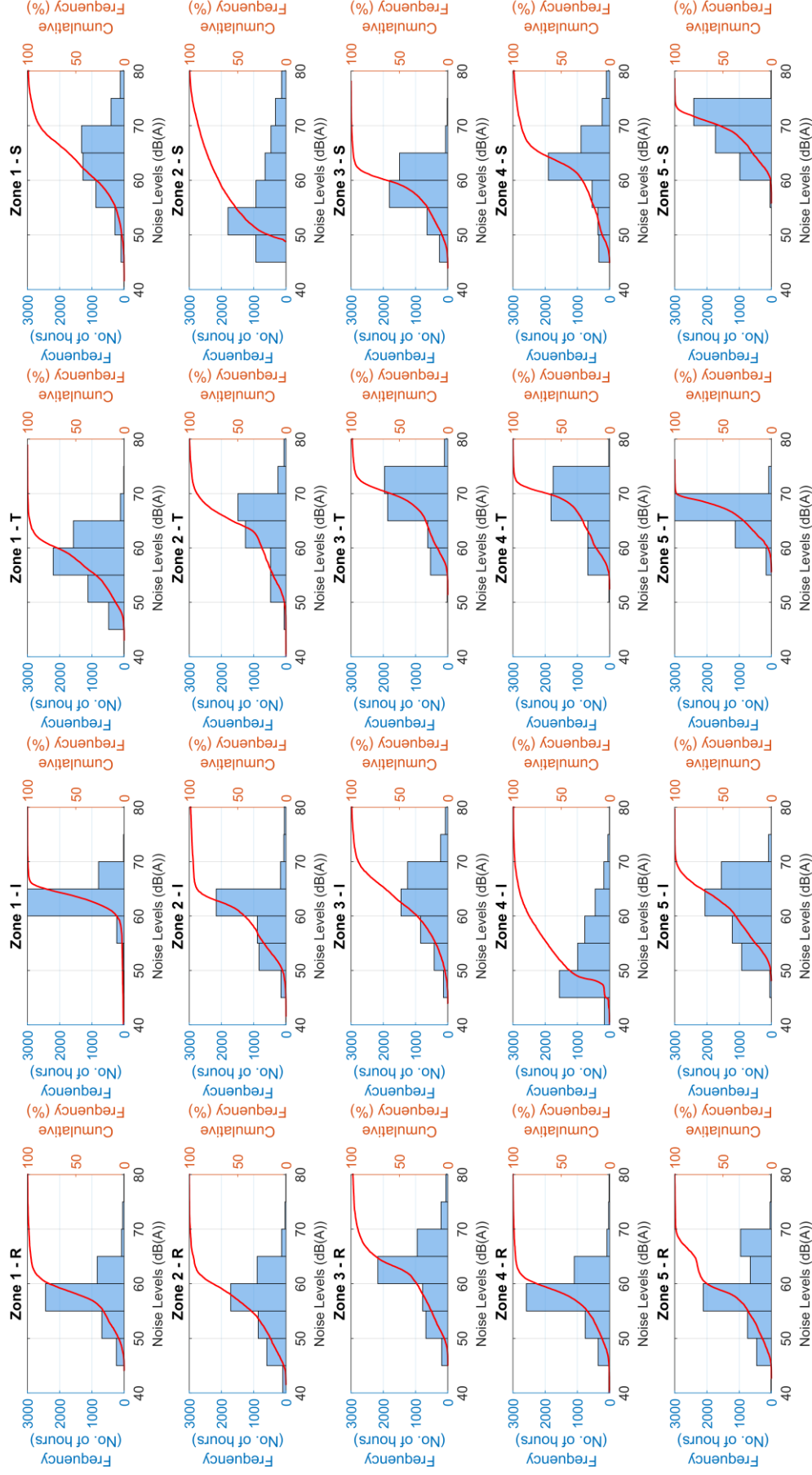


Figure 5.12 Cumulative frequency distribution for the North zones

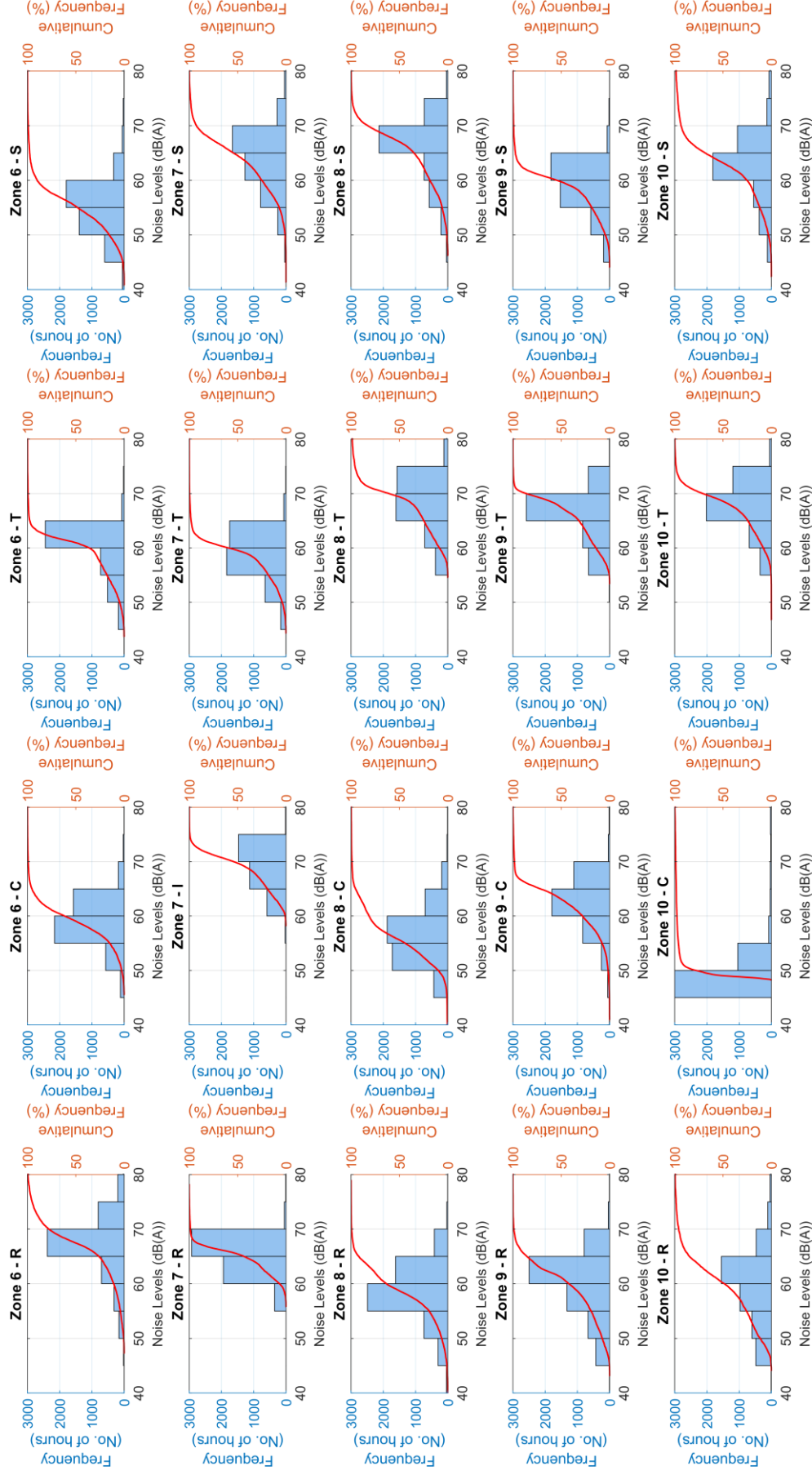


Figure 5.13 Cumulative frequency distribution for the Central zones

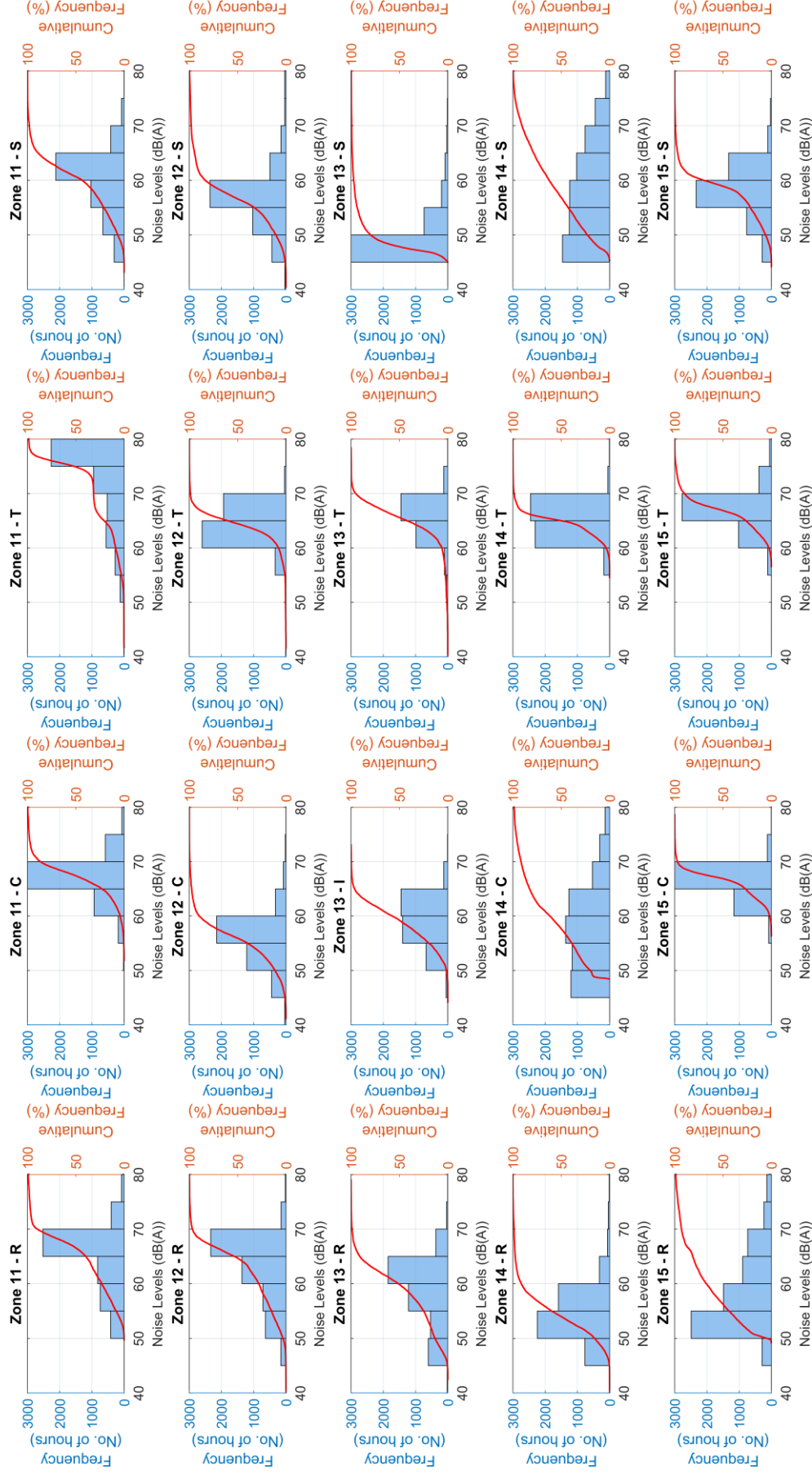


Figure 5.14 Cumulative frequency distribution for the South zones

5.7 Temporal variations

Temporal characterization evaluates how noise levels change over time, providing insights into usage patterns, behavioural trends, and event-specific fluctuations.

5.7.1 Hourly variation analysis

The hourly variation analysis (Figure 5.15, Figure 5.16, and Figure 5.17) revealed strong diurnal cycles across most monitoring locations, reflecting the influence of human activity and traffic patterns. In general, noise levels were lowest during the early morning hours (00:00 – 06:00), after which they steadily increased, reaching distinct peaks during the morning (08:00 – 10:00) and evening (18:00 – 21:00) rush hours. Nighttime levels remained persistently above standards in many zones, suggesting a lack of interval for communities and pointing to continuous traffic, construction, or commercial activity. Many sites displayed a unimodal curve, characterized by a single daytime peak, while others exhibited a bimodal pattern with pronounced morning and evening peak values corresponding to traffic congestion periods. Certain industrial zones showed irregular patterns, driven by site-specific industrial operations, while a few locations exhibited relatively flat curves, suggesting that noisy activities persisted throughout without significant fluctuations. Importantly, in many zones, even the lowest nighttime values remained above CPCB standards, pointing to the absence of meaningful acoustic respite for residents.

5.7.2 Weekly variation analysis

Weekly variation analysis (Figure 5.18, Figure 5.19, and Figure 5.20) indicated that noise levels across most zones remained largely consistent throughout the week, underscoring the continuous nature of urban noise sources. In some industrial areas, a slight reduction in levels was observed during weekends, likely due to reduced operational activity. Conversely, a few locations displayed marginal increases during weekends, possibly reflecting higher recreational, commercial, or social activity. Despite these variations, the overall weekly profiles showed minimal change, with weekday and weekend averages remaining above prescribed standards. This persistence of elevated noise levels suggests that the population is continuously exposed to excessive noise irrespective of day of the week, highlighting the chronic and pervasive character of noise pollution in Chennai's urban environment.

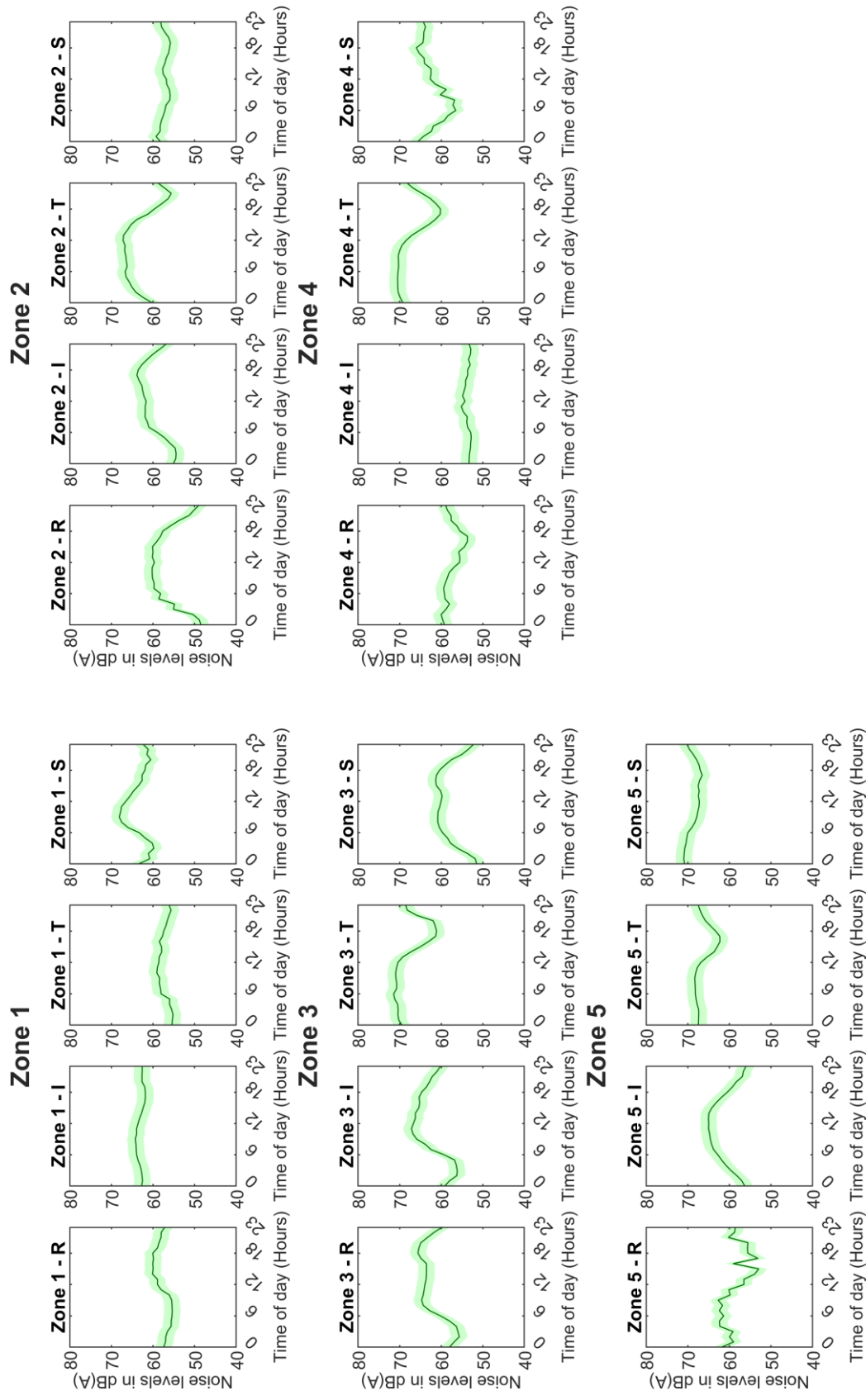


Figure 5.15 Hourly noise variations for the North zones

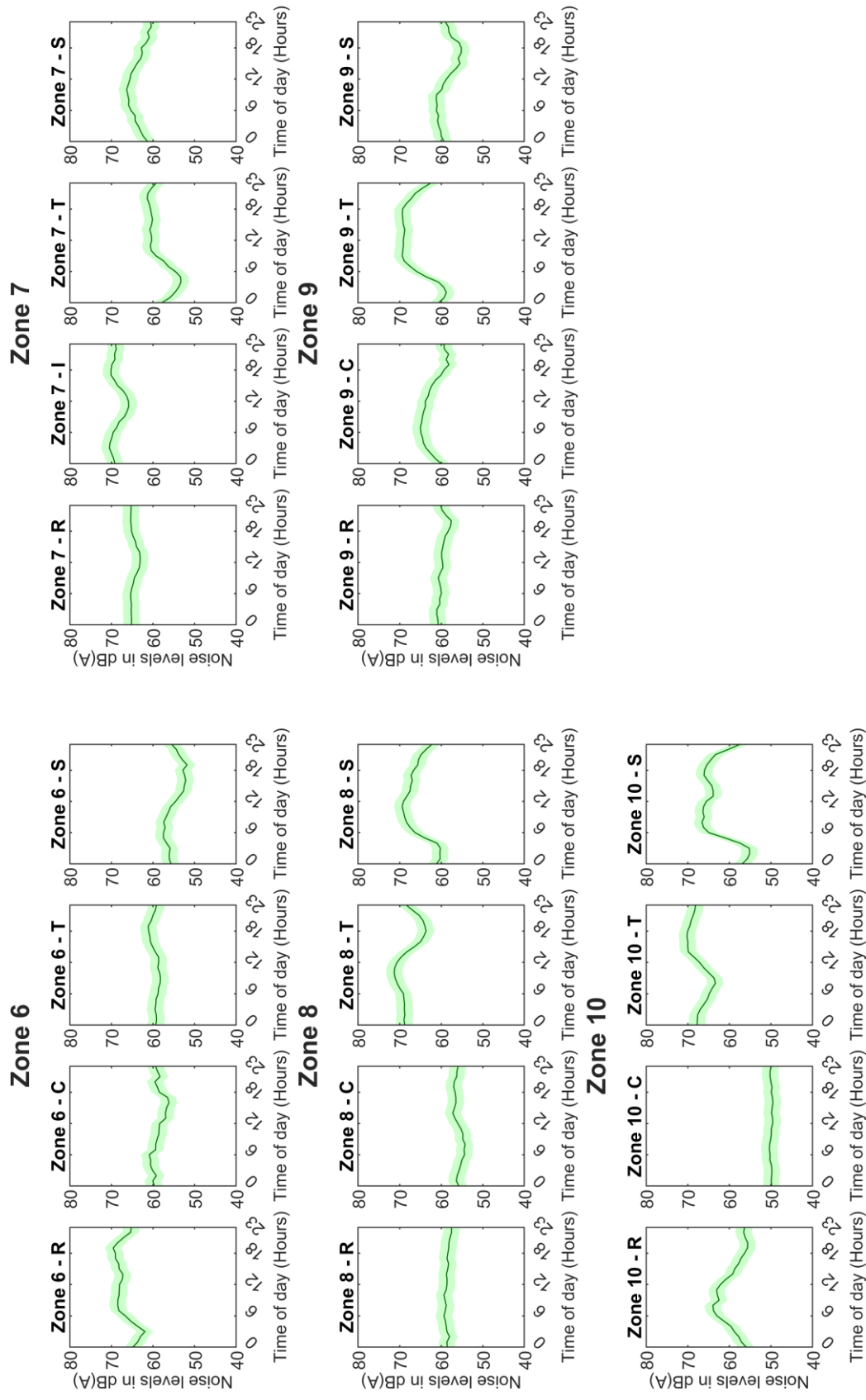


Figure 5.16 Hourly noise variations for the Central zones

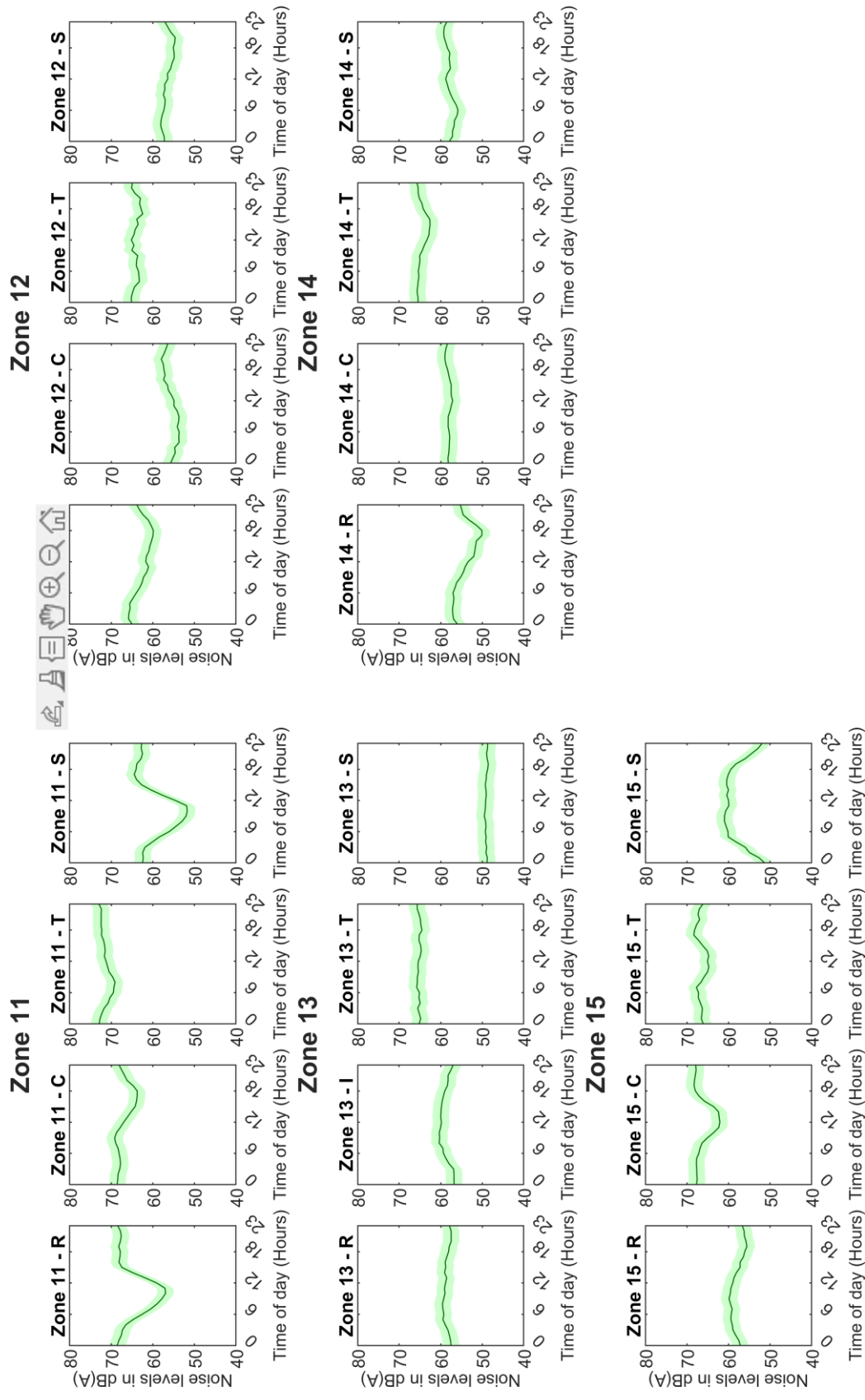


Figure 5.17 Hourly noise variations for the South zones

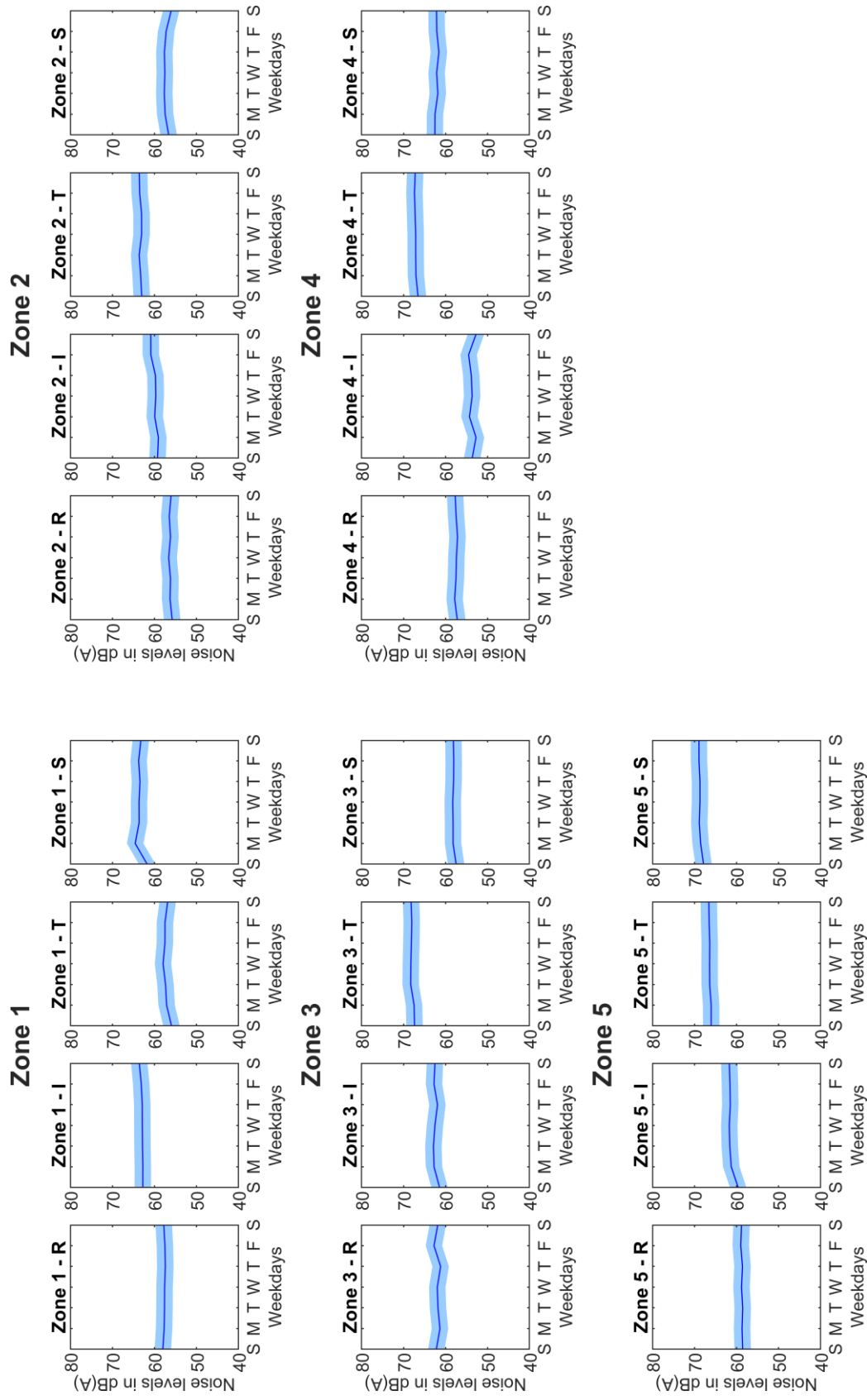


Figure 5.18 Weekly noise variations for the North zones

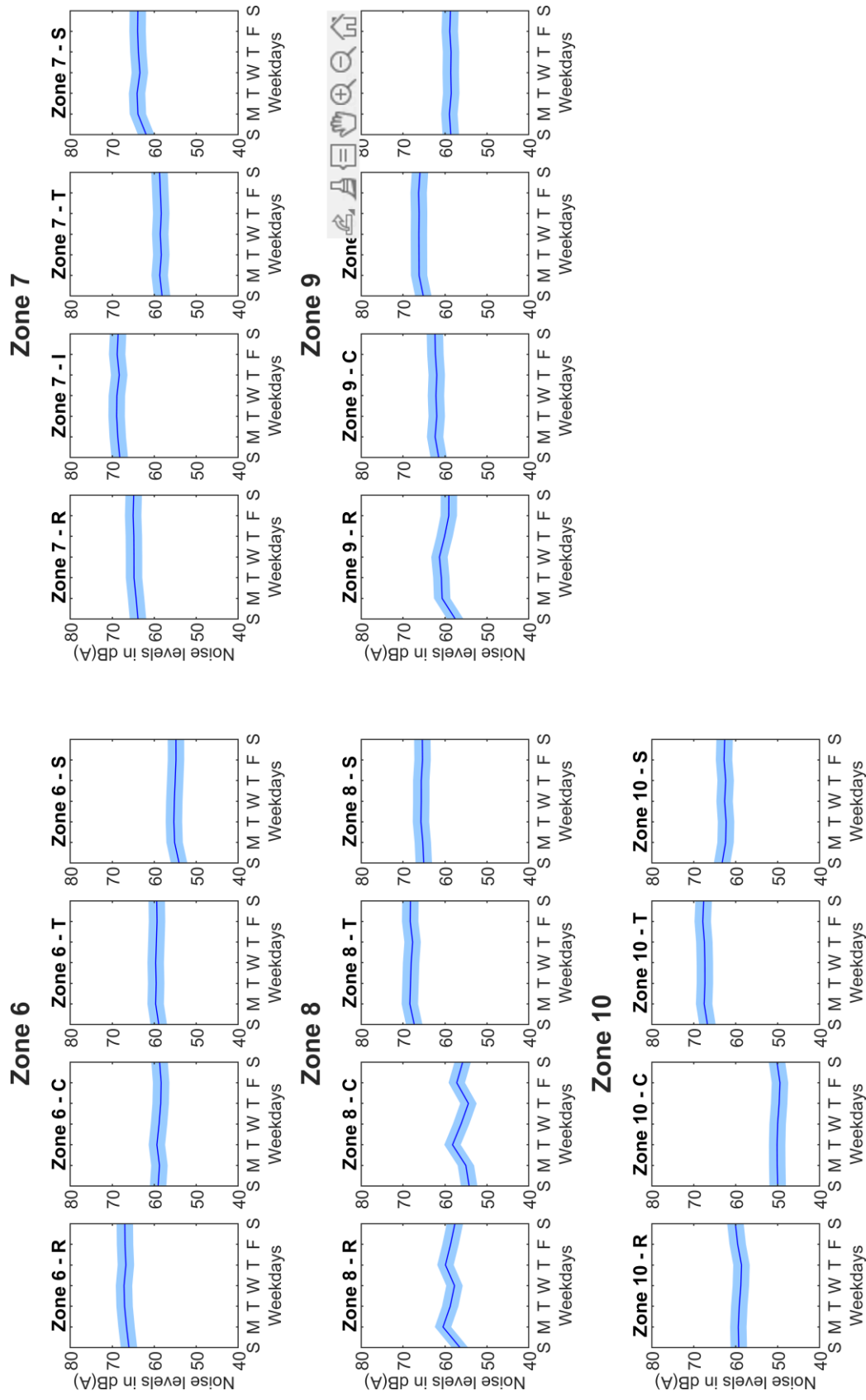


Figure 5.19 Weekly noise variations for the Central zones

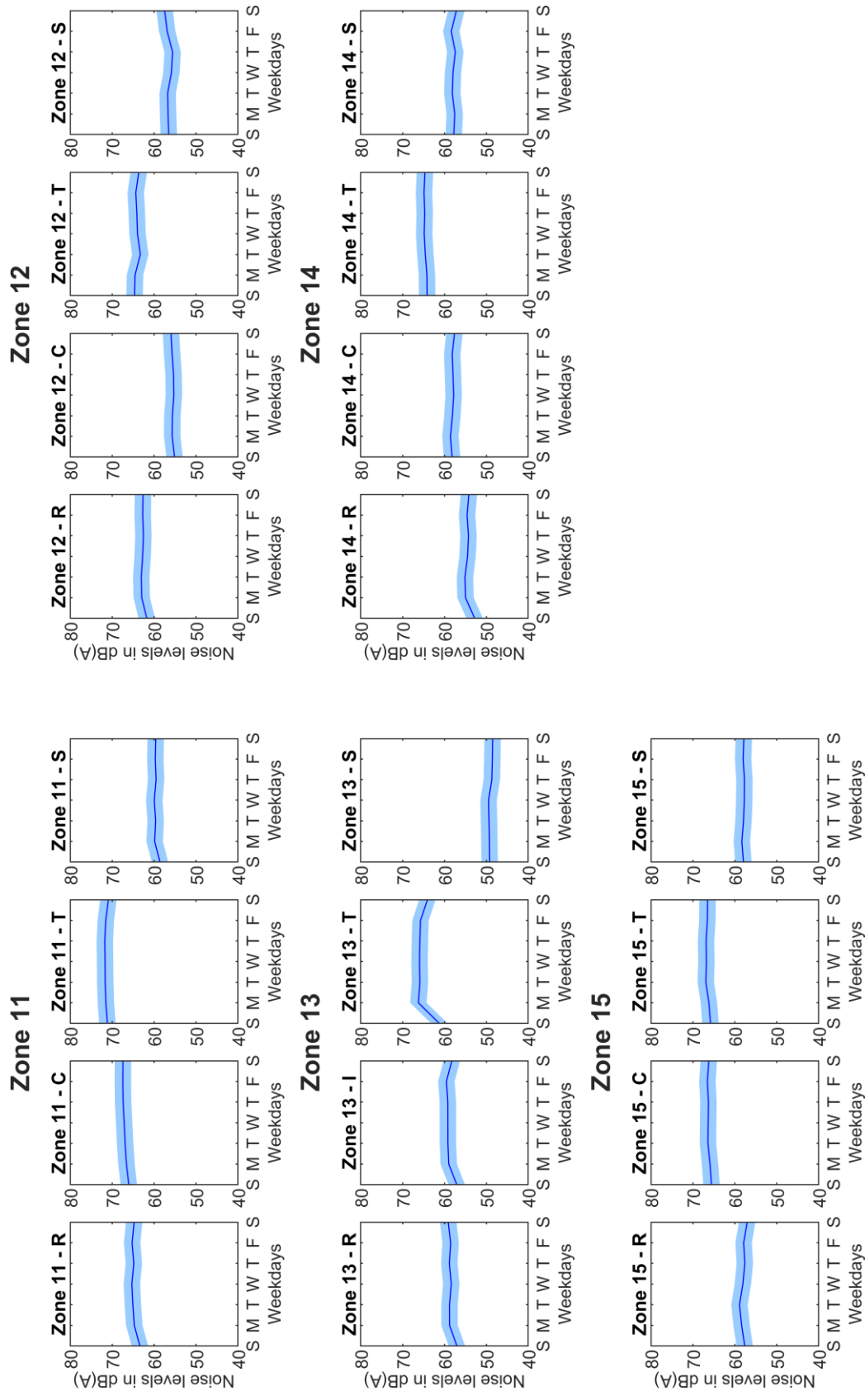


Figure 5.20 Weekly noise variations for the South zones

5.7.3 Heat map analysis

The heat map analysis distinctly illustrated the contrast between day and night noise levels across the city. Figure 5.21, Figure 5.22, Figure 5.23, Figure 5.24, Figure 5.25, Figure 5.26, Figure 5.27, Figure 5.28, Figure 5.29, and Figure 5.30 represent the day and night heat maps for the months of March, April, May, June, July, August, September, October, November, and December respectively. As expected, daytime levels were significantly higher in traffic-dominated and commercial zones, highlighting the role of vehicular flows and business activity as dominant sources. The most extreme case was observed at Zone11_T (Urban Primary Health Centre, Maduravoyal), where both daytime and nighttime noise levels remained equally high, indicating sustained exposure to transport-related noise throughout the day. In contrast, the lowest daytime levels were measured at Zone13_S (B.M. Birla Planetarium, Kotturpuram), a designated sensitive zone, while the lowest nighttime values were recorded at Zone13_T, reflecting localized land-use controls and reduced nocturnal activity. The heat map thus provided a spatially explicit understanding of hotspots and quieter pockets, offering critical evidence for targeted noise mitigation strategies.

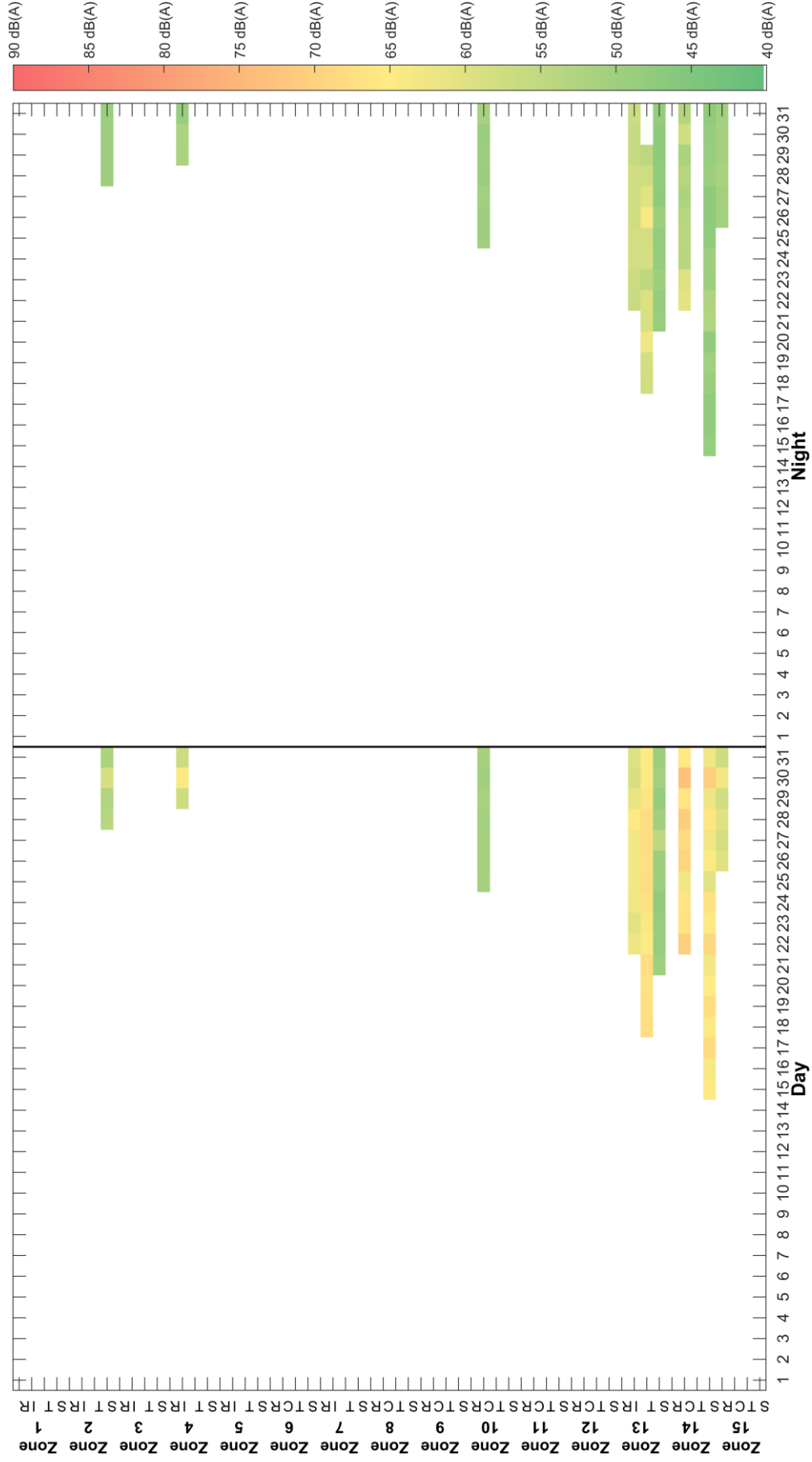


Figure 5.21 Heat map for the month of March 2025

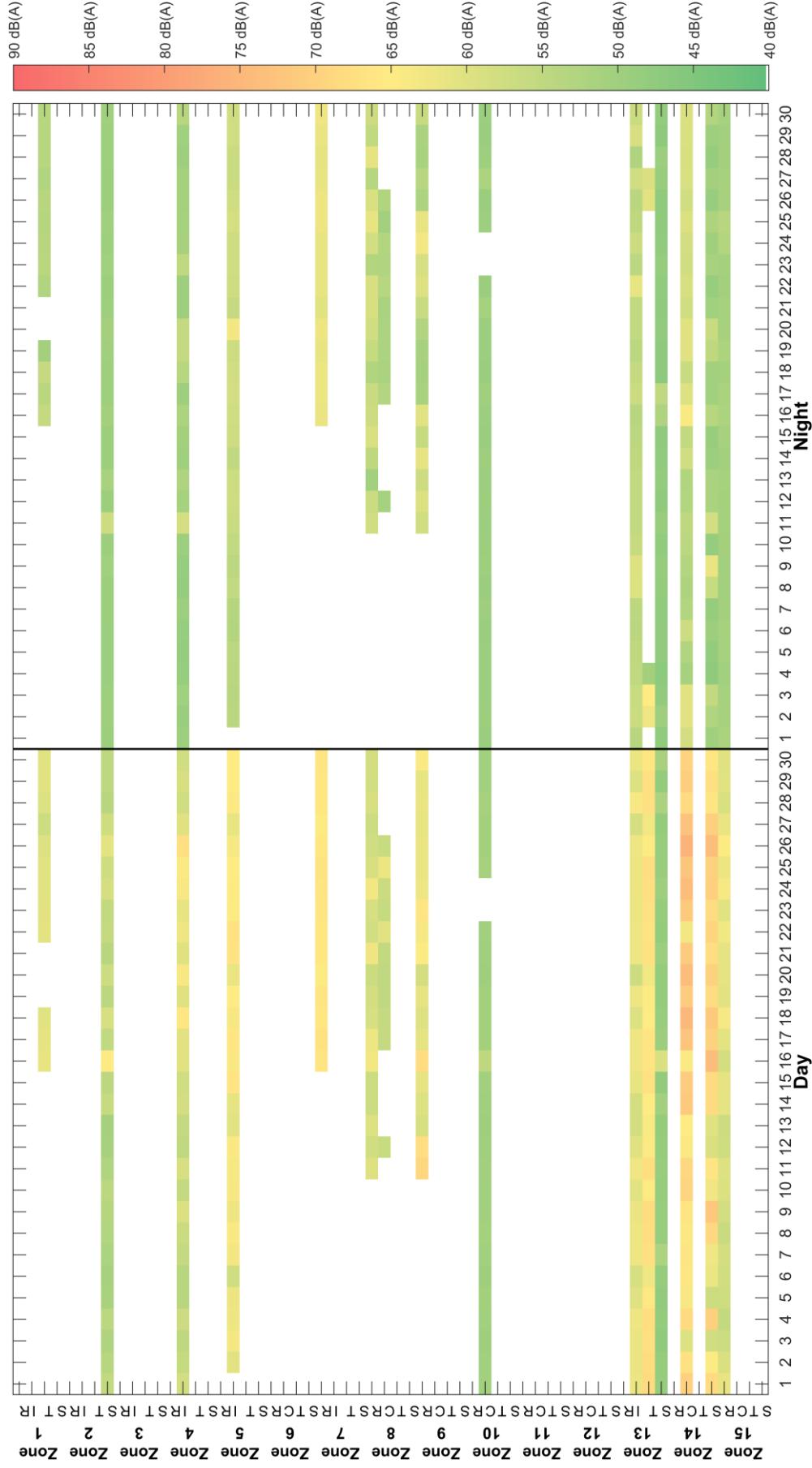


Figure 5.22 Heat map for the month of April 2025

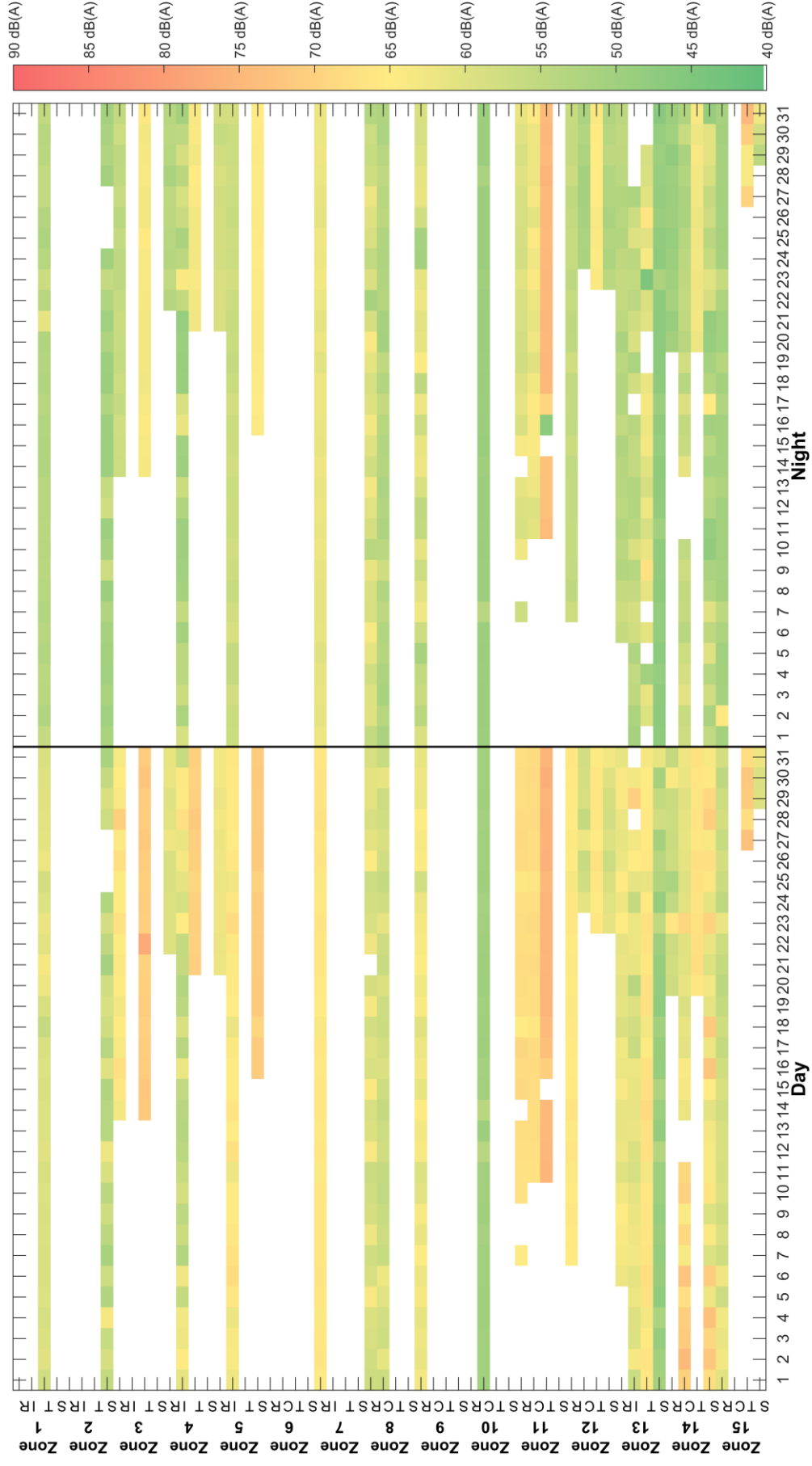


Figure 5.23 Heat map for the month of May 2025

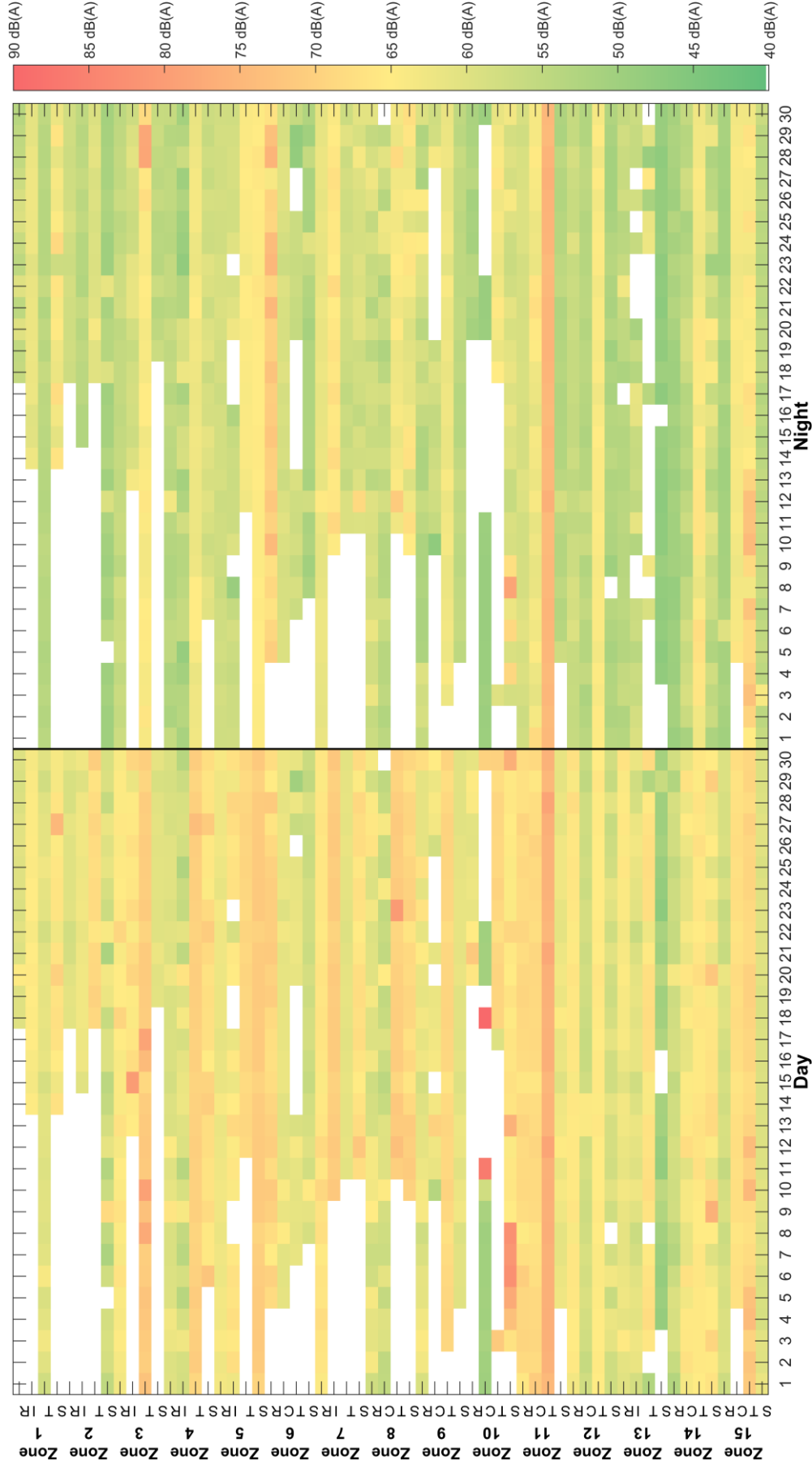


Figure 5.24 Heat map for the month of June 2025

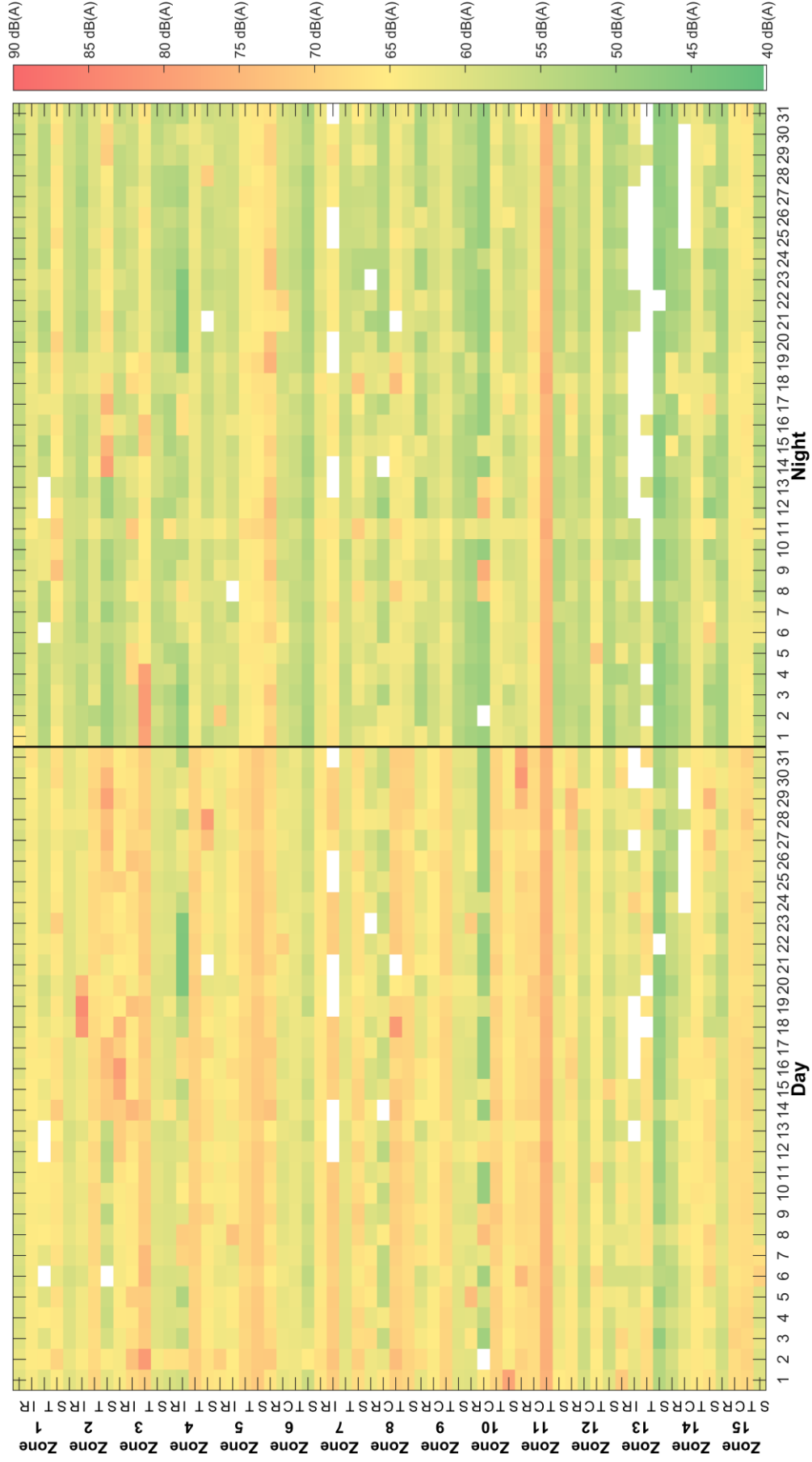


Figure 5.25 Heat map for the month of July 2025

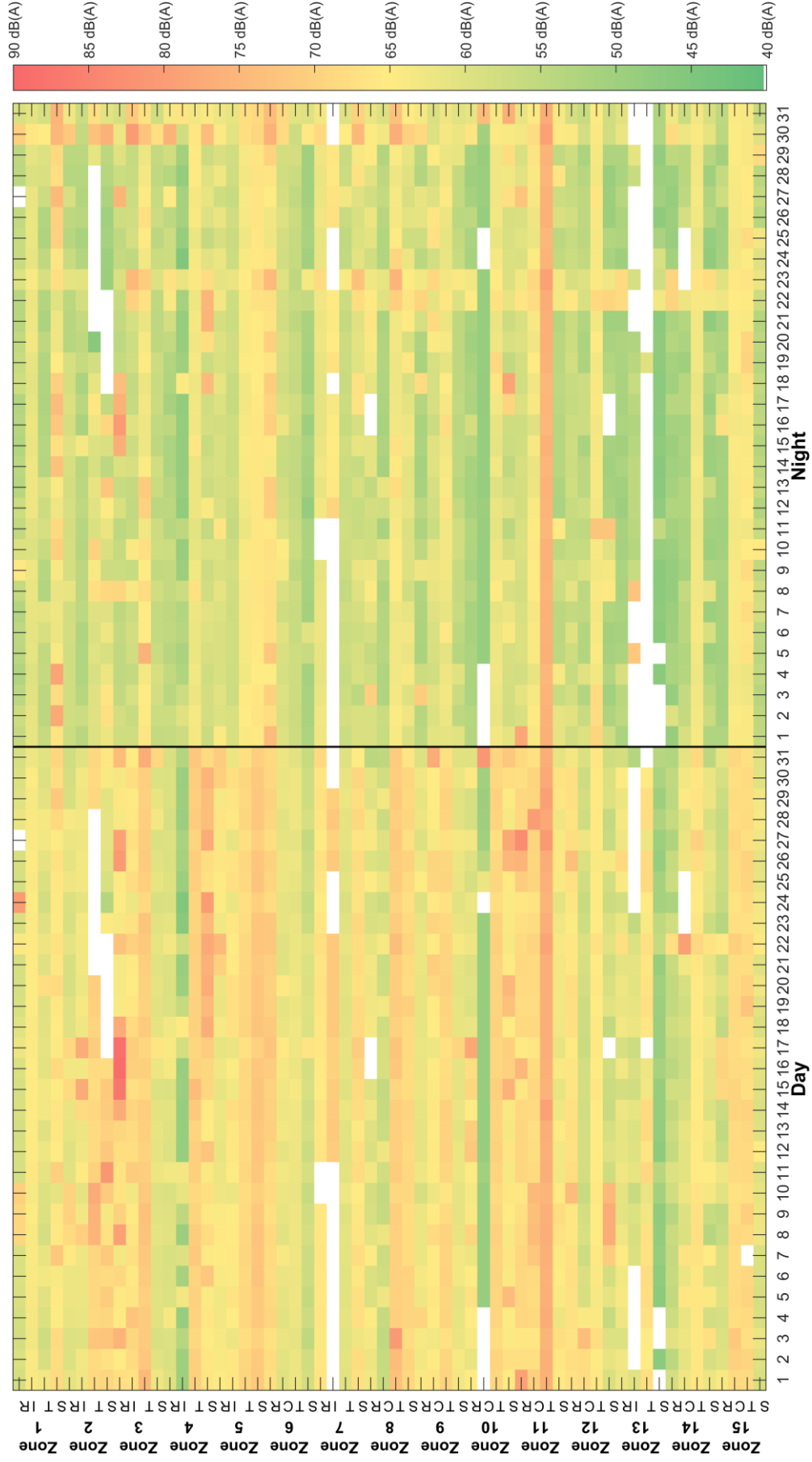


Figure 5.26 Heat map for the month of August 2025

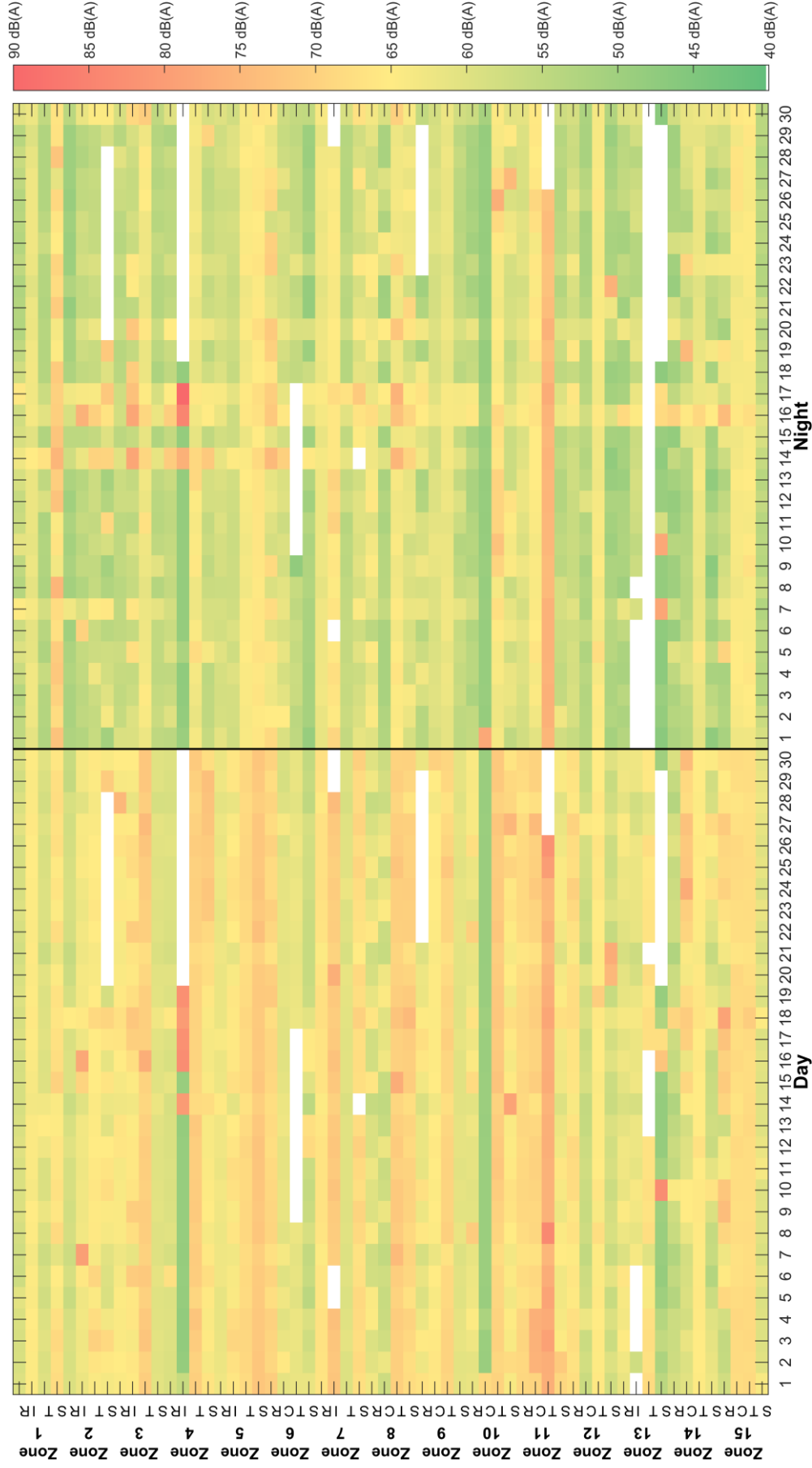


Figure 5.27 Heat map for the month of September 2025

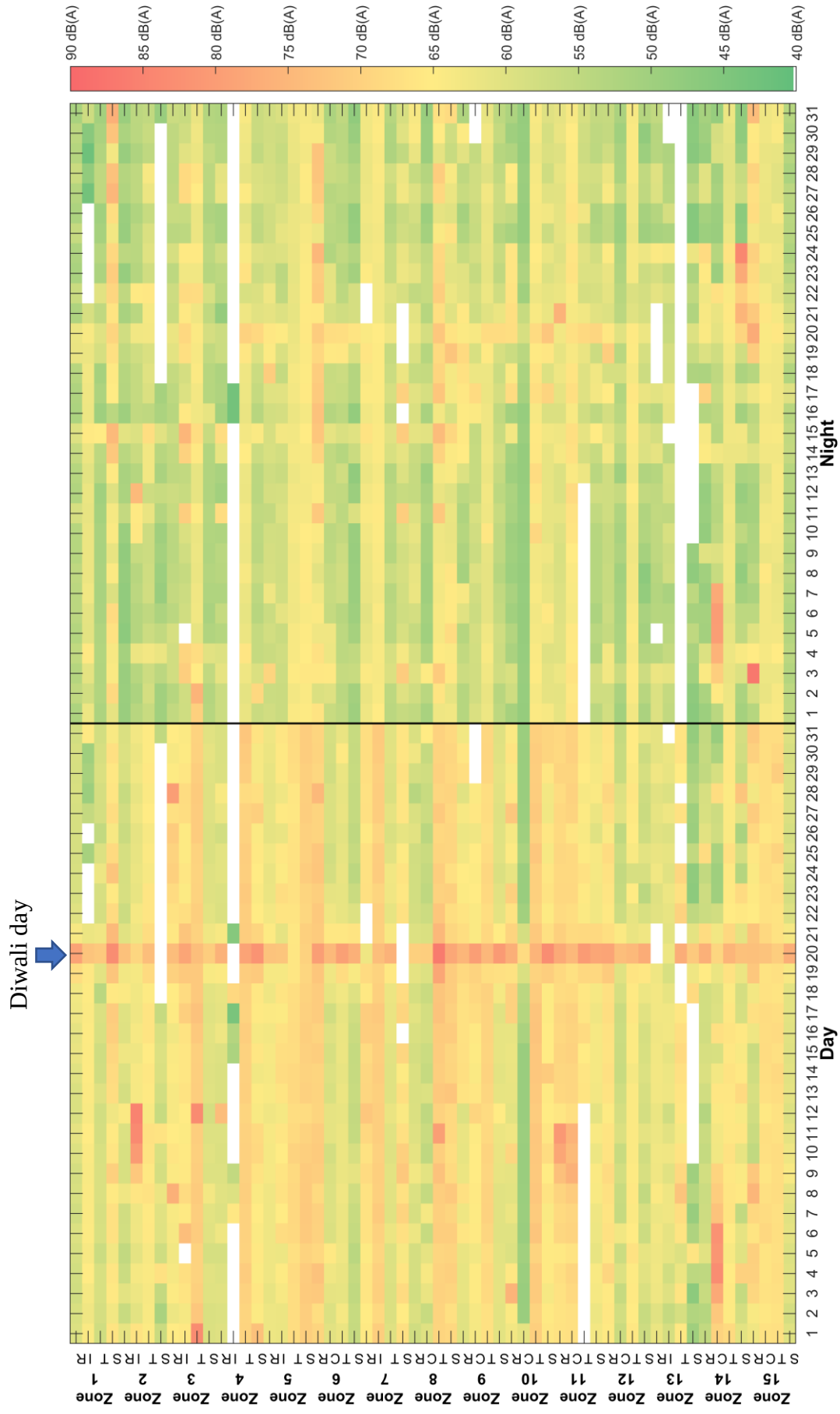


Figure 5.28 Heat map for the month of October 2025

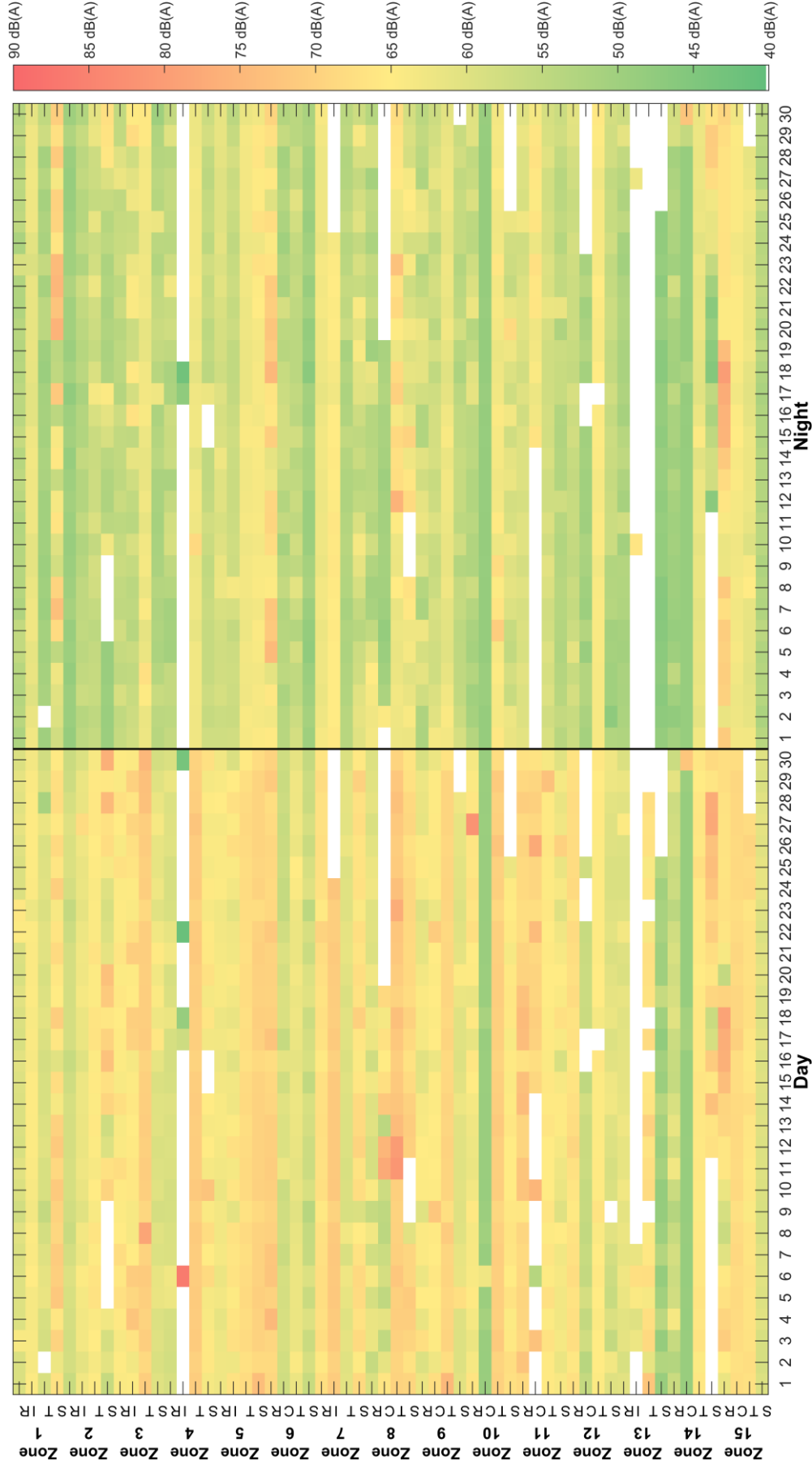


Figure 5.29 Heat map for the month of November 2025

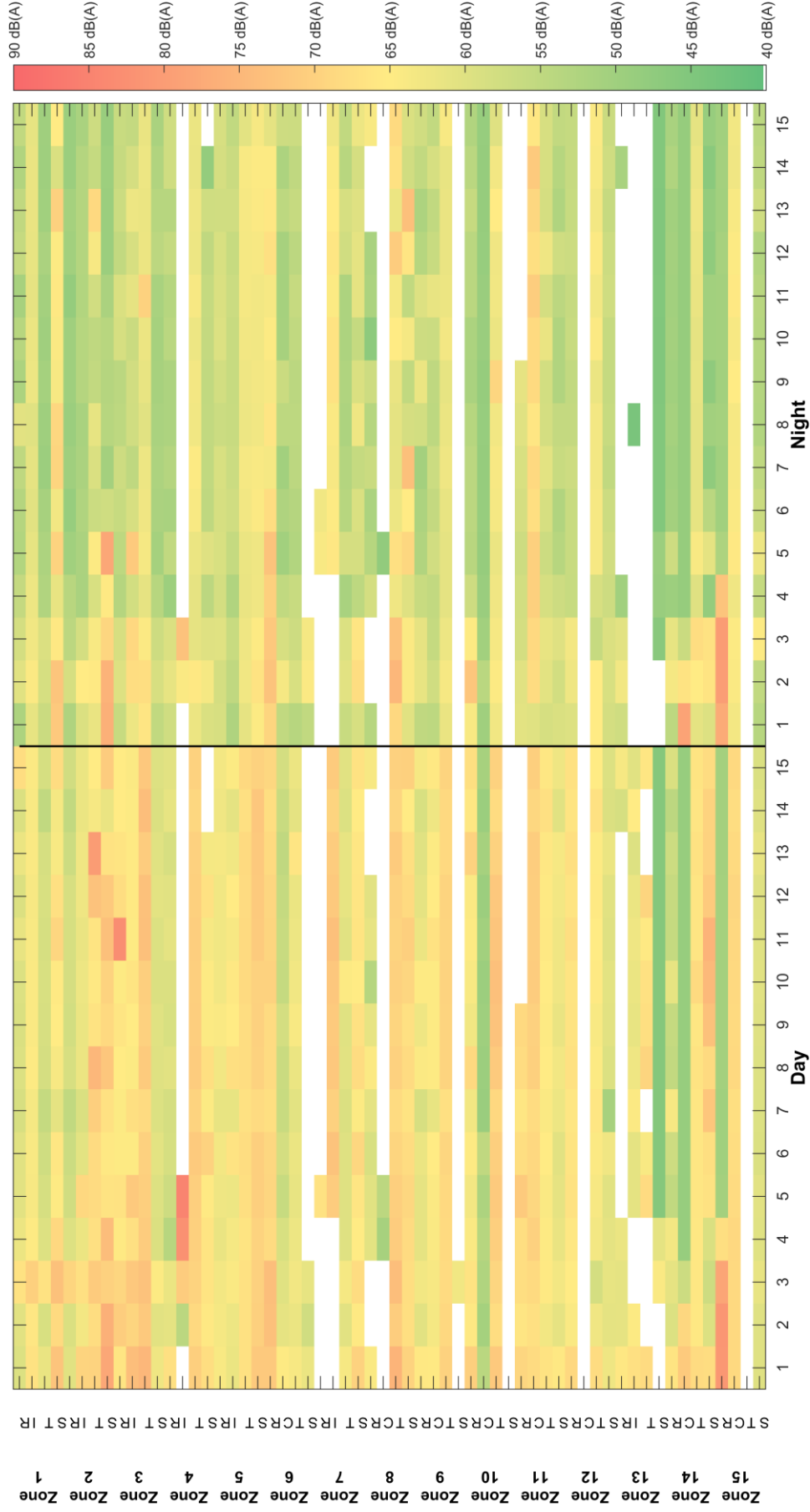


Figure 5.30 Heat map for the month of December 2025

5.7.4 Calendar plot analysis

The calendar plot revealed clear spatial and temporal clustering of noise levels across different urban zones (Figure 5.31, Figure 5.32, and Figure 5.33). The highest noise levels were consistently observed in Zone 7 (Ambattur) and Zone 11 (Valasaravakkam), both of which are characterized by dense traffic corridors and intense urban activity. By contrast, the lowest values were recorded in Zone 2 (Manali) and Zone 13 (Adyar), where traffic volumes and commercial intensity are relatively lower. Additionally, low levels were also noted in Zone 6 (Thiru-vi-ka-nagar), and Zone 12 (Alandur), suggesting that residential layouts and land-use characteristics provide some acoustic relief in these areas. Seasonal variation was also evident, with noise levels during the summer months generally lower than those observed during the monsoon, reflecting the combined influence of climatic conditions, traffic density, and social activity patterns on the urban soundscape.

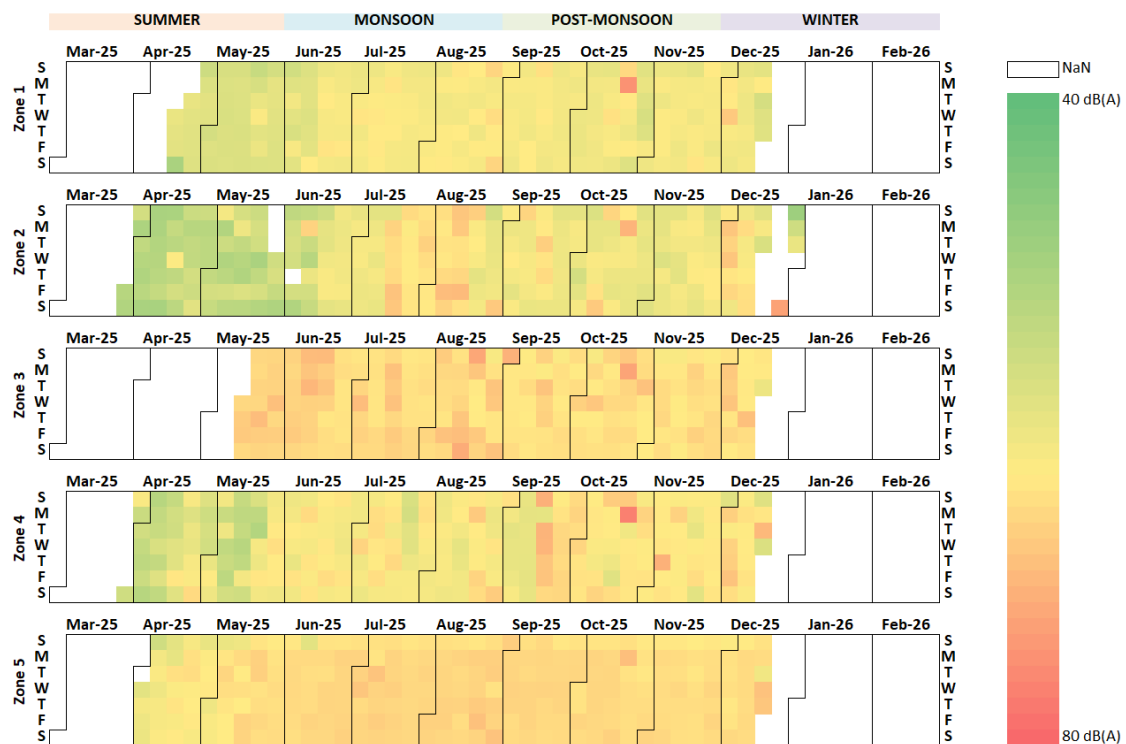


Figure 5.31 Calendar plot for North zones

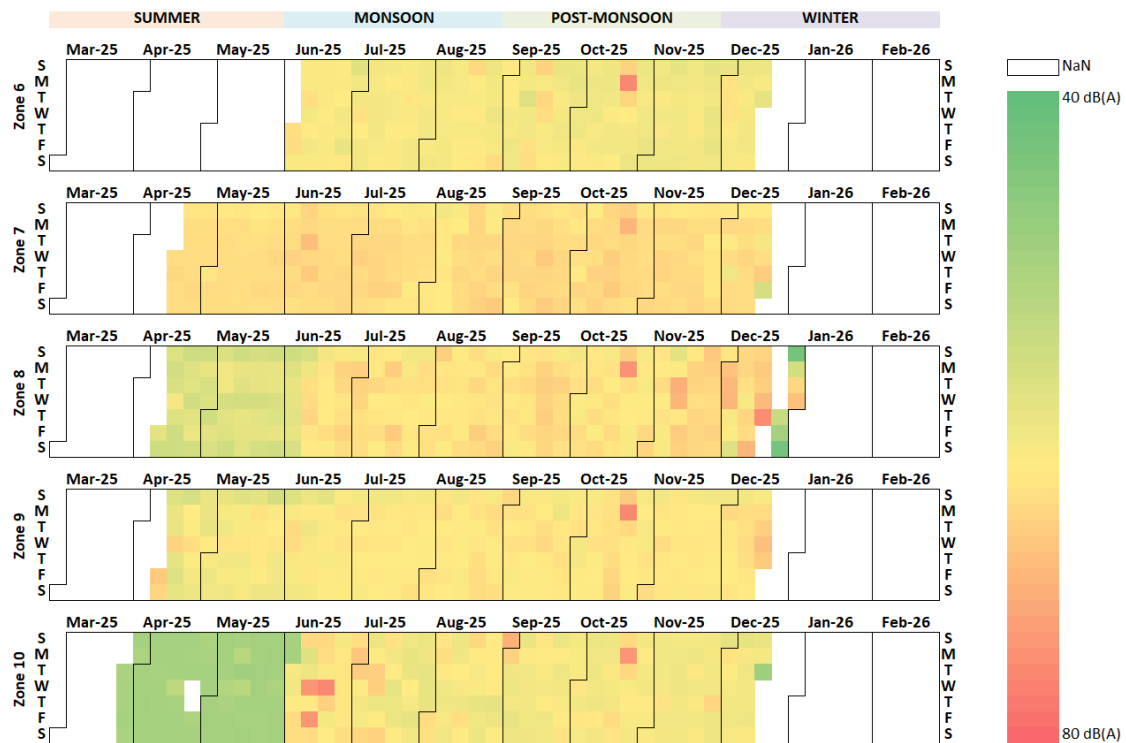


Figure 5.32 Calendar plot for Central zones

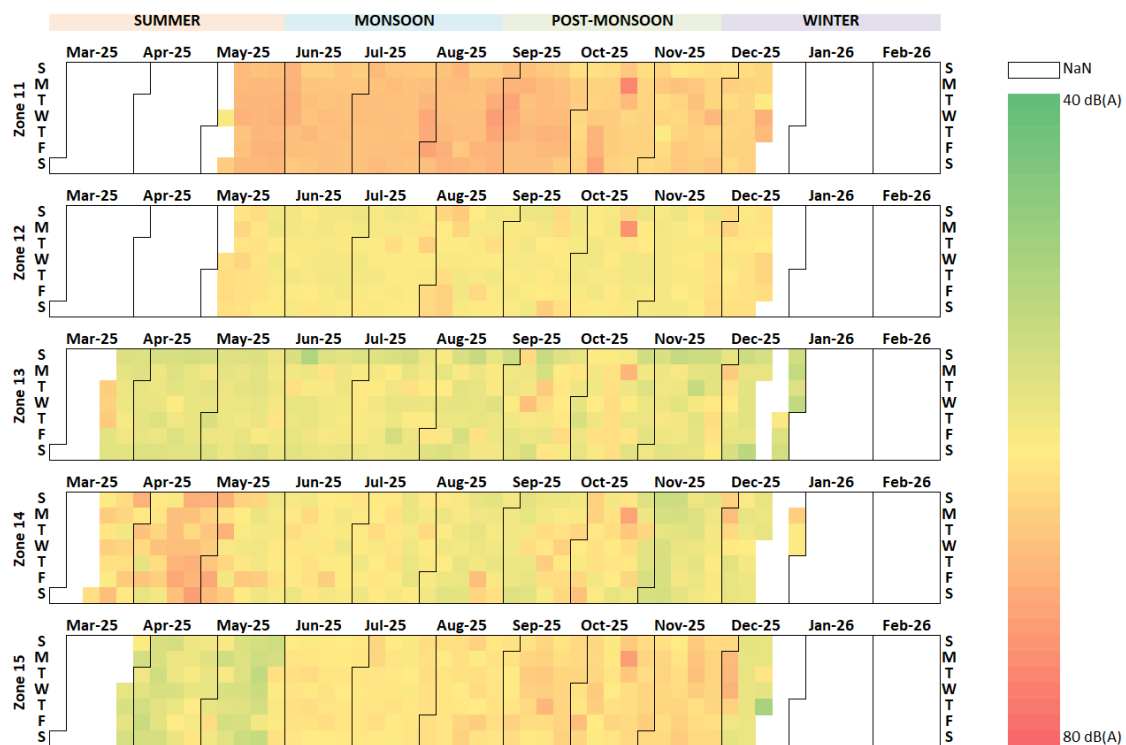


Figure 5.33 Calendar plot for South zones

The monitoring results clearly demonstrate that Chennai's urban environment is dominated by road-traffic-related noise, resulting in city-wide exceedance of CPCB

standards. Persistent violations in residential and sensitive zones raise serious concerns about public health impacts, including risks of sleep disturbance, cardiovascular stress, and cognitive impairment. The predominance of spatial homogeneity suggests that traffic control, stricter enforcement, and the integration of noise-mitigating infrastructure (e.g., green buffers, barriers, and regulated construction schedules) could yield benefits at a city-wide scale. At the same time, the presence of localized heterogeneity underscores the importance of targeted interventions for specific land-use contexts, especially in silent and commercial zones.

6. NOISE MAPPING

This chapter discusses the concept of noise mapping, emphasizing its importance as a tool for assessing and managing urban noise environments. It outlines the development of both spatial and strategic noise maps, which provide detailed insights into localized noise levels and city-wide noise exposure patterns, respectively. The chapter further presents and analyzes noise maps generated for the months of March to July, highlighting key results and their implications for identifying hotspots, assessing compliance with standards, and guiding noise mitigation strategies..

6.1 Basics of noise mapping

Noise mapping is a modern and effective tool used to visualize the distribution of environmental noise in a given area. A noise map is essentially a graphical representation of sound levels across different locations, developed using data collected over a defined period of time. These maps can be generated for single noise sources such as road traffic noise, railway noise, aircraft noise, or industrial noise or for a combination of multiple sources, offering a comprehensive understanding of the noise climate in urban and rural settings.

The primary objective of noise mapping is to provide an evidence-based assessment of how noise impacts communities and the environment. By analyzing these maps, urban planners, policymakers, and environmental agencies can identify areas that exceed permissible noise limits, thereby highlighting zones that may pose health risks to residents. This data-driven approach facilitates informed decision-making for noise control and management. Additionally, noise maps serve as a vital monitoring tool to evaluate the effectiveness of existing mitigation strategies. The implementation of noise barriers, restrictions on traffic movement, or changes in industrial operations can be studied through updated noise maps to determine whether these interventions have reduced noise levels. As such, noise mapping not only assists in current noise management but also plays an important role in forecasting and preparing for future urban expansion and associated noise challenges.

Noise maps hold significant importance for public awareness and engagement. By making these maps accessible, city residents gain a clearer understanding of noise

exposure in their neighbourhoods, empowering them to participate in discussions on environmental quality. Thus, noise mapping bridges the gap between scientific analysis, governance, and community participation, making it an essential component of sustainable urban development.

The benefits of noise mapping may be summarised as follows:

- Identifies noise hotspots in urban areas
- Ensures compliance with existing noise standards
- Assists in meeting future policy requirements related to environmental noise
- Helps integrate noise action plans into broader city/state development strategies
- Facilitates the evaluation of effectiveness of noise mitigation strategies

6.2 Methodology for noise mapping

The development of a noise map begins with the collection of accurate and reliable noise data. This typically involves deploying noise monitoring sensors at selected GPS-referenced locations across the city. Since it is not feasible to monitor noise at every point in an urban area, sampling points are carefully chosen to represent traffic density, land use patterns, and potential noise sources. The measured data is then integrated with digital spatial information of the city, including road networks, building layouts, industrial zones, and open spaces. Using geo-statistical and spatial modelling techniques, the measured data is interpolated to predict noise levels in areas without direct measurements. This allows the generation of a continuous noise surface map that covers the entire city, effectively translating scattered sensor readings into a comprehensive view of the noise environment. Typically, separate maps are generated for day and night periods, as noise levels and human sensitivity to noise vary across time.

The final outputs include maps of noise levels at different times of day and identification of high-risk zones, which can then be compared against prescribed noise standards. Such maps enable decision-makers to pinpoint critical noise-affected areas, prioritize them for intervention, and develop noise abatement measures such as zoning adjustments, traffic diversions, or installation of sound barriers.

This study generates two types of noise maps: spatial noise maps and strategic noise maps. A spatial noise map is generated solely based on the measured noise levels at the monitoring location while a strategic noise map is generated by interpolating the measured noise levels across the city.

A spatial noise map provides a direct representation of the measured noise levels at specific monitoring station locations across the city. These maps are constructed using only the observed data from the deployed sensors, without applying interpolation or predictive modelling. As such, they offer a highly localized and accurate view of the noise environment at the measurement points themselves. Spatial noise maps are particularly useful for identifying immediate hotspots, such as busy traffic intersections, commercial areas, or zones surrounding sensitive locations like schools and hospitals. However, since they rely exclusively on measured data, spatial noise maps do not capture the complete noise profile of areas between monitoring points. Their primary strength lies in their reliability and precision at known sites, making them valuable for validating models, tracking temporal variations, and assessing compliance with prescribed standards at the monitoring stations.

In contrast, a strategic noise map provides a comprehensive city-wide representation of noise levels. It is generated by combining the measured data with spatial interpolation techniques to estimate noise levels at locations where no direct measurements were made. This approach creates a continuous noise distribution surface, allowing visualization of noise exposure across the entire study area. Strategic noise maps are not limited to point-specific measurements but instead integrate the influence of multiple factors such as traffic density, land use, and built environment. They are especially useful for long-term planning and policy development, as they can highlight high-exposure zones, identify populations at risk, and evaluate the effectiveness of noise mitigation strategies at a broader scale..

6.3 Noise mapping results

6.3.1 Spatial noise maps

The spatial noise maps provide a visualization of noise level variations across the measurement locations, with a suitable colour code assigned to represent values ranging from 45 dB(A) to 80 dB(A). Figure 6.1 presents the spatial noise map for both

day and night time. These maps highlight both spatial and temporal variations in noise levels across different land-use categories and monitoring zones.

The spatial noise map (Figure 6.1) shows a clear difference between day and night noise levels, with day values consistently higher. At one location, Zone11_T (Urban Primary Health Centre, Maduravoyal), the daytime and nighttime L_{eq} exceeded 75 dB(A). Several other traffic-dominated zones recorded levels between 70 and 75 dB(A), while the majority of locations registered values in the range of 65 – 70 dB(A) during the day. At night, noise levels were generally lower, falling between 55 and 65 dB(A), indicating a reduction of approximately 3 – 5 dB(A) compared to daytime levels.

The monthly spatial noise maps are shown in APPENDIX E. In March and April, only a limited number of monitoring stations were operational. Despite this, the results consistently showed that daytime noise levels exceeded nighttime values, with nighttime levels remaining below 65 dB(A) (Figure E.1 and Figure E.2). By May, higher noise levels were recorded at multiple locations. Zone11_T (Urban Primary Health Centre, Maduravoyal) exceeded 74 dB(A) during both day and night, while Zone3_T (Corporation Ward Office - 25 - Madhavaram) and Zone5_S (Rajiv Gandhi Government General Hospital) exceeded 70 dB(A) during the day (Figure E.3). Several traffic, residential, and commercial zones registered noise levels between 65 and 70 dB(A), although the majority of sites remained within the 55 – 65 dB(A) range during daytime. Nighttime levels, however, remained below 65 dB(A).

For June and July, the maps reveal that noise levels were comparatively higher in June than in July. During June, many locations recorded levels above 70 dB(A), with two sites [Zone11_T (Urban Primary Health Centre, Maduravoyal) and Zone10_C (Corporation Office (Division 136), T Nagar)] exceeding 75 dB(A) during the day (Figure E.4). In contrast, July showed slightly lower levels across most sites, although daytime levels still remained above 65 dB(A) in many areas (Figure E.5). Nighttime noise levels in both months remained below 65 dB(A) for the majority of monitoring locations, reaffirming the general trend of lower noise exposure during night. During August, daytime levels at two locations [Zone11_T (Urban Primary Health Centre, Maduravoyal) and Zone3_R (Sanitary Inspector Office, Surapet)] exceeded 75 dB(A),

while majority of levels were between 65 – 75 dB(A) (Figure E.6). During night, levels at majority of locations ranged between 60 – 70 dB(A).

During September, levels at two locations [Zone11_T (Urban Primary Health Centre, Maduravoyal) and Zone4_I (Manual AQM station, Kodungaiyur)] exceeded 75 dB(A) during both day and night (Figure E.7). For most other locations, the nighttime levels were lower than daytime levels. For the October month, the daytime levels were much higher due to the occurrence of the Diwali festival (Figure E.8). Many stations had levels between 70 and 75 dB(A). Nighttime values for a majority of stations varied from 55 to 65 dB(A). Daytime levels during November exceeded 75 dB(A) at two locations [Zone4_I (Manual AQM station, Kodungaiyur) and Zone13_S (B.M. Birla Planetarium, Kotturpuram)] (Figure E.9). The nighttime levels were comparatively lower and ranged from 50 to 60 dB(A) in a majority of locations. During the month of December, daytime level at one location [Zone4_I (Manual AQM station, Kodungaiyur)] exceeded 75 dB(A), while the nighttime levels ranged from 50 to 60 dB(A) in a majority of locations (Figure E.10).

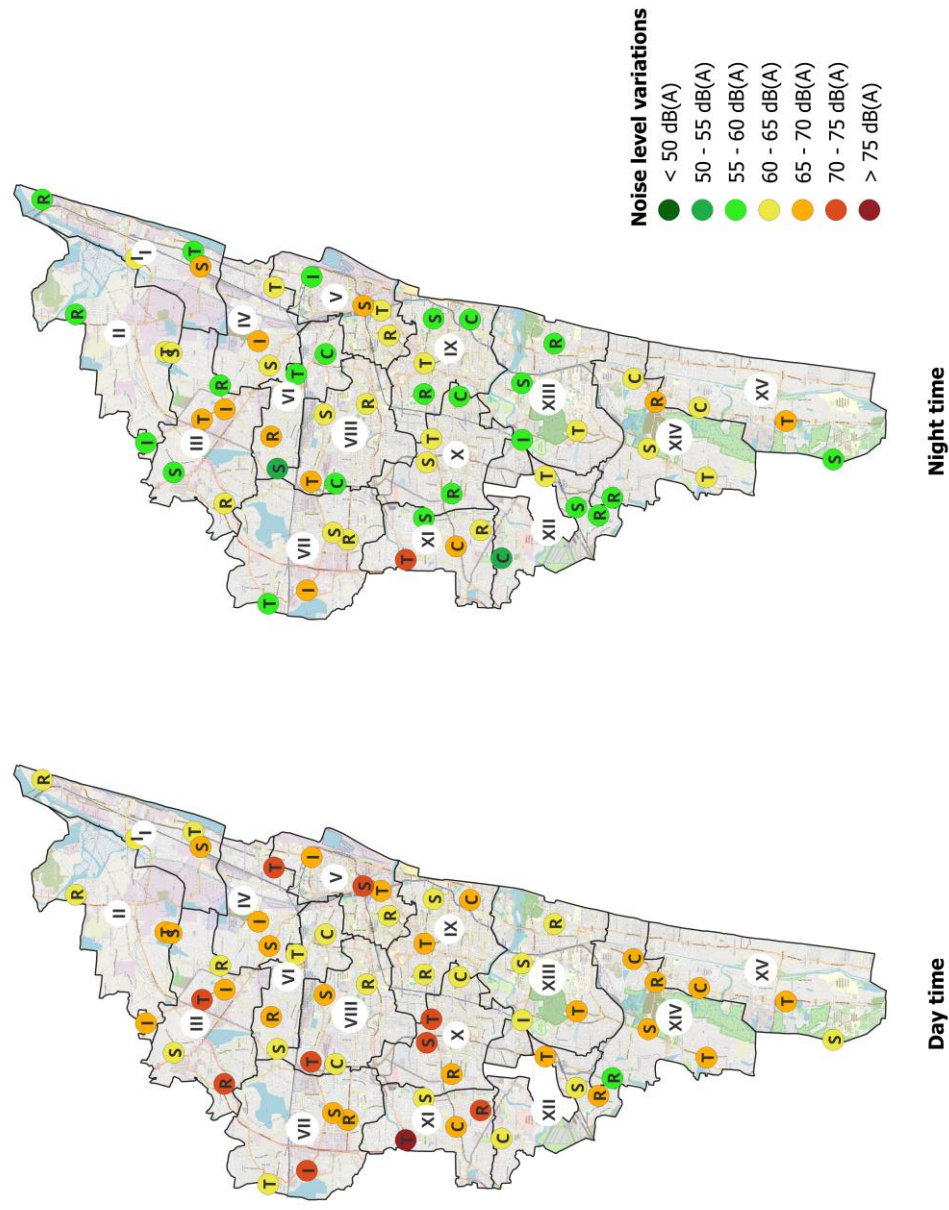


Figure 6.1 Spatial noise maps for day and night time

6.3.2 Strategic noise maps

Strategic noise maps were developed using spatial interpolation techniques to generate a continuous representation of noise distribution across the entire city. Unlike spatial maps, which show point-specific measurements, strategic maps allow visualization of noise patterns in areas where no sensors were deployed, thereby providing a comprehensive overview of the city's acoustic environment. Figure 6.2 shows the strategic noise map developed for day and night L_{eq} values.

The strategic noise map reveals a distinct difference between day and night noise levels, with daytime values consistently higher (Figure 6.2). Several locations in Zones III, IV, V, VII, VIII, X, and XI recorded levels exceeding 70 dB(A) during the day, marking them as prominent noise hotspots. In contrast, night time noise levels were generally lower, mostly falling within the 50 – 65 dB(A) range. This highlights the persistence of elevated daytime noise exposure in certain zones, while night time conditions are comparatively quieter. The monthly strategic noise maps are shown in APPENDIX E. During March and April, noise variations were minimal due to the limited deployment of sensors. The maps for these months primarily show variation in the southern zones, where sensors were available. In May, distinct spatial patterns emerged, with Zones III, IV, V, XI, and XV exhibiting consistently higher levels, while Zones II and XIII recorded comparatively lower noise levels. The June maps highlight elevated noise levels across most of northern and central Chennai, with Zone XI continuing to show higher noise exposure even during night time. Most of the hotspot locations visible during June persisted in July also. Distinct hotspot locations were visible in Zone III and Zone XI during August month also. The noise maps for September showed patterns similar to those observed in August, indicating sustained noise exposure in these regions. In October, daytime noise levels were slightly higher, likely attributable to Diwali-related activities. Overall, the noise maps for October, November, and December exhibited similar spatial patterns, with the emergence of new hotspot locations, particularly in southern Chennai.

Both spatial and strategic noise maps illustrate that daytime noise levels are consistently higher than night time values, and they clearly capture both spatial and temporal variations across the study period. Zones III and XI emerge as persistent noise hotspots, while Zone XIII is identified as a relatively quiet area.

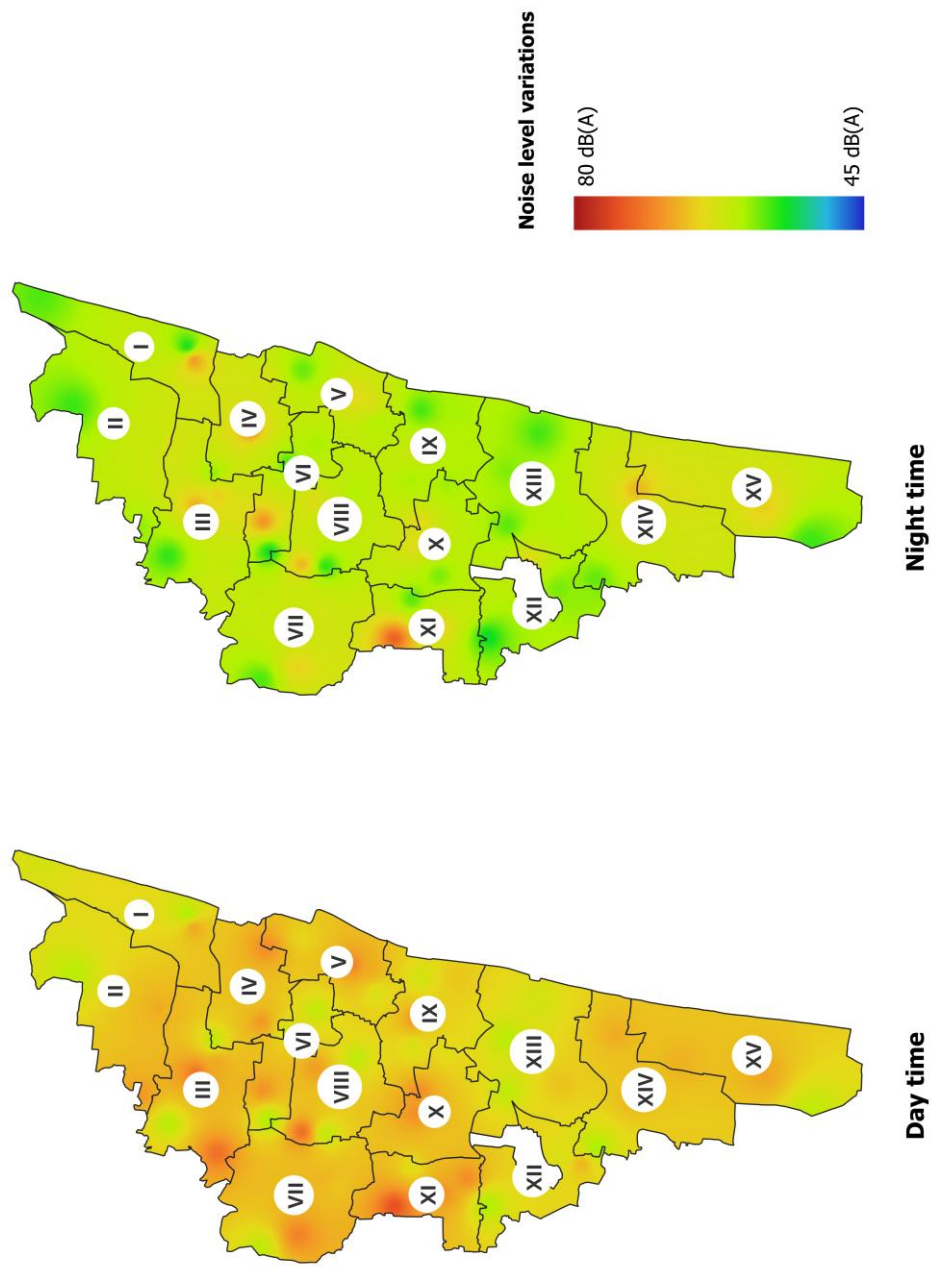


Figure 6.2 Strategic noise maps for day and night time

7. URBAN NOISE POLLUTION MANAGEMENT FRAMEWORK

Overall, the results reinforce the urgent need for comprehensive noise management policies, supported by continuous monitoring and evidence-based urban planning. The findings not only highlight the magnitude of Chennai's noise pollution problem but also demonstrate the utility of spatial noise mapping in identifying hotspots, prioritizing mitigation efforts, and guiding policy for healthier urban environments.

The urban environment of Chennai is rapidly evolving and is characterised by diverse land-use patterns, due to which, the noise levels varies significantly across residential, industrial, commercial, traffic-dominated, and noise-sensitive areas. A uniform mitigation approach is therefore inadequate to address the varying sources, exposure pathways, and vulnerability of affected populations. In this context, the following sections propose location-specific noise control measures tailored to the functional characteristics of each zone, alongside technical and policy recommendations aimed at strengthening Chennai's overall noise management framework. By integrating engineering controls, urban planning strategies, regulatory instruments, and people-centric mobility concepts, these recommendations seek to support effective noise reduction, improved public health outcomes, and the development of a more livable and acoustically sustainable city.

7.1 Location-specific noise control measures

7.1.1 Residential areas

Residential zones require both building-level interventions and neighbourhood-level planning to effectively mitigate noise exposure.

Building and architectural measures

- Use of sound-absorbing materials in walls, ceilings, and facades.
- High-performance doors - Doors with molded plates and honeycomb or closed-air core fillings for improved sound insulation (Garg et al., 2012; Xu, Zhang, & Ma, 2014).

- High-performance windows - Double hollow or double-glazed glass windows to reduce airborne noise (Garg et al., 2012; Xu, Zhang, & Ma, 2014).
- Wall insulation using materials such as glass wool, mineral wool, rock wool, or vermiculite; higher density and thickness improve low-frequency noise attenuation (Figure 7.1 and Figure 7.2).
- Floor insulation using high-quality surface layers to reduce impact and structure-borne noise (Xu, Zhang, & Ma, 2014).
- Interior furnishings - Wooden furniture and fabric-based furnishings to enhance sound absorption and diffusion (Xu, Zhang, & Ma, 2014).
- Vibration isolation for household equipment (Xu, Zhang, & Ma, 2014).
- Air-conditioning noise control, including silenced air outlets and lined ducts (Xu, Zhang, & Ma, 2014).

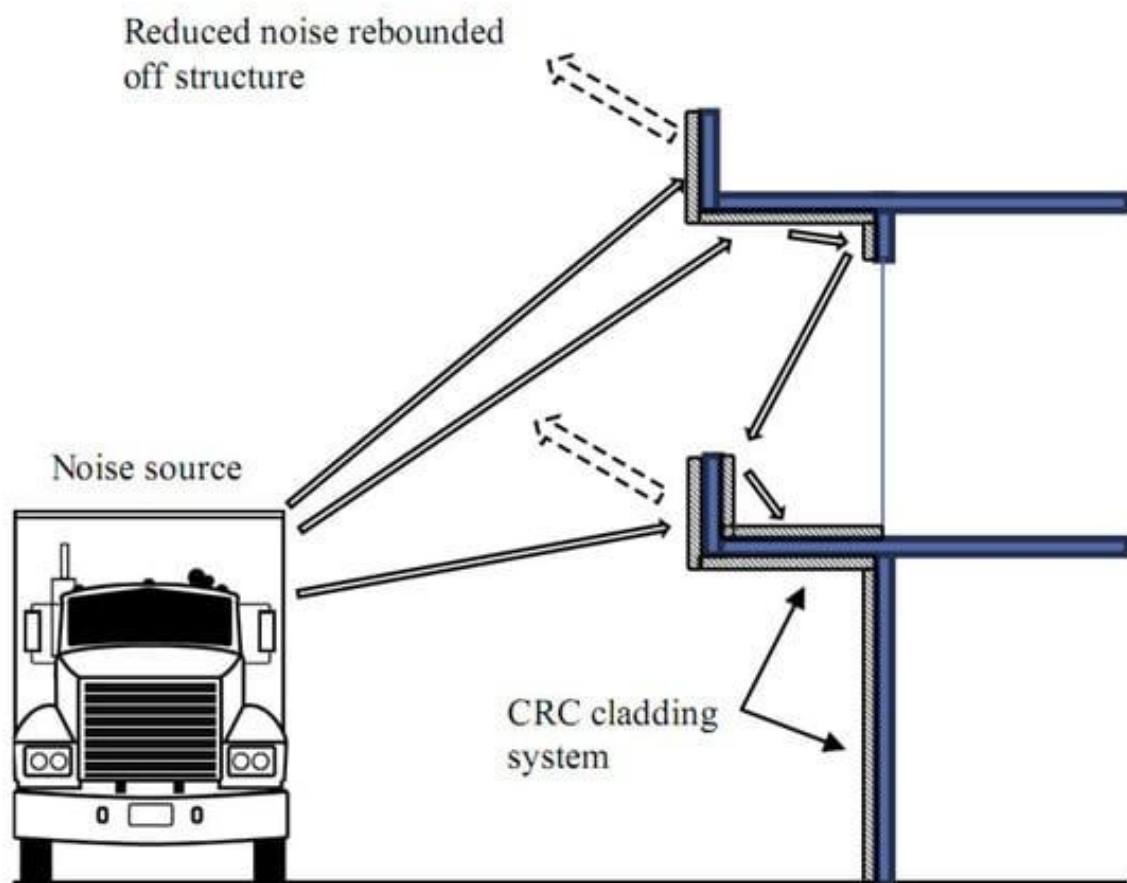


Figure 7.1 A crumb rubber concrete (CRC) cladding installed on a multi-storey structure to avoid the diffusion of sound (Fediuk et al., 2021)

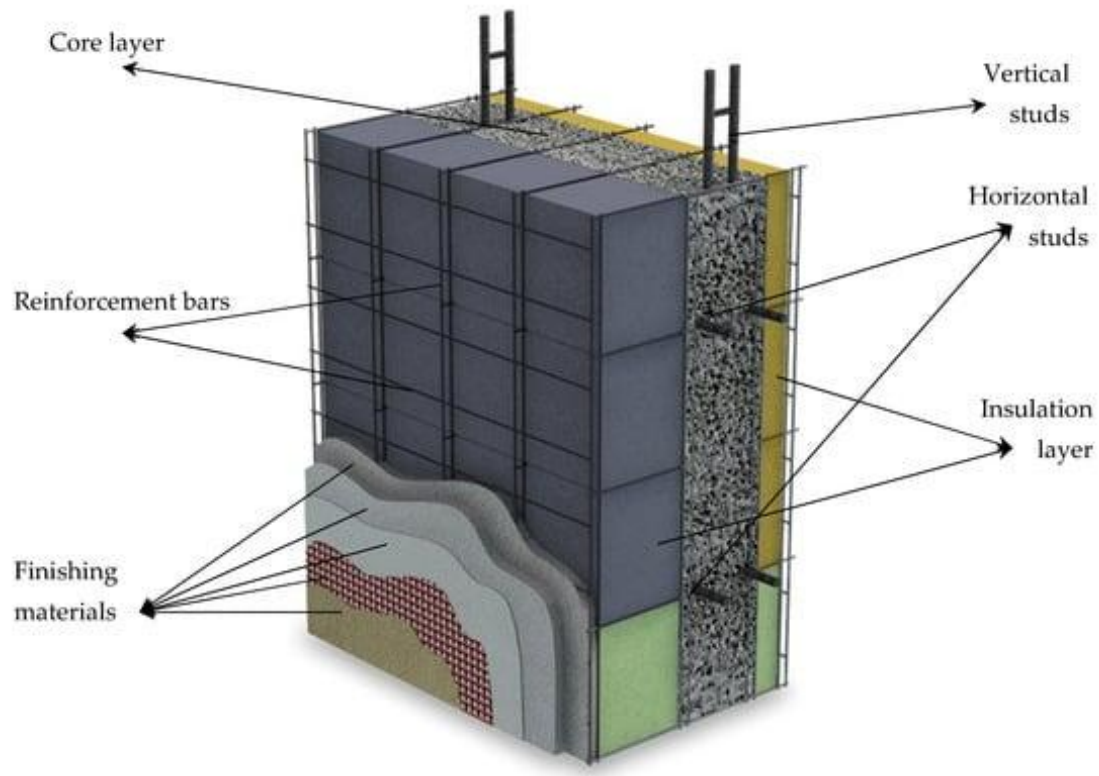


Figure 7.2 Model for the construction of reinforced concrete walls with extremely high acoustic insulation (Fediuk et al., 2021)

Site planning and layout measures

- Logical regional planning separating residential areas from industrial and high-traffic corridors (Xu, Zhang, & Ma, 2014).
- Strategic room placement - bedrooms and living areas located farthest from noise sources (Garg et al., 2012).
- Minimization of wall openings facing noise sources.
- Installation of sound barriers along major roads and rail corridors.
- Use of natural barriers such as vegetation and terrain, particularly effective for low-rise housing (Figure 7.3).
- Placement of balconies away from noise sources; use of sound-absorbing materials on balcony undersides in high-rise buildings (Garg et al., 2012).
- Incorporation of courtyards and open spaces as acoustic buffers.

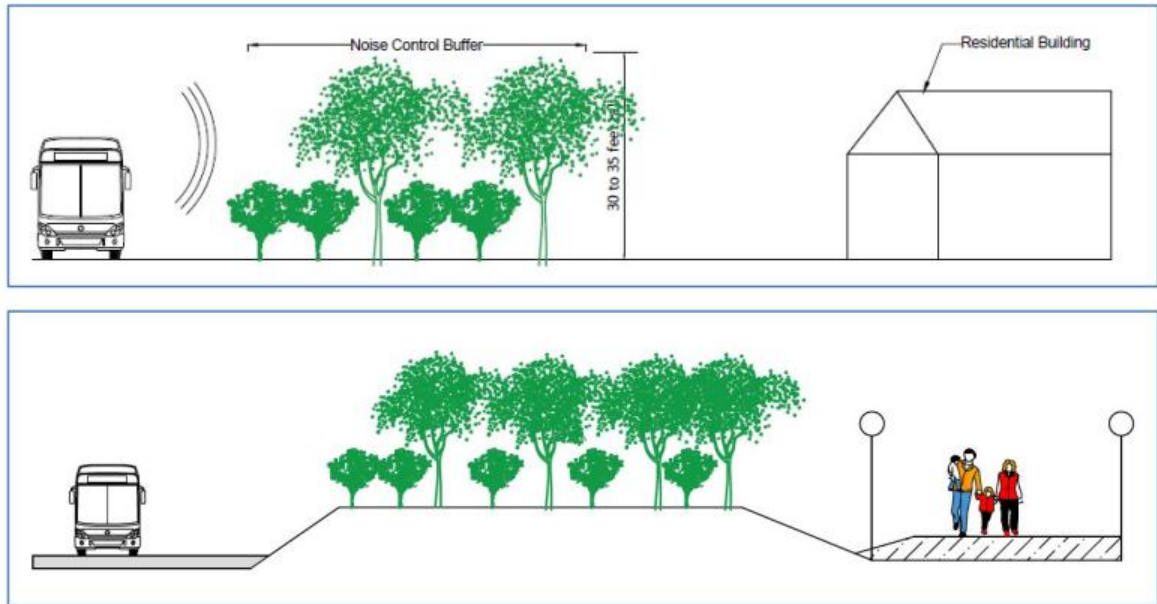


Figure 7.3 Use of natural barriers for noise reduction (Sultan et al., 2024)

Urban design

- Maximizing distance between noise sources and residences.
- Locating noise-compatible land uses (commercial spaces, parking areas) between noise sources and dwellings.
- Using buildings themselves as noise shields.
- Orienting noise-sensitive buildings away from dominant noise sources.

Planned Unit Development (PUD)

- Concentration of buildings to preserve open spaces that act as noise buffers.
 - Integration of green spaces between roads and housing clusters.
 - Optimization of building shape, orientation, and internal spatial arrangement.
- (Garg et al., 2012).

7.1.2 Industrial areas

Industrial noise control should prioritize source reduction, followed by path control and receiver protection.

Design and engineering controls

- Incorporation of noise control during initial machine and factory design.

- Use of mufflers, enclosures, barriers, vibration isolation systems, and high transmission-loss factory walls.
- Strategic layout planning to separate noisy machinery from workers and quieter processes.

Maintenance and operational controls

- Regular maintenance: balancing equipment, lubrication, replacement of worn parts.
- Use of properly sharpened and shaped cutting tools.

Substitution strategies

- Material substitution (e.g., plastic for metal components).
- Equipment substitution (electric tools instead of pneumatic; hydraulic presses instead of mechanical).
- Component substitution (helical gears for spur gears; damped saw blades; belt drives instead of gear drives).
- Process substitution (pressing instead of forging; welding instead of riveting; progressive pressure instead of impact operations).
- Replacement of internal combustion engines with electric motors.

Administrative measures

- Minimizing simultaneous operation of noisy machines.
- Use of partial or full enclosures and lined ducts.
- Reverberation control using sound-absorbing materials.
- Application of active noise control where feasible.
- Provision of personal protective equipment (earplugs, headsets).
- Sound-insulated control rooms for operators.

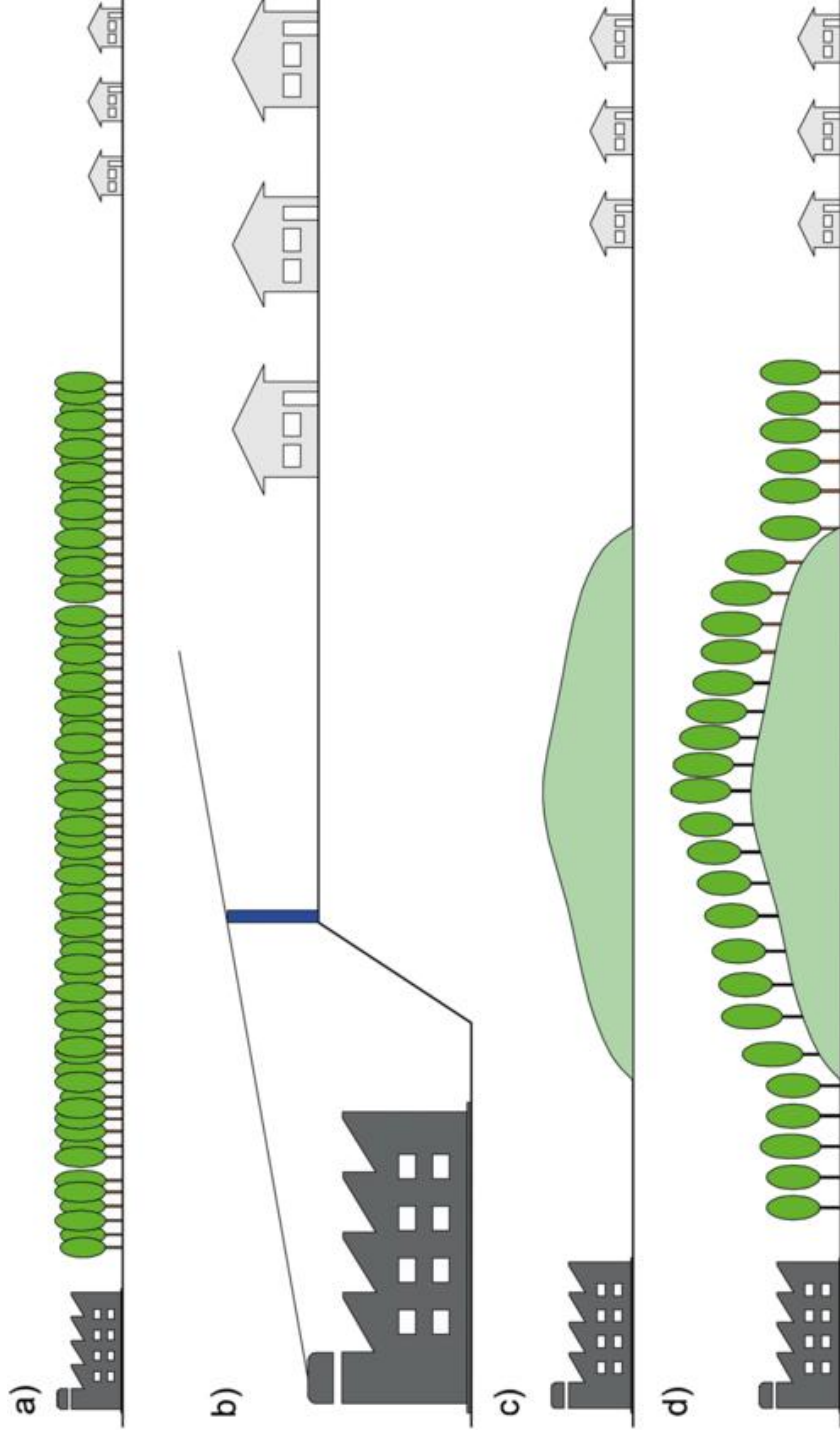


Figure 7.4 The improvement strategies of industrial noise control (Bozkurt, 2021)⁴

⁴ a) increasing distance and designing protective green zones between industrial areas and settlements, b) designing the industrial zone at the lower elevation according to the residential area and barrier design, c) earth mounds barrier type, d) earth mounds barrier type extended planting

7.1.3 Commercial areas

- Commercial zones often act as transition buffers between residential and traffic-heavy areas.
- Regulation of public address systems, generators, and HVAC equipment.
- Mandatory installation of acoustic enclosures for diesel generators.
- Time restrictions on loading/unloading and commercial activities.
- Use of acoustically treated facades and interiors.
- Zoning controls to prevent spillover of noise into adjacent residential or sensitive areas.
- Promotion of mixed-use developments with internal noise buffering through design.

7.1.4 Traffic areas

Traffic noise is the dominant contributor to urban noise in Chennai.

Traffic measures

- Promotion of electric vehicles, public transport, and non-motorized transport (Rahman et al., 2025).
- Efficient traffic management to reduce congestion and stop-go conditions (Garg et al., 2012).
- Reduced speed limits and smooth traffic flow through synchronized traffic signals (Garg et al., 2012).
- Strict enforcement of no-honking zones, especially near sensitive areas (Garg et al., 2012).
- Prohibition or rerouting of heavy vehicles from residential streets (Garg et al., 2012).

Infrastructure and planning measures

- Land-use planning with bypasses, ring roads, and buffer zones (Garg et al., 2012).
- Placement of parking bays and open spaces between roads and receivers (Garg et al., 2012).
- Use of low-noise road surfaces and optimal tyre-road combinations (Garg et al., 2012) (Figure 7.5).

- Mandatory periodic noise and emission certification for vehicles (Garg et al., 2012).
- Installation of noise barriers along high-traffic corridors (Figure 7.6).

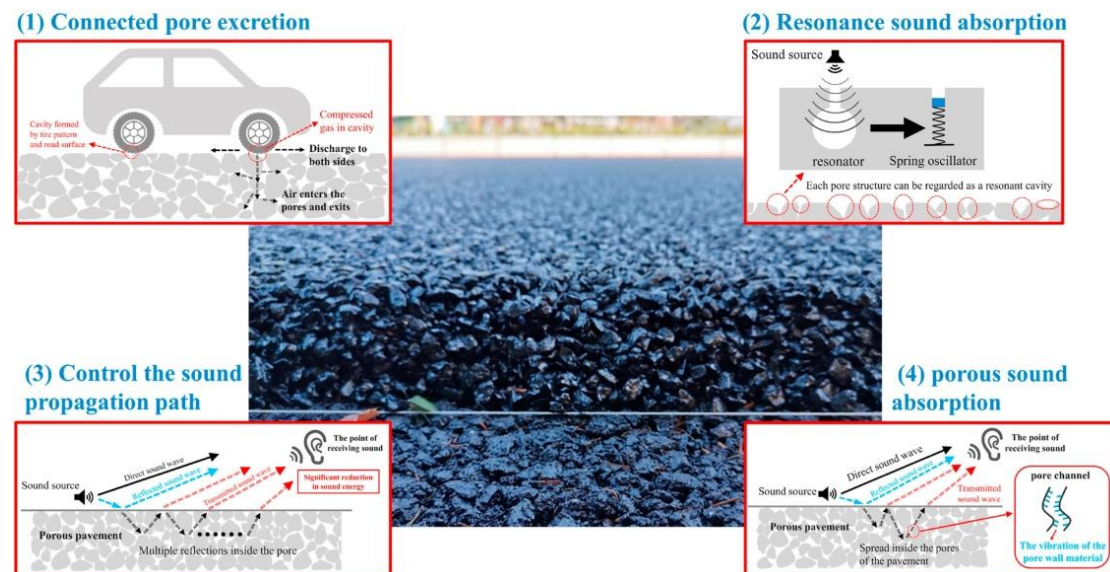


Figure 7.5 Porous asphalt pavement for noise reduction (Ling et al., 2021)

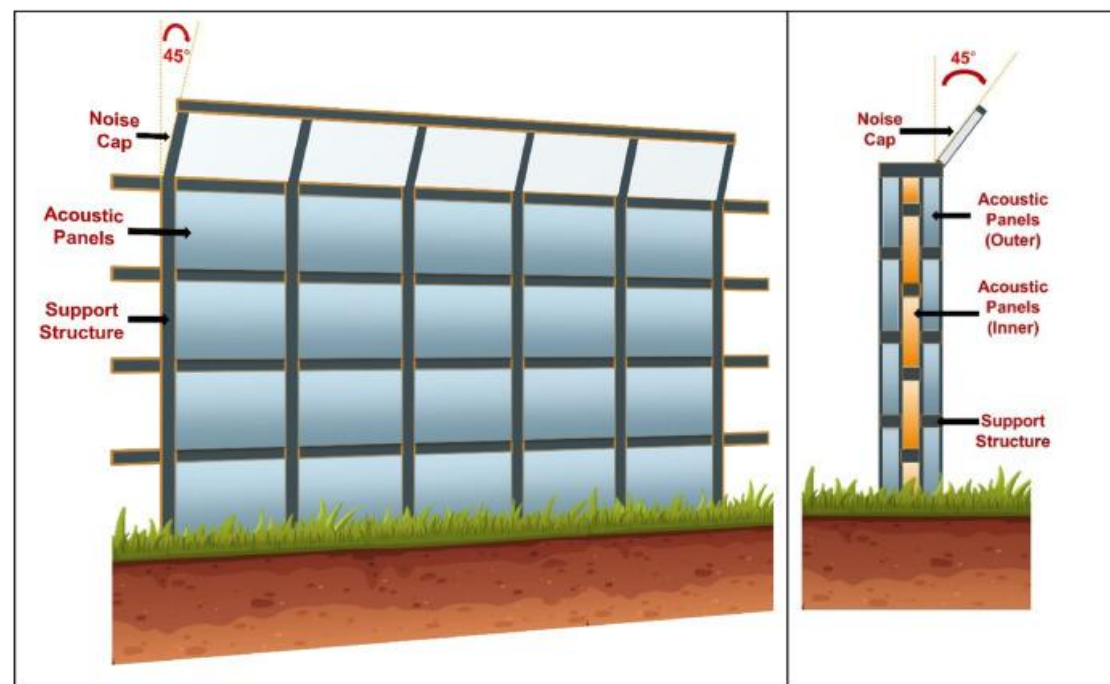


Figure 7.6 Installation of noise barriers along high-traffic corridors (Thakre et al., 2024)

7.1.5 Sensitive areas

Hospitals

- Declaration of ‘Quiet Zones’ with strict no-honking and speed regulations.
- Rerouting of heavy vehicles and restriction of construction activities nearby.
- Use of soundproof doors, windows, walls, and acoustic panels.
- Noise barriers and vegetation buffers around hospital premises.
- Designation of quiet internal zones (ICUs, wards, recovery rooms).
- Use of low-noise medical and mechanical equipment.
- Awareness programs for staff, visitors, and nearby communities.
- Regular noise monitoring and accessible complaint redressal mechanisms.

Schools

- Installation of sound walls/barriers (Shaaban & Abouzaid, 2021) (up to ~ 3.5 m height) to achieve classroom noise targets (~ 40 dB) (Reenen & Plessis, 2021).
- Use of special low-noise pavements around schools (Shaaban & Abouzaid, 2021).
- Proper insulation of classrooms using acoustic materials (Shaaban & Abouzaid, 2021; Chahdi et al., 2024).
- Double-glazed windows as a practical and cost-effective solution (Chahdi et al., 2024; Rigi et al., 2025).
- Shielding and buffering design strategies.
- Location of new schools away from major roads and noise sources (Reenen & Plessis, 2021; Chahdi et al., 2024; Rigi et al., 2025).
- Tree plantation and vegetation buffers (noise reduction of up to 4 – 6 dB).
- Strict enforcement of no-honking and low-speed zones (Chahdi et al., 2024).
- Awareness programs for students, staff, and the public.
- Long-term planning to relocate existing schools where feasible.

7.2 Technical and policy recommendations

7.2.1 Noise reduction at source

- Mandatory periodic certification of vehicles for noise and emissions.
- Promotion of low-noise technologies and equipment across sectors.
- Gradual phase-out of high-noise machinery and vehicles.

7.2.2 Traffic and transport policy

- City-wide speed regulation and horn restrictions.
- Intelligent traffic signal coordination.
- Expansion of public transport and non-motorized infrastructure.

7.2.3 Land-use and urban planning

- Strict noise zoning aligned with CPCB standards.
- Development of buffer zones between incompatible land uses.
- Integration of ring roads and bypasses to divert through-traffic.
- Mandatory noise impact assessment for major infrastructure projects.

7.2.4 Noise barriers and green infrastructure

- Strategic deployment of noise barriers along highways and railways (Figure 7.7).
- Use of green belts as complementary noise mitigation tools.

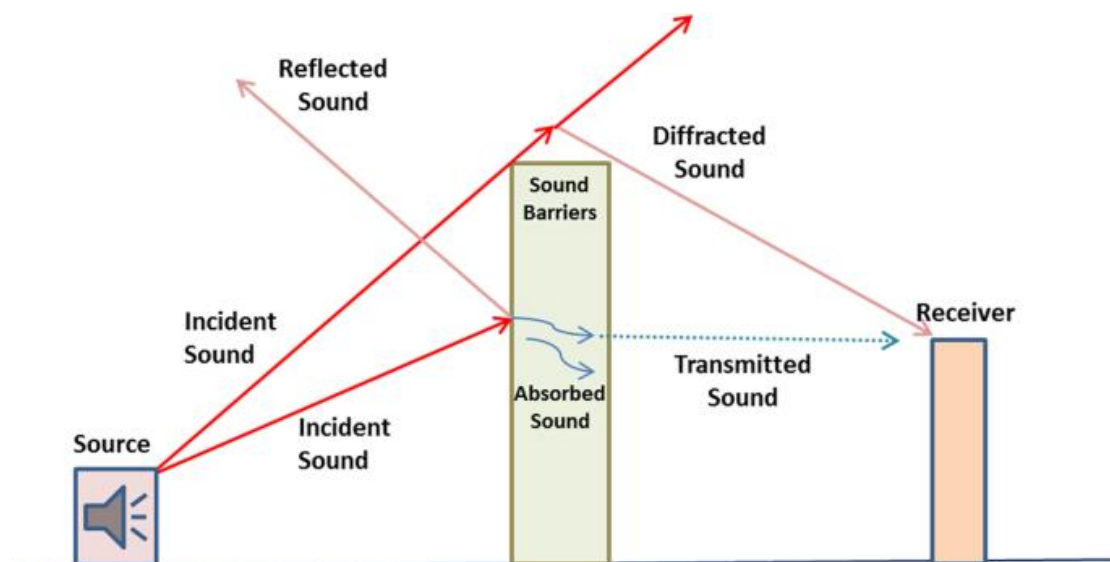
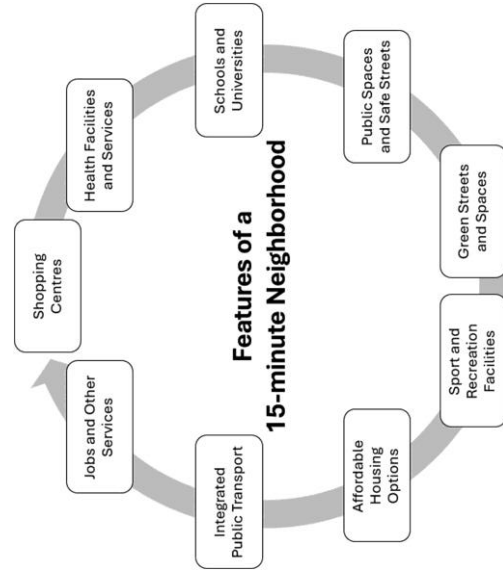


Figure 7.7 Working principle of noise barriers (Laxmi, Thakre, & Vijay, 2022)

7.2.5 Adoption of new urban models

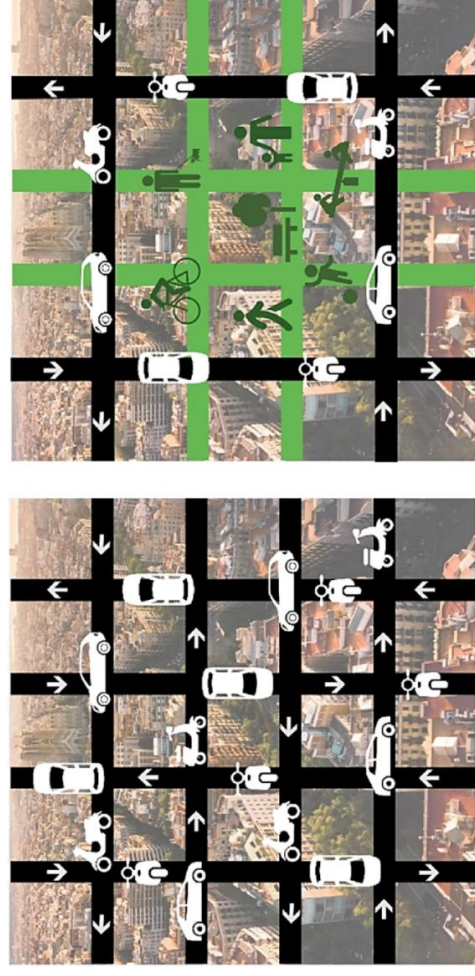
- Implementation of 15-minute city, superblocks, low-traffic neighbourhoods, and car-free zones (Rigi et al., 2025) (Figure 7.8).
- Prioritization of walking, cycling, and public transport over private cars.
- Reclaiming road space for green areas, social spaces, and active mobility.
- These models collectively reduce noise, air pollution, carbon emissions, and heat island effects while improving public health and quality of life.



Features of the 15-minute City Urban Design Framework (Bencekri et al., 2025)



Low traffic neighbourhoods, London (Xiao et al., 2023)



Superblocks model

Baseline situation

Superblocks (Nieuwenhuijsen, 2021)



Car-free street in Sweden (Marcheschi et al., 2022)

Figure 7.8 New urban models

7.2.6 Governance and monitoring

- Time-bound noise reduction targets with periodic review.
- Expansion of continuous noise monitoring networks.
- Public access to noise maps and data-driven decision-making.
- Integration of noise considerations into climate action and public health policies.

An effective noise management in Chennai demands an integrated and location-specific approach that combines source control, pathway mitigation, and protection of sensitive receivers through informed urban planning, engineering interventions, and robust policy enforcement (Figure 7.9). By aligning technological solutions with sustainable mobility and inclusive urban design, Chennai can significantly reduce noise pollution, enhance public health, and improve overall quality of urban life.

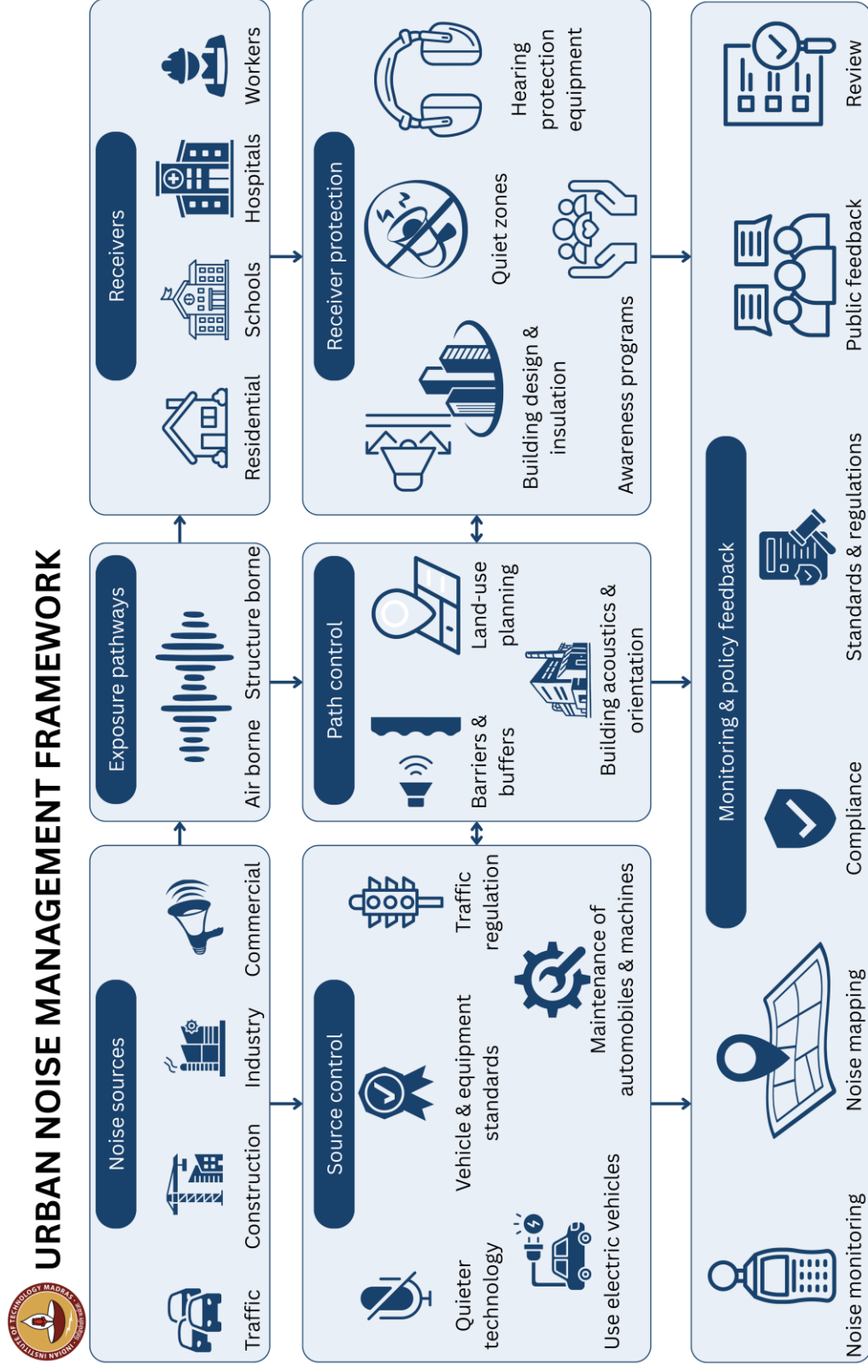


Figure 7.9 Integrated urban noise mitigation framework for Chennai

8. CONCLUSION

This section presents the key conclusions derived from the study, consolidating the findings on environmental noise in Chennai. It provides a comprehensive summary of the major insights obtained from the monitoring, analysis, and mapping of noise levels across the city. The first section outlines the conclusions from the characterization of noise levels, highlighting spatial and temporal variations, compliance with regulatory standards, and identification of critical hotspots. The subsequent section focuses on the noise mapping results, emphasizing the value of spatial and strategic maps in visualizing the distribution of noise pollution and identifying priority areas for intervention. Together, these conclusions provide a holistic understanding of Chennai's urban soundscape and its implications for public health, urban planning, and policy development.

8.1 Characterization of noise levels in Chennai

The characterization of noise levels across Chennai highlights the dominance of traffic as the primary contributor to urban noise pollution. Measurements consistently revealed exceedance of CPCB standards in residential and sensitive zones, with values at several locations surpassing permissible thresholds. Statistical indicators such as L_{10} , L_{50} , and L_{90} confirmed persistently high background levels, while indices like NC and TNI indicated unstable and annoyance-prone acoustic environments. The analysis underscores that noise exposure in the city is not only widespread but also severe in areas where vulnerable populations are most at risk.

Spatial and temporal analyses further revealed important patterns. Correlation and CoD results showed that noise levels across most monitoring locations were strongly homogeneous, driven by similar sources, primarily road traffic. However, localized heterogeneity was evident between certain zones, particularly where land use and urban activity differed markedly. Temporal assessments demonstrated strong diurnal cycles, with peak levels during commuting hours. Weekly variations suggested a marginal reduction in noise on Sundays, but not sufficient to bring levels within permissible limits.

Comparative and visual analyses, including box plots, cumulative frequency distributions, heat maps, and calendar plots, reinforced these findings by identifying clear noise hotspots and quieter areas. Zone XI (Valasaravakkam) consistently emerged as a high-exposure area, while Zone XIII (Adyar) offered some acoustic relief. The results confirm that Chennai's urban environment suffers from chronic and pervasive noise pollution, with high public health implications, and they highlight the urgent need for comprehensive noise management policies that combine city-wide measures with site-specific interventions.

8.2 Noise mapping

Noise mapping provided a spatial representation of Chennai's acoustic environment, translating measured data into visual patterns of noise exposure. Spatial maps illustrated the variation in noise levels across different land-use categories, consistently showing higher daytime values compared to night time. Hotspots such as Zone11_T (Urban Primary Health Centre, Maduravoyal) and Zone5_S (Rajiv Gandhi Government General Hospital) repeatedly exceeded 70 dB(A). These maps effectively highlighted how land-use and traffic intensity shape the city's noise climate.

Strategic noise maps, generated through interpolation, offered a more comprehensive view by filling gaps between monitoring stations and revealing city-wide patterns. The consolidated maps confirmed the persistence of elevated noise levels during the day, particularly in central and northern zones such as Zone IV, V, VII, XI, and XV. Night time values were relatively lower but still exceeded thresholds in several hotspots.

Together, spatial and strategic noise maps provide evidence of the scale and distribution of noise pollution in Chennai. They not only confirm the dominance of traffic-related sources but also help distinguish between chronic hotspots and relatively quieter areas. These insights are crucial for urban planning and policy, as they enable targeted mitigation in the most affected zones while ensuring the preservation of existing quiet areas. The mapping outcomes thus serve as an essential tool for evidence-based noise management and sustainable urban development.

8.3 Urban noise pollution management framework

Overall, effective noise management in Chennai requires a comprehensive, location-specific strategy that integrates engineering controls, urban design principles, and regulatory enforcement across residential, industrial, commercial, traffic, and sensitive zones. Addressing noise at the source through quieter technologies, improved traffic management, and better industrial practices, while simultaneously mitigating its transmission through building design, barriers, and green buffers, is essential for protecting public health. Special emphasis on schools and hospitals underscores the need to safeguard vulnerable populations by creating and strictly enforcing quiet zones supported by continuous monitoring and community awareness.

In the long term, strengthening Chennai's noise management practices must go beyond isolated mitigation measures and be embedded within broader urban and transport planning frameworks. The adoption of people-centric urban models offers a sustainable pathway to reduce dependence on private vehicles, reclaim public space, and lower environmental noise levels. Coupled with data-driven policymaking, periodic review of noise reduction targets, and active public participation, these approaches can help Chennai transition towards a healthier, more livable, and acoustically sustainable urban environment.

APPENDIX A.

DESIGN, DEVELOPMENT, AND VALIDATION OF SENSOR-BASED NOISE MEASURING DEVICE

Accurate, comprehensive, and real-time noise data is vital for effective urban noise mitigation and raising public awareness. Though precise, traditional noise monitoring instruments like Type 1 and Type 2 Sound Level Meters (SLMs) are often expensive, bulky, and maintenance-intensive, making them impractical for widespread deployment across large urban areas. With advancements in microelectronics, wireless communication, and the Internet of Things (IoT), low-cost sensor networks (LCSNs) have emerged as a promising alternative. These sensors are compact, affordable, and capable of providing continuous, real-time acoustic data at high spatial and temporal resolution, making monitoring noise across an entire city or region feasible.

LCSNs enable scalable and distributed environmental monitoring, offering a cost-effective solution to track noise pollution across diverse urban settings. Their lightweight design allows for flexible installation on street poles, buildings, or other infrastructure, while real-time data transmission enables timely responses to changing soundscapes. LCSNs can be deployed in different configurations, such as fixed sensors, mobile sensors, and mobile participatory sensing using smartphones. This study employs a network of fixed low-cost sensors for long-term monitoring. The effectiveness of such networks depends on several factors, including sensor accuracy, data handling capabilities, power availability, communication systems, environmental conditions, and maintenance. As cities transition into smart cities, integrating LCSNs is vital in supporting data-driven decision-making and fostering sustainable urban development.

Sensor design

The sensor system is developed using Internet of Things (IoT) technology to enable affordable, continuous noise monitoring as a substitute for conventional methods. Sound levels are captured through a microphone, processed by a microcontroller, and transmitted to cloud storage using a wireless communication protocol. The data is

then accessible through a web-based visualization platform, allowing users to view information in graphical or tabular formats. The system architecture is illustrated in Figure A.1.

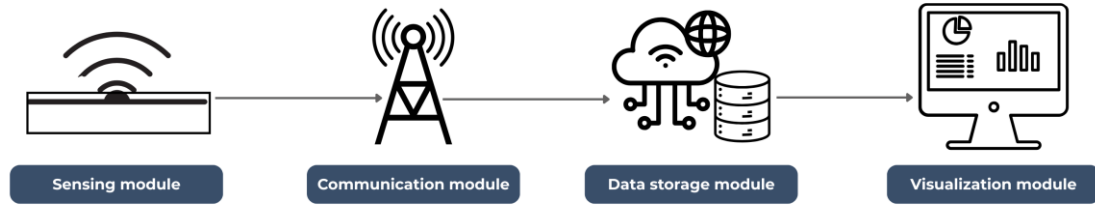


Figure A.1 Sensor system architecture

Each sensor unit consists of four key modules:

1. Sensing module
2. Communication module
3. Data storage module
4. Visualization module

Sensing module

This module includes sensors equipped with a microphone that continuously capture ambient noise levels. At the core of the sensing unit is a Renke RS-ZS-N01-FL industrial noise sensor with a condenser microphone, capable of measuring levels between 30 and 120 dB(A). The technical specifications of the sensor are detailed in Table A.1 (Robu.in, n.d.).

The device computes real-time acoustic metrics such as $L_{\max}$, $L_{\min}$, L_{eq} , and statistical indicators like L_{10} , L_{50} , and L_{90} , using onboard signal processing on 125 ms data windows. Given below is the formula used for computing L_{eq} :

$$L_{eq} = 10 \log_{10} \left(\frac{1}{n} \sum_{i=1}^n 10^{\frac{L_i}{10}} \right) \quad (A.1)$$

where, L_i is the instantaneous noise measurement at i th time and n is the total number of noise measurements.

The analog audio signal is processed by a microcontroller unit (MCU), which converts it into decibel values using a logarithmic root mean square (RMS) method. The readings are formatted into JSON (JavaScript Object Notation) packets and transmitted to a cloud server via GSM (Global System for Mobile Communications) communication at one-minute intervals.

Table A.1 Characteristics of the sensor component

Model Type:	Renke RS-ZS-N01-FL Industrial Noise Sensor
Microphone type:	Condenser microphone
Range:	30 to 120 dB(A)
Noise accuracy	± 0.5 dB(A) (at reference pitch, 94dB(A) @1kHz)
Resolution:	0.1 dB(A)
Frequency band:	20 Hz to 12.5 kHz
Voltage rating:	10 to 30 V DC
Power consumption:	0.1 W
Power supply:	10 to 30 V DC
Response time:	≤ 3 s
Environmental temperature:	-20°C to +60°C
Relative humidity:	0% RH to 80% RH
Sensor weight:	0.397 kg
Sensor dimensions:	25 × 21 × 9 cm

The sensor module is configurable and can integrate additional modules for measuring temperature, humidity, particulate matter, and gaseous pollutants, making it suitable for multi-parameter environmental monitoring.

Communication module

This component enables data transfer from the sensor node to the central cloud infrastructure. While both wired and wireless options exist, wireless communication is generally preferred for city-wide deployment due to its flexibility. The Global System for Mobile Communications (GSM) technology is employed in this study for its wide coverage and real-time data transfer capabilities. However, each sensor node requires individual SIM (Subscriber Identity Module) cards, raising operational costs. Alternative technologies such as Wi-Fi (Wireless Fidelity) and Bluetooth offer limited

range and higher power consumption, making them less suitable for continuous environmental monitoring.



Figure A.2 Prototype of a single sensor unit

The sensing and communication modules are enclosed in a weather-resistant casing to protect them from dust, heat, and moisture (Figure A.2). The unit operates on a wired AC power supply and includes a rechargeable battery backup for uninterrupted operation during power outages. Future designs may incorporate solar panels or high-capacity batteries for improved autonomy.

Data storage module

The sensor network generates large volumes of data, which are managed using a centralized cloud-based server. This cloud infrastructure is the main repository, automatically receiving and securely storing data from all sensor nodes. The system supports real-time data handling from multiple locations, allowing for long-term historical recordkeeping essential for trend analysis, predictive modeling, and policy formulation. Cloud storage enables remote access for stakeholders, researchers, and planners, with built-in security and data backup features. Integration with advanced

analytics tools further allows the development of real-time dashboards and interactive data applications.

Visualization module

Collected data is presented through a web-based dashboard (Figure A.3), which facilitates easy access, visualization, and download of real-time and historical noise data. This user-friendly interface supports stakeholders in data-driven decision-making and enhances public engagement through transparency.

The sensor node described above is individually calibrated and validated before deployment. A network of such sensor nodes, strategically installed across urban locations, enables comprehensive city-wide noise monitoring. This high-resolution data helps detect spatial and temporal trends in noise pollution, supports the generation of noise maps, and informs targeted mitigation strategies, thereby aiding policy development and public awareness initiatives.

Sensor calibration

While low-cost sensors offer numerous advantages such as affordability and scalability, they are susceptible to certain limitations. Variations in individual sensor hardware, environmental factors like temperature and humidity, and potential electromagnetic interference can introduce measurement inconsistencies. These discrepancies may arise not only between low-cost sensors and standard reference instruments, but also among identical low-cost sensor units. Therefore, calibration and validation are essential to ensure that the data collected is accurate and reliable.



Tamil Nadu Pollution Control Board

REAL-TIME AMBIENT NOISE MEASUREMENT AND NOISE MAPPING FOR CHENNAI CITY

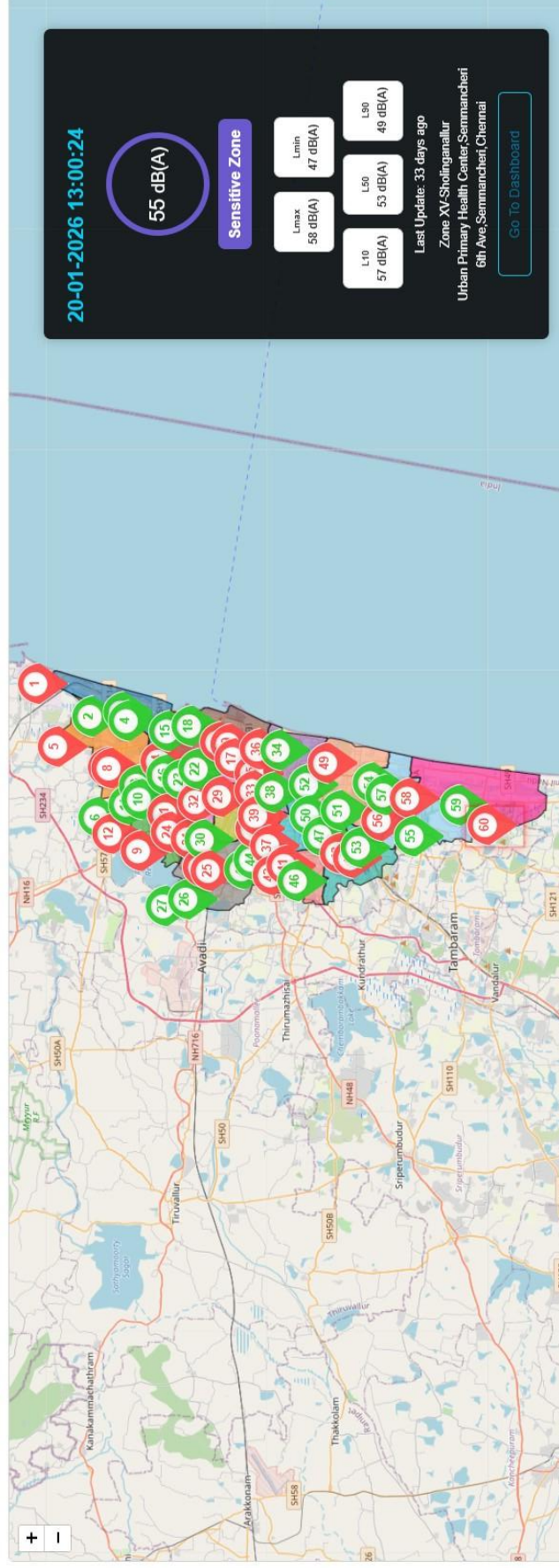


Figure A.3 Web-based dashboard for data visualization and download

Calibration refers to the process of adjusting sensor outputs to match those of a reference instrument under controlled conditions. In this study, calibration was conducted in a laboratory setting using a certified Type 1 SLM as the reference standard. Each sensor unit was placed at the same height and distance from a stable sound source alongside the SLM (Figure A.4). An initial 60-minute recording session captured pre-calibration data. The average deviation between the sensor and SLM readings was calculated, and a correction coefficient was determined for each sensor. This coefficient was integrated into the sensor's internal algorithm to adjust future readings.

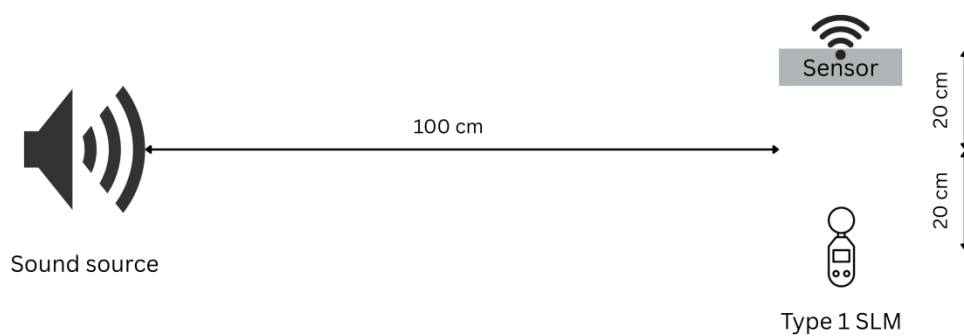


Figure A.4 Calibration setup

Figure A.5 and Figure A.6 show the correlation between noise levels from sensor and reference instrument for one particular sensor unit after calibration. The values indicate high correlation (0.97), indicating that the sensor readings are in agreement with the standard reference instrument.

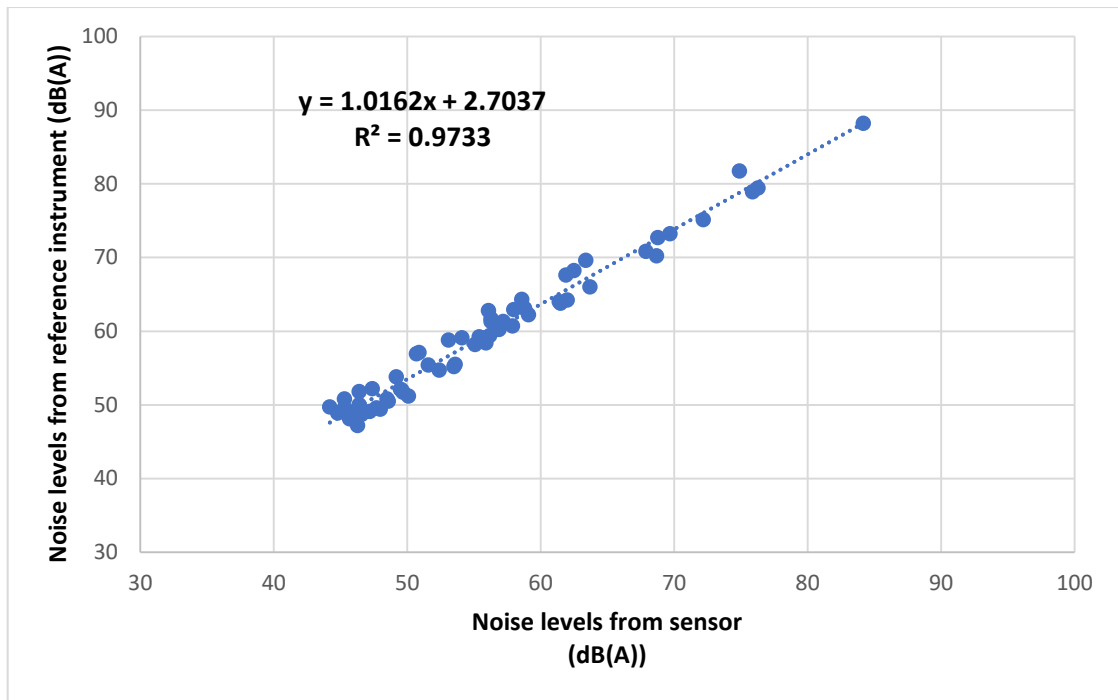


Figure A.5 Correlation between noise levels measured by sensor and reference instruments

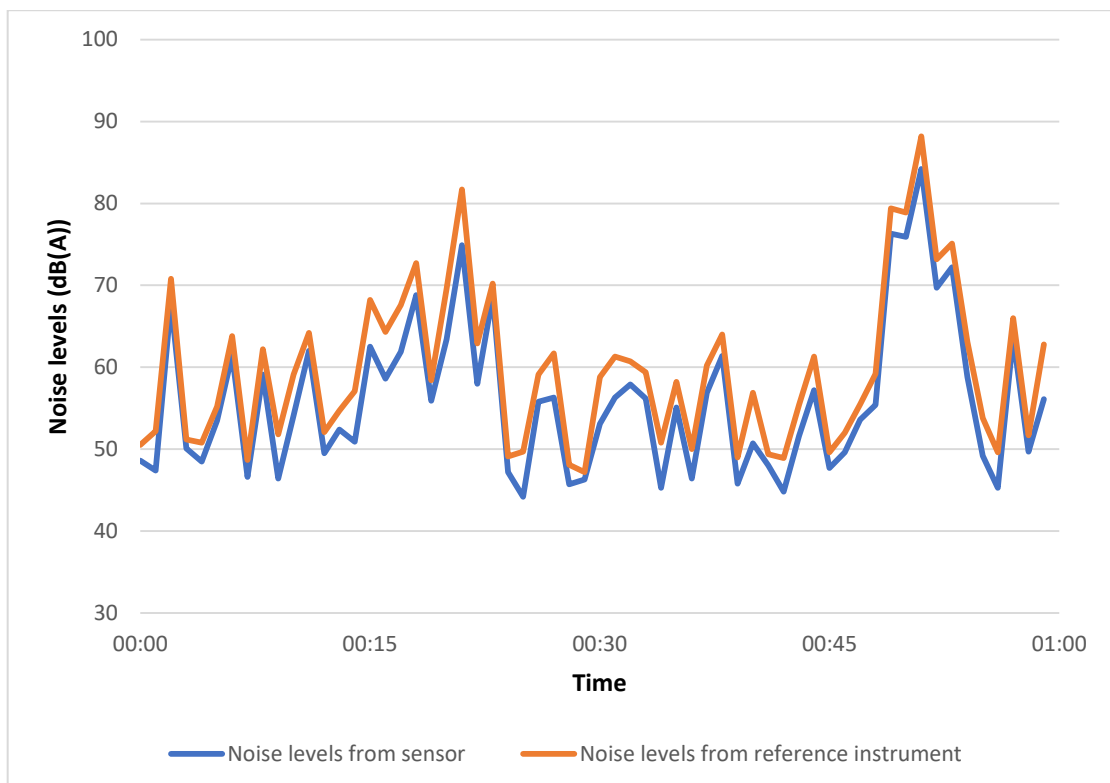


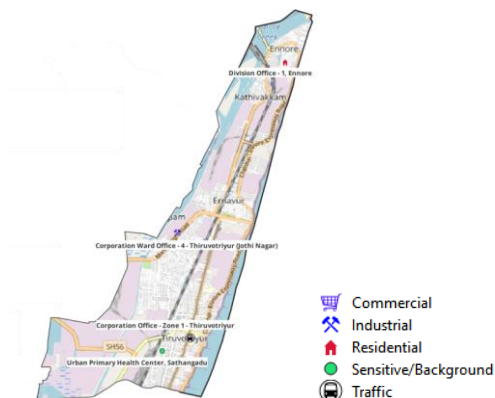
Figure A.6 Post-calibration measurements - a comparison between measurements from sensor and reference instrument

APPENDIX B.

NOISE MONITORING LOCATION DETAILS

The details of each monitoring location with geo-tagged photographs are described here.

Zone I – Thiruvotriyur

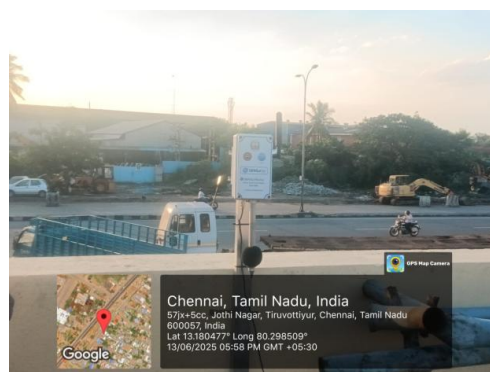


Residential



Division Office - 1, Ennore

Industrial



Corporation Ward Office - 4 - Jothi Nagar

Traffic



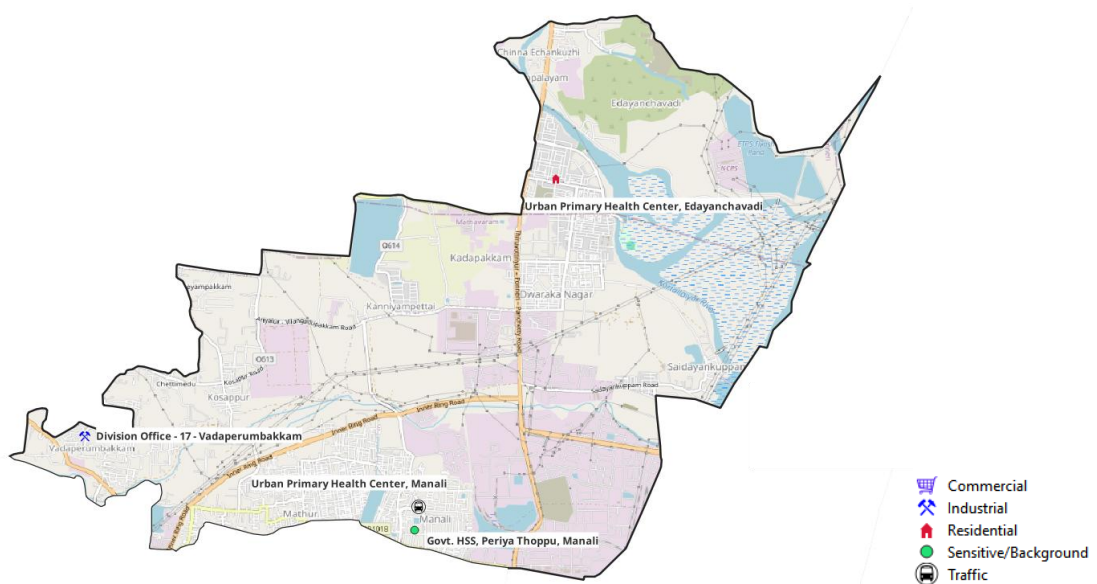
Corporation Office - Zone 1 -
Thiruvotriyur

Sensitive



Urban Primary Health Center, Sathangadu

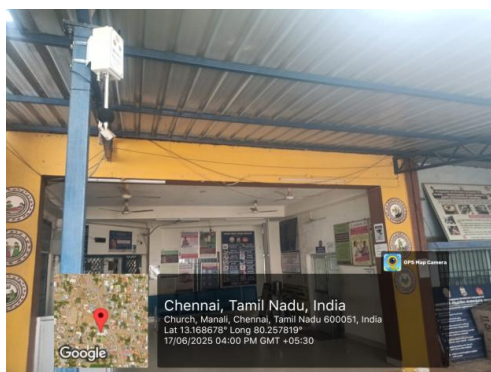
Zone II – Manali

Residential

Urban Primary Health Center,
Edayanchavadi

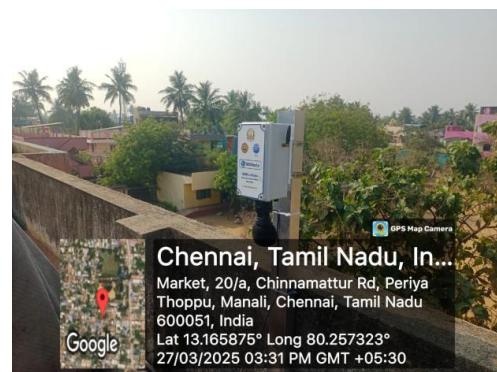
Industrial

Division Office - 17 - Vadaperumbakkam

Traffic

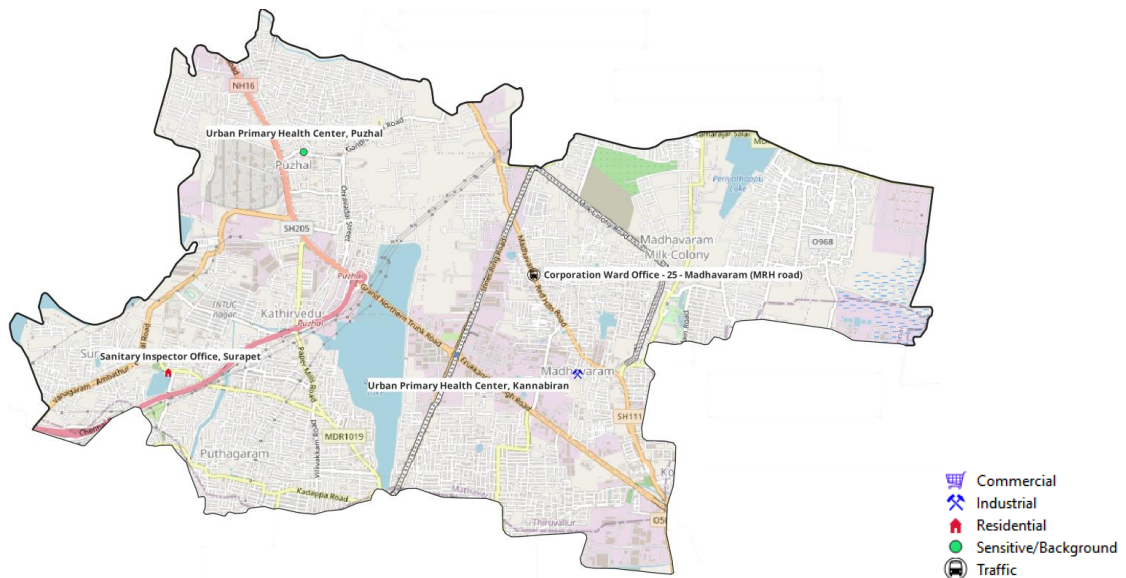
Urban Primary Health Center, Manali

Sensitive

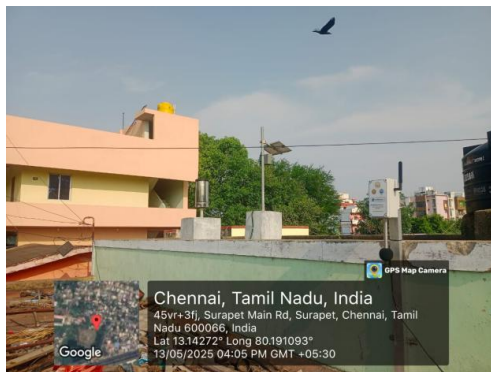


Govt. HSS, Periya Thoppu, Manali

Zone III – Madhavaram



Residential



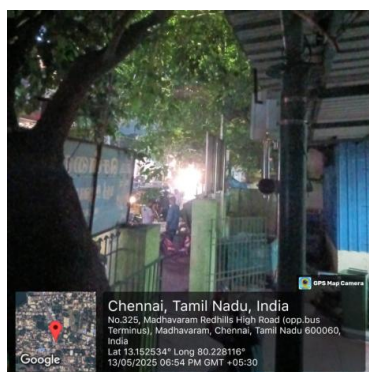
Sanitary Inspector Office, Surapet

Industrial



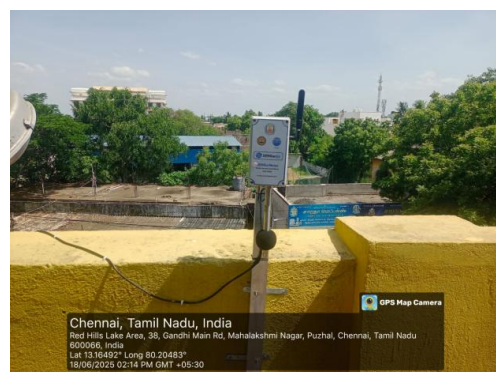
Urban Primary Health Center, Kannabiran

Traffic



Corporation Ward Office - 25 -
Madhavaram (MRH road)

Sensitive



Urban Primary Health Center, Puzhal

Zone IV – Tondiarpet

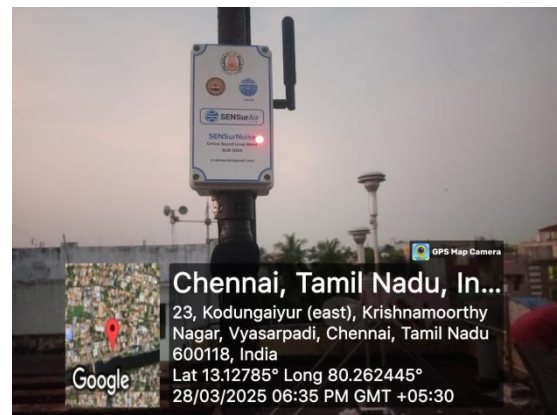


Residential



Corporation Ward Office - 34

Industrial



Manual AQM station, Kodungaiyur

Traffic



Corporation Office - Zone 4 - Tondiarpet

Sensitive



Urban Primary Health Center, Vyasarpadi

Zone V – Royapuram

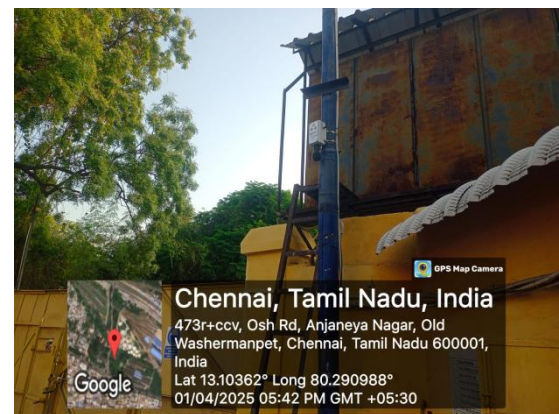


Residential

Industrial



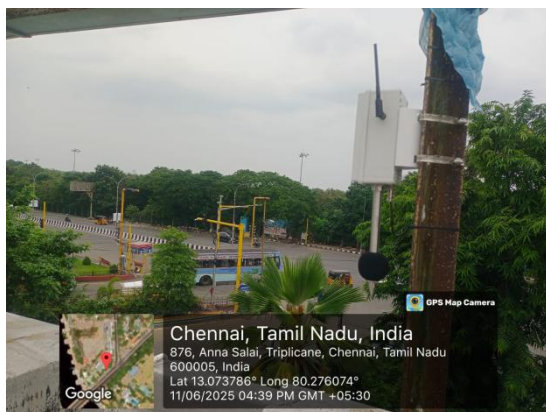
Division Office - 63 - Egmore



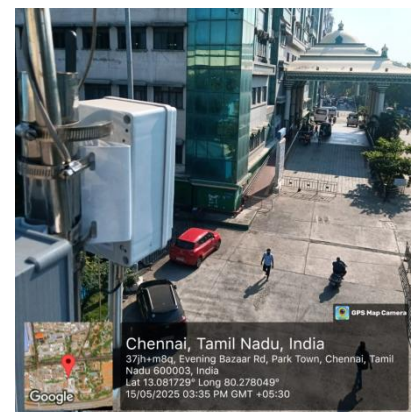
Manual AQM station, Old Washermanpet

Traffic

Sensitive

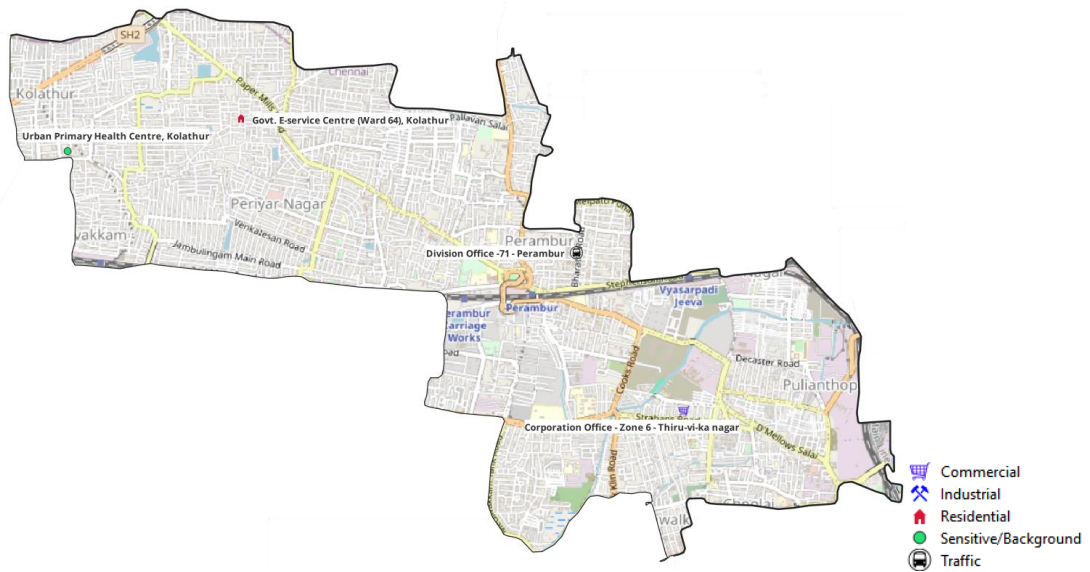


Chennai Metropolitan Transport Corporation Limited, Park Town



Rajiv Gandhi Government General Hospital

Zone VI – Thiru-vi-ka nagar

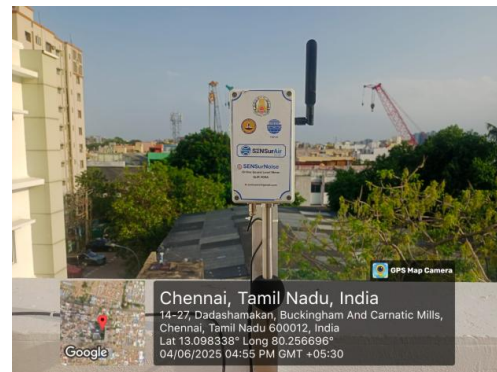


Residential



Govt. E-service Centre (Ward 64),
Kolathur

Commercial



Corporation Office - Zone 6 - Thiru-vi-ka
nagar

Traffic



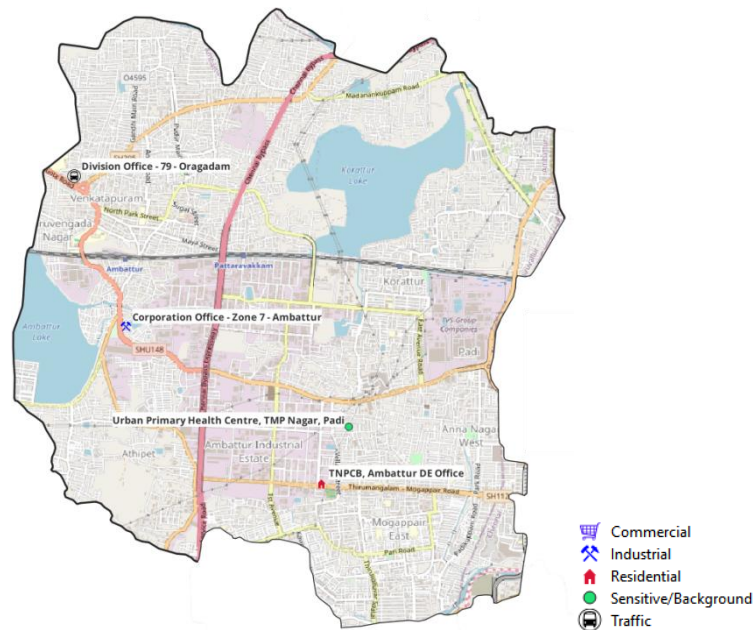
Division Office -71 - Perambur

Sensitive



Urban Primary Health Centre, Kolathur

Zone VII – Ambattur

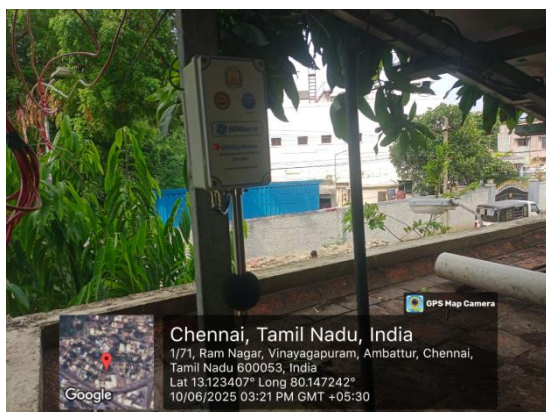


Residential



TNPCB, Ambattur DE Office

Traffic



Division Office - 79

Industrial



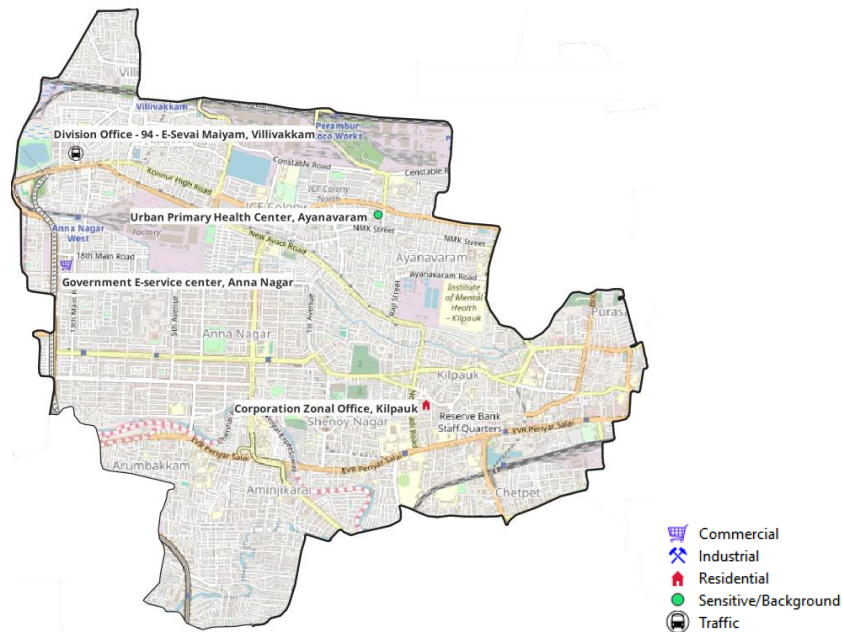
Corporation Office - Zone 7 - Ambattur

Sensitive



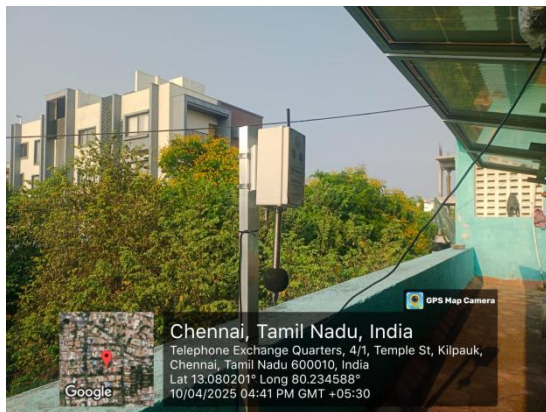
Urban Primary Health Centre, TMP Nagar, Padi

Zone VIII – Anna Nagar



Residential

Commercial



Corporation Zonal Office, Kilpauk



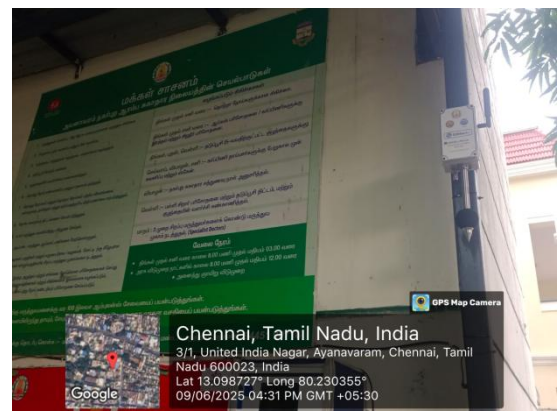
Government E-service center, Anna Nagar

Traffic

Sensitive

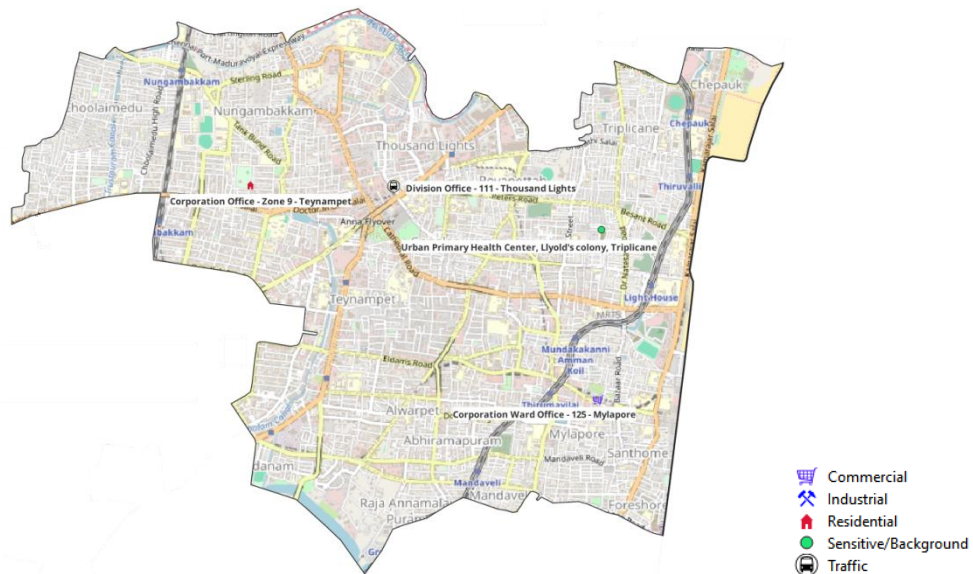


Division Office - 94 - E-Sevai Maiyam,
Villivakkam

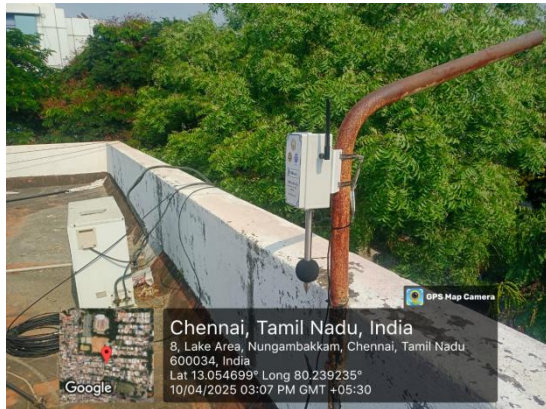


Urban Primary Health Center, Ayanavaram

Zone IX – Teynampet



Residential



Corporation Office - Zone 9 - Teynampet

Commercial



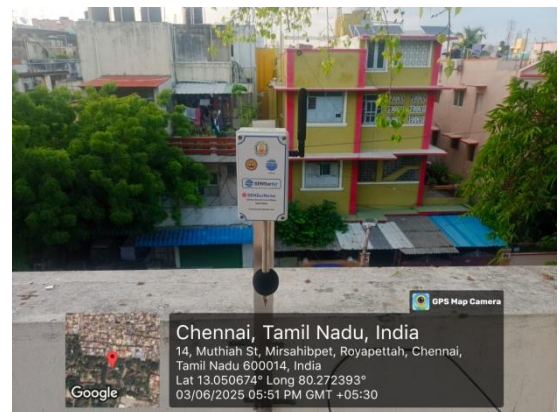
Corporation Ward Office - 125 - Mylapore

Traffic



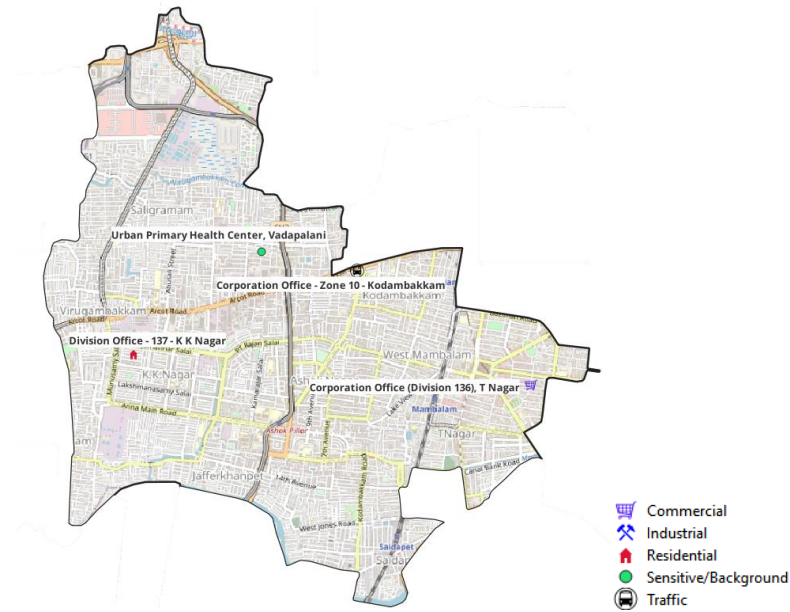
Division Office - 111 - Thousand Lights

Sensitive



Urban Primary Health Center, Llyold's colony, Triplicane

Zone X – Kodambakkam



Residential



Division Office - 137 - K K Nagar

Traffic



Corporation Office - Zone 10 - Kodambakkam

Commercial



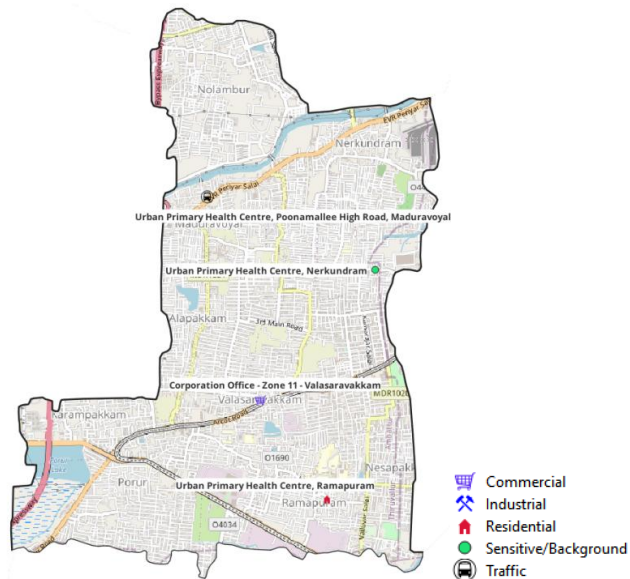
Corporation Office (Division 136), T Nagar

Sensitive

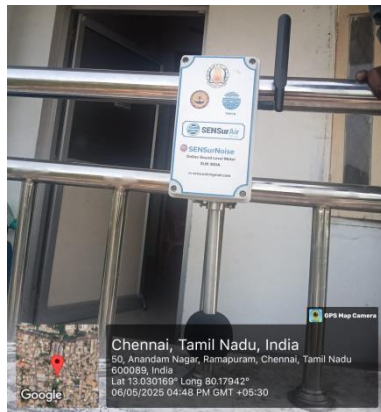


Urban Primary Health Center, Vadapalani

Zone XI – Valasaravakkam



Residential



Urban Primary Health Centre,
Ramapuram

Commercial



Corporation Office - Zone 11 -
Valasaravakkam

Traffic



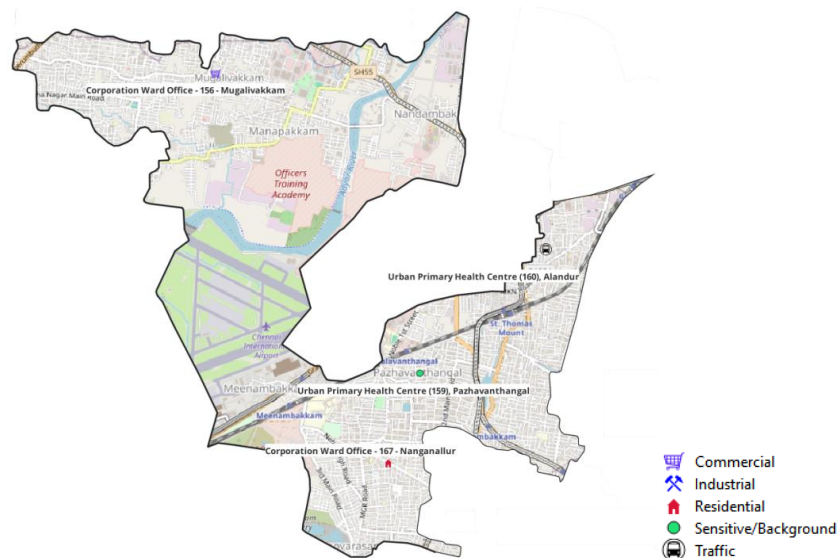
Urban Primary Health Centre,
Maduravoyal

Sensitive



Urban Primary Health Centre, Nerukundram

Zone XII – Alandur

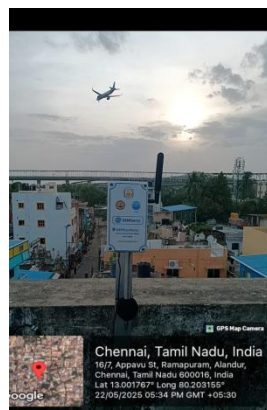


Residential



Corporation Ward Office - 167 -
Nanganallur

Traffic



Urban Primary Health Centre (160),
Alandur

Commercial



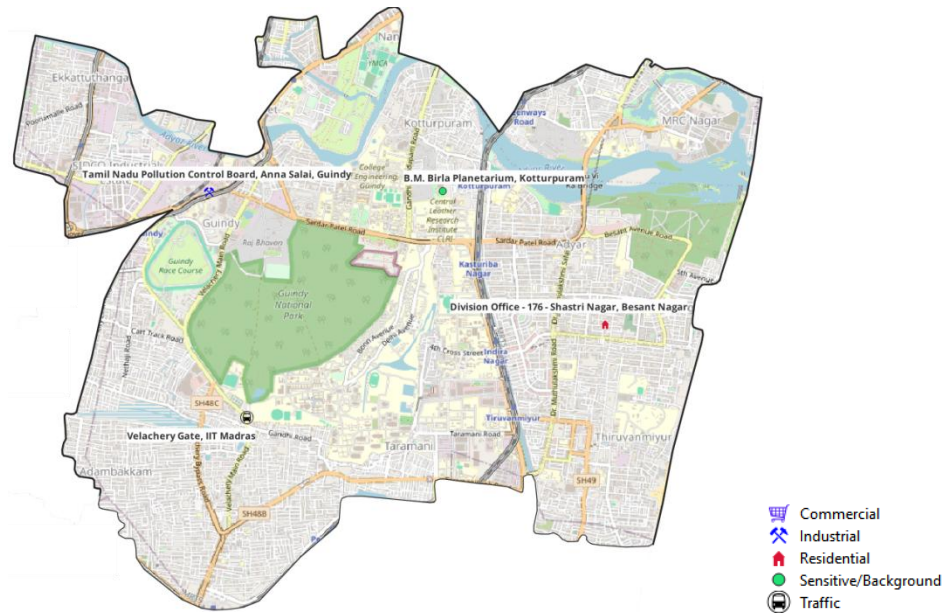
Corporation Ward Office - 156 -
Mugalivakkam

Sensitive

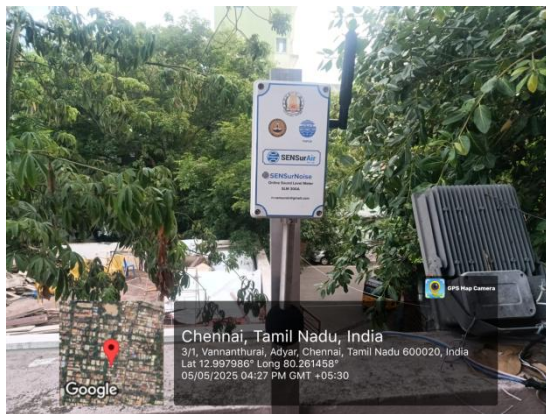


Urban Primary Health Centre (159),
Pazhavanthangal

Zone XIII – Adyar



Residential



Division Office - 176 - Shastri Nagar,
Besant Nagar

Industrial



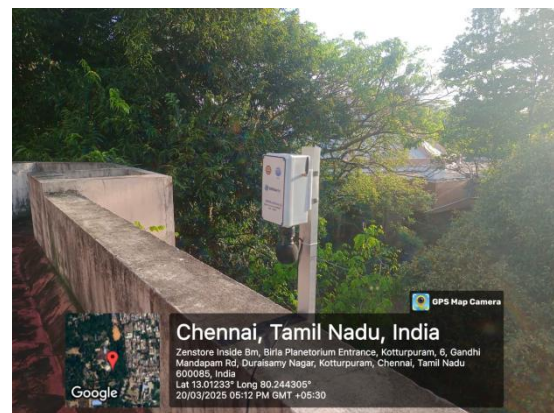
Tamil Nadu Pollution Control Board,
Guindy

Traffic



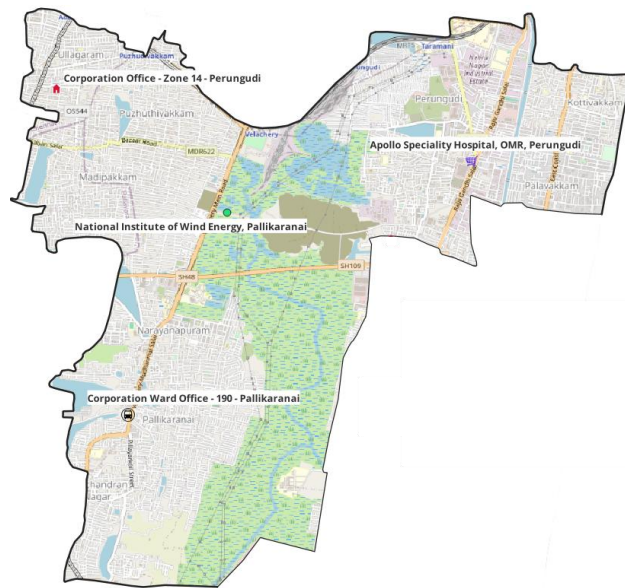
Velachery Gate, IIT Madras

Sensitive



B.M. Birla Planetarium, Kotturpuram

Zone XIV – Perungudi



Residential



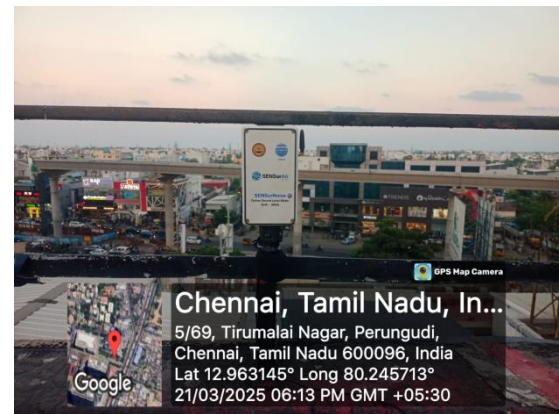
Corporation Office - Zone 14 - Perungudi

Traffic



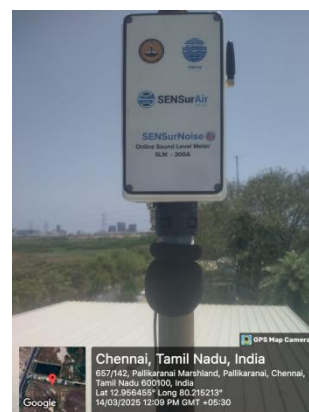
Corporation Ward Office - 190 - Pallikaranai

Commercial



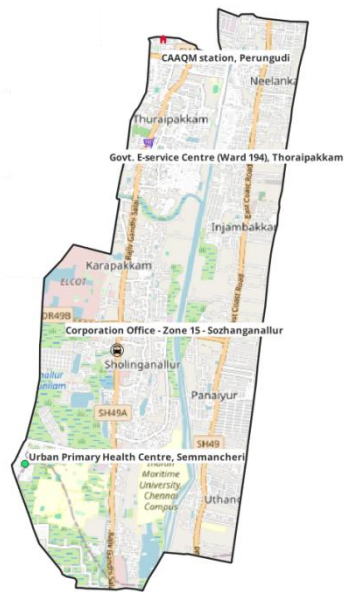
Apollo Speciality Hospital, OMR, Perungudi

Sensitive

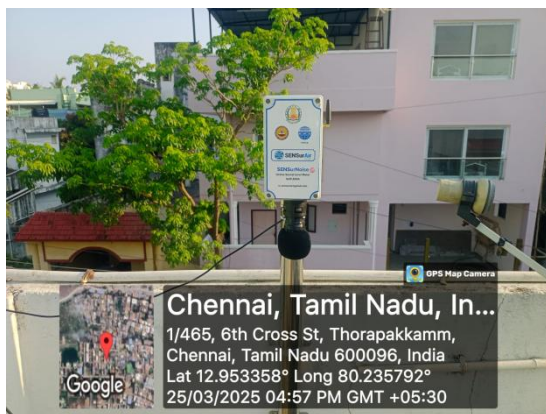


National Institute of Wind Energy, Pallikaranai

Zone XV – Sholinganallur



Residential



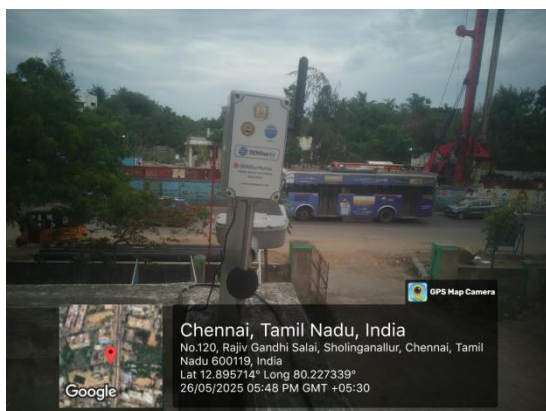
CAAQM station, Perungudi

Commercial



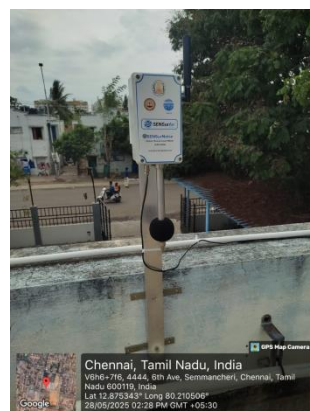
Govt. E-service Centre (Ward 194), Thoraipakkam

Traffic



Corporation Office - Zone 15 - Sholinganallur

Sensitive



Urban Primary Health Centre, Semmancheri

APPENDIX C.

DESCRIPTION OF NOISE MONITORING LOCATIONS

The description of the noise monitoring locations is given below.

Sl. No.	Location	Latitude	Longitude	Address
1.	Division Office - 1, Ennore – Residential	13.22274	80.32473	9th Cross St, Tulsi Kuppam, Ennore, Chennai
Tulsi Kuppam is a residential neighborhood within Ennore, with well-defined streets and cross streets. It is located between Kathivakkam Highway Road, Ennore Express Road, and a small central pond. This residential area has nine streets and sixteen cross streets arranged in a rectangular grid.				
2.	Corporation Ward Office - 4 - Thiruvottiur (Jothi Nagar) – Industrial	13.18173	80.29882	Jothi Nagar, Tiruvottiur, Chennai
This location is near the industrial areas between the Kosasthalai River and Manali High Road. Industries include metal and alloy works, fabric units, hardware workshops, and other small-scale industries.				
3.	Corporation Office - Zone 1 – Thiruvottiur – Traffic	13.15635	80.30193	Thiruvottiur High Rd, Sathya Moorthy Nagar, Rajakadai, Tiruvottiur, Chennai
It is located near the Thiruvottiur Theradi area, which has both a bus stop and a metro station. It also covers Rajakadai, a high-traffic area, with roads connecting to Ennore High Road.				
4.	Urban Primary Health Center, Sathangadu – Sensitive	13.15318	80.29522	LIG Colony 1st St, Balakrishna Naidu Colony, Kaladipet, Tiruvottiur, Chennai
This UPHC provides medical facilities mainly for residents of LIG Colony but also serves people from Balakrishna Naidu Colony, Perumal Kovil Street, Vanniar Street, and nearby areas.				
5.	Urban Primary Health Center, Edayanchavadi – Residential	13.20799	80.27426	Elandanur, Edayanchavadi, Manali New Town, Manali, Chennai
It covers residential areas near the 29th and 35th blocks of Manali New Town, including housing board quarters in Edayanchavadi.				

Sl. No.	Location	Latitude	Longitude	Address
6.	Division Office - 17 - Vadaperumbakkam – Industrial	13.17718	80.21780	Ranga Garden, Vadaperumbakkam, Chennai
Vadaperumbakkam has several factories, including machinery manufacturing (GKR Industries, hydraulics, goods lifts), plastic product manufacturing (Royal Plastics, Esh Polymers), packaging industries (Varanaa Industries), and engineering firms such as Danieli India Ltd and Naga Precision Tooling Systems.				
7.	Urban Primary Health Center, Manali – Traffic	13.16865	80.25783	Padasalai St, Manali
This UPHC is located on a busy roadway that connects to Nedunchezhan Street, which further leads to Jawaharlal Nehru Salai. On the other side, it connects to Kamarajar Salai, the central roadway for residential and commercial activities on both sides.				
8.	Govt. HSS, Periya Thoppu, Manali – Sensitive	13.16589	80.25732	Parthasarathy St, Periya Thoppu, Manali, Chennai
This is an important school zone that caters to students from surrounding areas such as CPCL Nagar, Shastri Nagar, Padmagiri Nagar, and Jagdesh Nagar, within a 2 km radius.				
9.	Sanitary Inspector Office, Surapet – Residential	13.14275	80.19113	Surapet Main Rd, Surapet, Chennai
This location covers residential areas such as Pillaiyar Kovil Street (near Puthagaram Road), DG Main Nagar, and JP Nagar, near Surapet Main Road.				
10.	Urban Primary Health Center, Kannabiran – Industrial	13.14257	80.23254	TVK Colony, Madhavaram, Chennai
The location is influenced by nearby steel, aluminum, metal, and packaging industries.				
11.	Corporation Ward Office - 25 - Madhavaram (MRH Road) – Traffic	13.15254	80.22812	Madhavaram Redhills High Rd, Madhavaram, Chennai
This location is near Madhavaram Arumandai Road and the Madhavaram New Bus Stand, at a junction that also connects to Perumal Kovil Street.				
12.	Urban Primary Health Center, Puzhal – Sensitive	13.16497	80.20479	Gandhi Main Rd, Mahalakshmi Nagar, Puzhal, Chennai
This UPHC is important for the surrounding areas, serving residents of Sakthivel Nagar, Mahalakshmi Nagar, and St. Antony Nagar.				

Sl. No.	Location	Latitude	Longitude	Address
13.	Corporation Ward Office 34 – Residential	13.14458	80.24309	Venkateshwara Colony Main Rd, Kodungaiyur, Chennai
This peaceful residential area is away from major road disturbances. It covers RV Nagar, Arul Nagar, Seetharam Nagar, and Bank Colony.				
14.	Manual AQM Station, Kodungaiyur – Industrial	13.12787	80.26245	Kodungaiyur (East), Krishnamoorthy Nagar, Vyasarpadi, Chennai
Industries near this station include plastic manufacturers (Saraswathi Plastic Industries), PVC pipe producers (Hirawat Industries), and machinery makers (Durga Industries), mostly located in the SIDCO and TNHB Industrial Estates.				
15.	Corporation Office - Zone 4 - Tondiarpet – Traffic	13.12095	80.28618	Thiruvottiyur High Rd, Sanjeevarayanpet, Old Washermanpet, Chennai
This location is close to Thiruvottiyur Main Road and Tondiarpet Bus Stand. Noise from the nearby Tondiarpet Railway Station also impacts this area.				
16.	Urban Primary Health Center, Vyasarpadi – Sensitive	13.12296	80.25174	SA Colony, 8th Cross Rd, Sivakami Amman Colony, Vyasarpadi, Chennai
This UPHC serves people within a 1 km radius, including residents of Kakkani Colony, Subramania Nagar, and SA Colony.				
17.	Division Office 63 – Egmore – Residential	13.07054	80.26502	Veerabadran St, Pudupet, Komaleeswaranpet, Egmore, Chennai
This is a densely populated triangular area bounded by the Cooum River, Rumani Lakshmipathi Road, and Adithanar Road. It also includes Police Housing Colony and Police Quarters.				
18.	Manual AQM Station, Old Washermanpet – Industrial	13.10438	80.29074	Surya Narayana St, Anjaneya Nagar, Old Washermanpet, Chennai
Nearby industries include metal works, engineering, manufacturing, logistics, steel production, casting, and industrial suppliers.				

Sl. No.	Location	Latitude	Longitude	Address
19.	Chennai Metropolitan Transport Corporation Limited, Park Town – Traffic	13.07404	80.27598	Pallavan House, Mount Road, Pallavan Salai, Park Town, Chennai
This is a major traffic zone. It captures noise from Anna Salai (connecting Chintadripet and Park Town Railway Station) and roadways linking Central Railway Station and Beach Station.				
20.	Rajiv Gandhi Government General Hospital – Sensitive	13.08175	80.27808	Grand Southern Trunk Rd, Park Town, Chennai
One of the largest government hospitals in India, it provides facilities from basic to advanced care. The adjoining medical college further increases daily footfall, with huge crowds visiting every day.				
21.	Govt. E-service Centre (Ward 64), Kolathur – Residential	13.12216	80.22060	4th St, Anjugam Nagar, Kolathur, Chennai
This location covers a densely populated area, including KVR Nagar, Balaji Nagar, and Thiru Vi Ka Street, situated between Surapet Main Road and Perambur Red Hills High Road.				
22.	Corporation Office - Zone 6 - Thiru-vi-ka Nagar – Commercial	13.09824	80.25683	Dadashamakan, Buckingham and Carnatic Mills, Chennai
This location covers an area with major commercial activities such as woodworking shops, optical stores, jewelry shops, supermarkets, pharmacies, food outlets, and thread shops.				
23.	Division Office - 71 - Perambur – Traffic	13.11113	80.24802	Bharathi Rd, Chinnaiyan Colony, Perambur, Chennai
This location covers the traffic zone of Perambur High Road and is located near Perambur Railway Station.				
24.	Urban Primary Health Center, Kolathur – Sensitive	13.11943	80.20646	Srinivasa Nagar, Kolathur, Chennai
This UPHC is located in Senthil Nagar and Srinivasa Nagar, near Kolathur Main Road.				
25.	TNPCB, Ambattur DE Office – Residential	13.08867	80.17526	Ambattur Industrial Estate, Chennai
This location serves Gopal Naicker Nagar, VGP Nagar, and Mohanram Nagar, situated near Ambattur Estate Road.				

Sl. No.	Location	Latitude	Longitude	Address
26.	Corporation Office - Zone 7 - Ambattur – Industrial	13.10648	80.15295	Chennai–Tiruttani Hwy, Kamarajapuram, Ambattur, Chennai
This location includes a wide range of industries within the Ambattur Industrial Estate, housing engineering companies, IT firms, manufacturing units, and textile businesses.				
27.	Division Office - 79 – Traffic	13.12349	80.14708	Bank St, Ram Nagar, Ambattur, Chennai
This location is near the junction of State Highway 716 and Surapet Main Road, forming a triangular intersection.				
28.	Urban Primary Health Center, TMP Nagar, Padi – Sensitive	13.09503	80.17834	Church St, Mathiyazhagan Nagar, TMP Nagar, Padi, Chennai
This UPHC serves residents of Mathiyazhagan Nagar and nearby areas between Ambattur Estate Road and State Highway 716.				
29.	Corporation Zonal Office, Kilpauk – Residential	13.08026	80.23491	Temple St, Telecom Quarters, Kilpauk, Chennai
This location covers residential areas between New Avadi Road and Taylors Road. It also includes Postal and Telephone Staff Quarters.				
30.	Government E-service Centre, Anna Nagar – Commercial	13.09391	80.19990	Bharathi Nagar, Anna Nagar West, Anna Nagar, Chennai
Commercial activities here include retail stores, shopping complexes, business centers, corporate offices, and entertainment facilities.				
31.	Division Office - 94 - E-Sevai Maiyam, Villivakkam – Traffic	13.10472	80.20082	1st Main Rd, Sidco Nagar, Villivakkam, Chennai
This office is located close to Madras Thiruvalluvar High Road, near where New Avadi Road branches off.				
32.	Urban Primary Health Center, Ayanavaram – Sensitive	13.09880	80.23028	United India Nagar, Ayanavaram, Chennai
This UPHC serves residents of United India Nagar, Bharathi Nagar, and Officers Colony, near Ayanavaram Road.				
33.	Corporation Office - Zone 9 - Teynampet – Residential	13.05508	80.23928	4th Cross St, Lake Area, Nungambakkam, Chennai
This location covers residential areas such as Kamarajapuram and Kakkan Colony, near Kodambakkam High Road.				

Sl. No.	Location	Latitude	Longitude	Address
34.	Corporation Ward Office - 125 - Mylapore – Commercial	13.03480	80.27201	Kutchery Rd, Girija Garden, Mylapore, Chennai
Retail and sales activities are concentrated here, largely due to the presence of the Kapaleeshwarar Temple.				
35.	Division Office - 111 - Thousand Lights – Traffic	13.05489	80.25277	Aziz Mulk 9th St, Thousand Lights West, Thousand Lights, Chennai
This is a key location near Anna Salai, close to the Anna Flyover and Gemini Flyover, both major traffic hubs.				
36.	Urban Primary Health Center, Lloyd’s Colony, Triplicane – Sensitive	13.05083	80.27235	Mirsahibpet, Lloyd’s Colony, Triplicane, Chennai
This UPHC is situated near Dr. Natesan Road, which connects with Dr. Besant Road, a busy traffic route.				
37.	Division Office - 137 - K.K. Nagar – Residential	13.04286	80.19547	61st St, Santhiniketan Colony, K.K. Nagar, Chennai
This location lies near the center of Santhiniketan Colony, with clearly defined boundaries and a rectangular grid pattern of residential streets around Munuswamy Salai and Ponnambalam Salai.				
38.	Corporation Office (Division 136), T. Nagar – Commercial	13.03956	80.23817	Masilamani St, T. Nagar, Chennai
T. Nagar is a well-known commercial hub, and Masilamani Street is dominated by retail businesses, especially in South Indian textiles and gold jewelry.				
39.	Corporation Office - Zone 10 - Kodambakkam – Traffic	13.05181	80.21954	Arcot Rd, Kamarajar Colony, Kodambakkam, Chennai
Arcot Road experiences heavy traffic, as it connects to Vadapalani Metro Station and also links with the Grand Southern Trunk Road.				
40.	Urban Primary Health Center, Vadapalani – Sensitive	13.05384	80.20921	Rajangam Middle St, Thangal Karai, Kumaran Colony, Vadapalani, Chennai
This UPHC is located in a densely populated area, serving residents of Thirunagar Colony, Dharan Singh Colony, and Kumaran Colony.				

Sl. No.	Location	Latitude	Longitude	Address
41.	Urban Primary Health Center, Ramapuram – Residential	13.03018	80.17945	Bajanai Koil St, Mullai Nagar, Ramapuram, Chennai
This location is central to Subashree Nagar, CRR Puram, Lalitha Nagar, and Parthasarathy Nagar.				
42.	Corporation Office - Zone 11 - Valasaravakkam – Commercial	13.04096	80.17225	Arcot Rd, Bhuvaneshwari Nagar, Valasaravakkam, Chennai
Commercial activities here include film production houses, home furnishing stores, real estate agencies, restaurants, and clothing and jewelry shops.				
43.	Urban Primary Health Center, Maduravoyal – Traffic	13.06306	80.16644	Poonamallee High Rd, Maduravoyal, Chennai
This UPHC is located near EVR Periyar Salai and close to the Maduravoyal Flyover.				
44.	Urban Primary Health Center, Nerkundram – Sensitive	13.05510	80.18471	Kadambadi Amman Nagar, Valasaravakkam, Chennai
This location is in a densely populated area that includes Dhanalakshmi Nagar, Meenakshi Amman Nagar, Gandhi Nagar, and Natesan Nagar.				
45.	Corporation Ward Office - 167 - Nanganallur – Residential	12.97843	80.18592	100 Feet Rd, Civil Aviation Colony, Nanganallur, Chennai
This office serves residential areas such as TNGO Colony, Civil Aviation Colony, Hindu Colony, and State Bank Colony.				
46.	Corporation Ward Office - 156 - Mugalivakkam – Commercial	13.02099	80.16707	Padasalai St, Dhanam Nagar, Kumudam Nagar, Mugalivakkam, Chennai
Commercial activities here include tailoring services, mobile stores, retail shops, a waste paper mart, and other small businesses.				
47.	Urban Primary Health Center – Traffic	13.00178	80.20316	Appavu St, Ramapuram, Alandur, Chennai
This location is influenced by aircraft noise, as it is close to the landing runway of Chennai International Airport and also near the Chennai–Trichy Highway.				

Sl. No.	Location	Latitude	Longitude	Address
48.	Urban Primary Health Center (159), Pazhavanthangal – Sensitive	12.98819	80.18944	New Colony 1st St, Pazhavanthangal, Chennai
This UPHC serves people from New Colony, Thillaiganga Nagar, Kanakammal Colony, and Nehru Colony, which is a densely populated area.				
49.	Division Office - 176 - Shastri Nagar, Besant Nagar – Residential	12.99784	80.26142	7, 8th Cross St, Shastri Nagar, Adyar, Chennai – 600020
This station covers Shastri Nagar, Jeevarathinam Nagar, and nearby residential areas at Vannathurai, near Besant Nagar.				
50.	Tamil Nadu Pollution Control Board, Guindy – Industrial	13.01194	80.21910	Anna Salai, Guindy Industrial Estate, Guindy, Chennai
This station is located near SIDCO Industrial Estate, covering automotive manufacturing, electronics, and software development industries.				
51.	Velachery Gate, IIT Madras – Traffic	12.98790	80.22314	Anna Garden, IIT Madras, Chennai
This location records traffic noise near Gurunanak Road, which experiences congestion due to Gurunanak College and the IIT Madras Velachery Gate. The road also connects to Velachery's 100 Feet Road.				
52.	B.M. Birla Planetarium, Kotturpuram – Sensitive	13.01203	80.24402	Gandhi Mandapam Rd, Duraisamy Nagar, Kotturpuram, Chennai
This is an important educational location, frequently visited by school students, college students, and other visitors for science-related exhibits and demonstrations.				
53.	Corporation Office - Zone 14 - Perungudi – Residential	12.97233	80.19366	Puzhuthivakkam Main Rd, Perungudi, Chennai
This location covers residential areas such as Amman Nagar, Swamy Nagar, and Defence Colony, located between Jawaharlal Nehru Salai and Medavakkam Main Road.				
54.	Apollo Speciality Hospital, OMR, Perungudi – Commercial	12.96314	80.24600	Rajiv Gandhi Salai, Tirumalai Nagar, Perungudi, Chennai
Commercial activities near Apollo Speciality Hospital include cafes, restaurants (e.g., Madras Espresso, Nasi and Mee), and hotels such as the Holiday Inn with in-house dining facilities.				

Sl. No.	Location	Latitude	Longitude	Address
55.	Corporation Ward Office - 190 - Pallikaranai – Traffic	12.93103	80.20265	Velachery– Tambaram Main Rd, Pallikaranai, Chennai
This location is close to Velachery Road, connecting to the Pallikaranai Flyover and Velachery Local Railway Station.				
56.	National Institute of Wind Energy, Pallikaranai – Sensitive	12.95656	80.21521	Pallikaranai Marshland, Pallikaranai, Chennai
This location is significant due to the presence of the National Institute of Wind Energy.				
57.	CAAQM Station, Perungudi – Residential	12.95336	80.23579	6th Cross St, Sri Sai Nagar, Thoraipakkam, Chennai
This station covers residential areas such as Thirumalai Nagar Annex, Sri Sai Nagar, and Seevaram, near the OMR Service Road.				
58.	Govt. E-service Centre (Ward 194), Thoraipakkam – Commercial	12.93422	80.23328	Rajiv Gandhi Salai, Raj Nagar, Thoraipakkam, Chennai
Commercial activities here include restaurants, accommodation, and services such as legal consultancies, photography, and courier services, reflecting the area’s IT hub status.				
59.	Corporation Office - Zone 15 - Sholinganallur – Traffic	12.89608	80.22735	Rajiv Gandhi Salai, Sholinganallur, Chennai
This location is close to Rajiv Gandhi Salai, connecting Perumbakkam Main Road and the OMR Service Road.				
60.	Urban Primary Health Center, Semmancheri – Sensitive	12.87529	80.21047	6th Ave, Semmancheri, Chennai
This UPHC serves residents of Semmancheri, including the Tsunami Colony area near the bypass road.				

APPENDIX D.

CHARACTERIZATION OF NOISE LEVELS

This section presents the monthwise statistical summary and variations of noise levels measured across different zones from March to December. Comparisons among locations across all zones are illustrated through box plots, while compliance with CPCB standards is assessed in terms of number and percentage of exceedances.

Table D.1 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for March – Day

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone II	Sensitive	Zone2_S	0.00	54.97	92.58	48.94	59.16	52.31	49.68	9.48	64.45	57.62
Zone IV	Industrial	Zone4_I	0.00	60.98	96.56	47.46	65.44	56.18	49.87	15.57	76.55	82.16
Zone X	Commercial	Zone10_C	0.00	50.65	90.58	48.34	51.50	50.26	49.50	2.01	52.66	27.52
Zone XIII	Industrial	Zone13_I	0.00	62.47	97.42	35.92	64.94	61.82	58.12	6.82	69.28	55.39
	Traffic	Zone13_T	3.57	66.77	96.72	30.28	69.66	65.85	62.11	7.56	74.32	62.33
	Sensitive	Zone13_S	16.48	50.44	96.71	38.19	51.04	48.23	47.23	3.81	54.25	32.46
Zone XIV	Commercial	Zone14_C	0.00	68.85	100.09	48.62	73.28	65.82	55.26	18.02	86.87	97.33
	Sensitive	Zone14_S	0.74	65.89	97.93	45.02	70.13	61.20	49.62	20.51	86.39	101.65
Zone XV	Residential	Zone15_R	0.00	59.91	96.89	48.97	64.58	57.13	51.66	12.92	72.82	73.32

Table D.2 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for March – Night

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone II	Sensitive	Zone2_S	0.00	49.43	79.54	48.82	49.87	49.29	49.16	0.71	50.14	21.99
Zone IV	Industrial	Zone4_I	0.00	51.02	84.72	47.29	53.33	49.85	48.41	4.91	55.94	38.07
Zone X	Commercial	Zone10_C	0.00	49.85	83.85	48.28	51.07	49.00	48.78	2.29	52.14	27.92
	Industrial	Zone13_I	0.00	57.17	93.67	40.98	59.57	55.62	52.61	6.96	64.13	50.45
Zone XIII	Traffic	Zone13_T	44.64	58.65	93.82	30.03	63.14	55.99	48.24	14.89	73.54	77.82
	Sensitive	Zone13_S	14.77	48.34	82.34	39.48	49.73	47.39	46.95	2.77	51.12	28.05
Zone XIV	Commercial	Zone14_C	0.00	56.13	91.40	47.87	59.91	51.55	49.97	9.94	66.07	59.72
	Sensitive	Zone14_S	0.00	49.30	85.68	45.63	50.58	47.72	47.25	3.34	52.64	30.59
Zone XV	Residential	Zone15_R	0.00	50.76	80.36	49.00	52.06	50.08	49.70	2.36	53.12	29.14

Table D.3 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for April – Day

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Traffic	Zone1_T	20.00	60.28	90.00	46.00	62.50	60.19	55.88	6.62	66.89	52.35
Zone II	Sensitive	Zone2_S	0.00	56.30	101.42	48.94	58.56	52.26	49.80	8.77	65.07	54.86
Zone IV	Industrial	Zone4_I	0.00	60.57	100.93	46.89	64.04	56.53	50.07	13.98	74.55	75.98
Zone V	Industrial	Zone5_I	0.00	64.02	96.99	46.32	67.15	63.13	58.45	8.70	72.71	63.24
Zone VII	Residential	Zone7_R	0.00	66.01	88.80	51.90	67.13	66.10	64.47	2.66	68.67	45.10
Zone VIII	Residential	Zone8_R	0.00	59.53	95.70	43.80	62.69	57.99	55.38	7.31	66.85	54.63
	Commercial	Zone8_C	47.87	57.53	85.00	44.70	61.79	55.89	53.17	8.62	66.15	57.65
Zone IX	Residential	Zone9_R	0.00	63.75	91.70	44.20	66.08	62.07	56.91	9.17	72.92	63.59
Zone X	Commercial	Zone10_C	7.08	50.63	93.92	48.28	51.24	50.09	49.45	1.79	52.42	26.61

Zone No.	Category	Station ID	% missing data	L _{req} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XIII	Industrial	Zone13_I	3.54	61.43	97.24	30.76	63.89	60.88	56.56	7.34	68.76	55.90
	Traffic	Zone13_T	23.75	66.45	98.64	30.03	69.02	65.69	62.35	6.67	73.12	59.03
	Sensitive	Zone13_S	3.33	50.11	97.18	30.03	49.71	48.00	47.18	2.53	52.64	27.30
Zone XIV	Commercial	Zone14_C	2.71	70.51	98.06	49.32	75.30	65.76	56.07	19.24	89.75	103.02
	Sensitive	Zone14_S	0.42	68.71	102.03	45.46	73.32	60.93	50.75	22.56	91.28	111.01
Zone XV	Residential	Zone15_R	0.00	60.48	97.22	49.08	64.64	57.62	52.28	12.37	72.85	71.74

Table D.4 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for April – Night

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Traffic	Zone1_T	24.17	53.97	82.10	41.70	57.71	51.43	48.34	9.37	63.34	55.82
Zone II	Sensitive	Zone2_S	0.00	50.39	93.49	48.85	50.46	49.42	49.21	1.25	51.65	24.21
Zone IV	Industrial	Zone4_I	0.00	51.94	95.74	45.29	54.17	48.97	48.18	5.99	57.93	42.16
Zone V	Industrial	Zone5_I	0.00	56.96	98.18	45.06	60.22	54.47	50.99	9.22	66.19	57.89
Zone VII	Residential	Zone7_R	0.00	61.64	88.00	42.70	63.98	61.05	58.98	5.01	66.65	49.00
Zone VIII	Residential	Zone8_R	0.00	57.58	90.20	37.60	62.26	52.32	46.37	15.89	73.47	79.92
	Commercial	Zone8_C	47.68	52.20	81.40	43.40	54.74	51.18	49.16	5.58	57.78	41.49
Zone IX	Residential	Zone9_R	0.00	57.77	82.20	38.70	62.29	52.95	46.45	15.84	73.61	79.82
Zone X	Commercial	Zone10_C	9.58	49.52	94.80	48.18	49.98	49.00	48.83	1.16	50.68	23.45

Zone No.	Category	Station ID	% missing data	L _{req} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XIII	Industrial	Zone13_I	5.83	56.19	97.80	34.67	58.47	54.03	51.24	7.23	63.42	50.16
	Traffic	Zone13_T	97.08	62.35	94.04	30.03	64.89	60.54	55.33	9.56	71.91	63.59
	Sensitive	Zone13_S	2.08	48.74	90.91	32.84	49.08	47.25	46.87	2.21	50.95	25.71
Zone XIV	Commercial	Zone14_C	0.83	58.03	92.35	48.62	62.47	53.82	50.36	12.11	70.14	68.79
	Sensitive	Zone14_S	0.00	53.22	92.79	45.37	55.94	48.13	47.29	8.65	61.87	51.90
Zone XV	Residential	Zone15_R	0.00	51.19	90.82	49.03	52.77	50.30	49.82	2.95	54.14	31.63

Table D.5 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for May – Day

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Traffic	Zone1_T	1.41	59.83	87.70	45.90	61.67	59.61	55.67	6.00	65.82	49.66
Zone II	Sensitive	Zone2_S	11.29	57.25	99.59	48.94	60.02	52.81	50.13	9.89	67.14	59.69
Zone III	Residential	Zone3_R	3.82	65.55	99.50	41.70	68.09	63.51	61.42	6.67	72.23	58.11
	Traffic	Zone3_T	2.43	71.67	114.50	49.90	72.40	70.64	68.35	4.05	75.72	54.55
Zone IV	Residential	Zone4_R	4.38	60.54	97.50	44.30	62.42	59.78	56.56	5.85	66.39	49.98
	Industrial	Zone4_I	3.23	60.83	100.62	46.28	64.59	55.27	49.65	14.94	75.77	79.42
	Traffic	Zone4_T	3.98	70.25	103.10	48.70	71.49	70.20	67.98	3.51	73.76	52.02
Zone V	Residential	Zone5_R	3.98	62.35	92.60	44.40	66.40	59.37	56.85	9.55	71.90	65.06
	Industrial	Zone5_I	1.41	65.24	98.68	46.48	67.86	64.48	60.23	7.63	72.87	60.73
	Sensitive	Zone5_S	2.73	71.05	92.70	60.50	72.34	71.00	69.12	3.22	74.27	52.00
Zone VII	Residential	Zone7_R	1.41	65.71	90.60	51.80	66.89	65.64	64.05	2.84	68.55	45.42

Zone No.	Category	Station ID	% missing data	L _{req} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VIII	Residential	Zone8_R	5.04	60.36	86.40	44.00	64.42	58.36	55.76	8.66	69.02	60.40
	Commercial	Zone8_C	3.43	58.25	90.30	44.30	61.17	56.92	52.42	8.75	67.00	57.43
Zone IX	Residential	Zone9_R	1.41	62.85	93.70	44.60	65.22	62.45	58.06	7.16	70.01	56.70
Zone X	Commercial	Zone10_C	6.85	50.50	87.63	48.31	51.00	50.05	49.40	1.60	52.10	25.79
Zone XI	Residential	Zone11_R	24.50	67.60	104.90	48.30	69.43	67.27	64.25	5.18	72.78	54.98
	Commercial	Zone11_C	2.68	67.60	96.80	35.60	69.14	67.43	65.33	3.81	71.41	50.58
	Traffic	Zone11_T	13.10	75.10	105.10	37.20	76.21	75.15	73.23	2.98	78.08	55.16
Zone XII	Residential	Zone12_R	1.75	65.11	93.00	46.00	66.84	64.98	62.23	4.61	69.72	50.66
	Commercial	Zone12_C	5.47	59.12	90.90	42.80	61.55	57.18	53.66	7.89	67.01	55.22
	Traffic	Zone12_T	4.86	65.70	94.90	47.00	67.65	65.55	62.40	5.26	70.96	53.42
	Sensitive	Zone12_S	5.56	60.08	91.30	43.40	62.89	57.86	54.32	8.58	68.65	58.62

Zone No.	Category	Station ID	% missing data	L _{req} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XIII	Residential	Zone13_R	2.88	62.72	89.70	45.40	65.14	61.41	56.94	8.20	70.91	59.72
	Industrial	Zone13_I	36.90	61.58	98.73	30.03	63.98	60.58	56.31	7.67	69.25	56.99
	Traffic	Zone13_T	19.56	65.88	98.16	30.03	68.62	65.10	61.64	6.98	72.86	59.57
	Sensitive	Zone13_S	4.64	51.46	94.41	34.51	52.99	48.28	47.19	5.80	57.26	40.38
Zone XIV	Residential	Zone14_R	3.65	59.58	95.70	41.50	59.55	55.79	51.38	8.17	67.76	54.08
	Commercial	Zone14_C	11.90	67.20	100.09	48.39	72.27	61.34	56.83	15.45	82.65	88.61
	Traffic	Zone14_T	4.69	66.59	93.20	51.50	68.61	66.09	64.83	3.78	70.36	49.94
	Sensitive	Zone14_S	1.41	67.34	102.08	45.06	71.36	60.55	50.51	20.85	88.19	103.92
Zone XV	Residential	Zone15_R	1.41	58.82	97.04	49.11	62.17	56.20	51.77	10.39	69.22	63.35
	Traffic	Zone15_T	0.00	70.83	100.50	53.90	74.47	67.99	66.80	7.68	78.50	67.50
	Sensitive	Zone15_S	0.00	60.59	90.30	30.00	62.16	59.53	57.55	4.62	65.21	46.01

Table D.6 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for May – Night

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Traffic	Zone1_T	0.00	54.50	89.10	39.60	57.41	52.50	48.75	8.66	63.15	53.38
Zone II	Sensitive	Zone2_S	12.50	52.46	99.02	48.82	54.11	49.90	49.28	4.83	57.29	38.58
Zone III	Residential	Zone3_R	4.17	56.09	91.30	36.20	59.56	54.03	50.10	9.45	65.55	57.92
	Traffic	Zone3_T	0.00	63.74	95.50	37.70	67.35	61.15	58.63	8.71	72.45	63.49
Zone IV	Residential	Zone4_R	0.00	53.90	86.50	39.50	57.07	52.28	48.28	8.79	62.69	53.43
	Industrial	Zone4_I	6.45	56.16	99.81	45.88	59.19	50.27	48.02	11.17	67.33	62.69
	Traffic	Zone4_T	0.00	63.64	100.40	37.90	67.67	61.50	57.62	10.05	73.69	67.82
Zone V	Residential	Zone5_R	0.00	58.23	91.00	39.90	65.15	53.39	47.76	17.40	75.62	87.35
	Industrial	Zone5_I	0.00	57.12	93.31	44.41	61.38	55.02	51.95	9.42	66.54	59.64
	Sensitive	Zone5_S	0.00	64.65	86.60	50.00	67.65	63.32	61.09	6.56	71.21	57.31
Zone VII	Residential	Zone7_R	0.00	61.74	91.30	42.90	63.93	61.31	59.16	4.77	66.51	48.23

Zone No.	Category	Station ID	% missing data	L _{req} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VIII	Residential	Zone8_R	5.24	59.91	89.80	40.20	64.09	54.75	48.59	15.50	75.41	80.61
	Commercial	Zone8_C	2.81	53.52	92.10	41.80	56.42	51.50	49.42	7.00	60.52	47.43
Zone IX	Residential	Zone9_R	0.00	59.60	87.60	38.60	62.26	59.30	48.64	13.62	73.22	73.13
Zone X	Commercial	Zone10_C	3.23	49.55	94.20	47.96	49.73	48.99	48.82	0.91	50.46	22.46
Zone XI	Residential	Zone11_R	22.50	59.43	89.90	45.50	62.58	58.07	53.73	8.84	68.27	59.11
	Commercial	Zone11_C	0.00	62.86	99.40	30.00	65.40	62.26	57.87	7.53	70.39	57.98
	Traffic	Zone11_T	9.52	74.10	108.80	37.40	75.75	74.05	72.17	3.58	77.68	56.48
Zone XII	Residential	Zone12_R	0.00	55.90	88.70	41.70	59.30	54.05	49.57	9.73	65.63	58.49
	Commercial	Zone12_C	3.13	51.76	84.30	36.70	55.77	49.64	46.68	9.08	60.85	53.02
	Traffic	Zone12_T	0.00	64.59	95.70	43.40	66.90	64.01	60.35	6.56	71.14	56.57
	Sensitive	Zone12_S	5.56	53.29	87.60	38.20	56.86	51.14	48.07	8.79	62.07	53.22

Zone No.	Category	Station ID	% missing data	L _{req} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XIII	Residential	Zone13_R	0.48	54.43	85.50	41.20	59.04	50.98	46.80	12.24	66.67	65.77
	Industrial	Zone13_I	44.76	55.46	96.64	30.28	57.94	53.65	51.15	6.80	62.26	48.33
	Traffic	Zone13_T	81.85	61.49	95.81	30.03	63.81	60.41	50.90	12.91	74.40	72.54
	Sensitive	Zone13_S	1.21	48.25	96.18	34.51	49.17	47.27	46.78	2.39	50.65	26.35
Zone XIV	Residential	Zone14_R	0.00	49.70	79.80	40.30	51.95	48.97	46.27	5.68	55.38	38.99
	Commercial	Zone14_C	12.90	56.00	92.66	48.62	59.31	53.85	50.48	8.84	64.84	55.82
	Traffic	Zone14_T	0.00	62.82	90.70	42.30	64.42	62.58	60.46	3.95	66.78	46.28
	Sensitive	Zone14_S	0.00	56.93	96.45	44.74	61.50	51.10	47.09	14.41	71.34	74.73
Zone XV	Residential	Zone15_R	0.00	54.09	97.42	49.05	52.53	50.32	49.85	2.68	56.77	30.58
	Traffic	Zone15_T	0.00	70.44	102.70	46.90	74.70	65.12	61.65	13.05	83.49	83.83
	Sensitive	Zone15_S	0.00	59.61	91.20	30.00	61.63	54.05	50.27	11.35	70.96	65.69

Table D.7 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for June – Day

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Residential	Zone1_R	0.00	60.54	101.80	30.00	61.59	59.53	57.90	3.69	64.23	42.67
	Industrial	Zone1_I	0.00	64.63	102.90	46.60	65.85	64.46	62.79	3.05	67.68	45.01
	Traffic	Zone1_T	0.00	60.72	88.30	47.10	62.36	60.50	56.34	6.02	66.75	50.43
	Sensitive	Zone1_S	0.00	67.47	106.50	42.00	69.19	63.96	59.95	9.24	76.72	66.92
Zone II	Residential	Zone2_R	0.00	60.11	92.90	41.80	62.00	59.40	56.85	5.15	65.26	47.43
	Industrial	Zone2_I	0.00	62.39	94.40	43.70	63.97	62.45	59.57	4.40	66.79	47.15
	Traffic	Zone2_T	0.00	68.40	96.30	30.00	70.37	67.58	65.50	4.87	73.27	54.98
	Sensitive	Zone2_S	8.75	60.19	101.42	48.94	61.88	54.50	50.37	11.51	71.70	66.41
Zone III	Residential	Zone3_R	0.42	65.34	98.70	43.20	67.95	63.83	61.57	6.38	71.72	57.09
	Industrial	Zone3_I	0.00	69.97	106.70	45.10	69.29	64.34	60.37	8.92	78.89	66.05
	Traffic	Zone3_T	0.00	72.82	117.10	49.80	72.80	70.73	68.24	4.56	77.38	56.48
	Sensitive	Zone3_S	0.00	60.67	92.70	45.60	61.92	60.33	58.13	3.79	64.46	43.28
Zone IV	Residential	Zone4_R	0.00	60.70	100.10	43.10	61.69	59.26	56.47	5.22	65.92	47.37
	Industrial	Zone4_I	0.00	59.95	99.44	45.84	62.85	55.84	49.79	13.06	73.01	72.04
	Traffic	Zone4_T	0.00	70.31	112.70	46.60	71.45	70.03	67.77	3.68	73.99	52.49
	Sensitive	Zone4_S	21.25	67.81	103.50	45.10	71.44	64.96	61.89	9.54	77.36	70.07
Zone V	Residential	Zone5_R	0.00	62.63	94.70	44.60	66.87	59.09	56.85	10.02	72.65	66.94
	Industrial	Zone5_I	32.71	66.23	96.77	46.40	69.03	65.07	60.73	8.30	74.53	63.93
	Traffic	Zone5_T	0.00	68.90	103.60	34.30	69.80	69.02	66.88	2.92	71.81	48.55
	Sensitive	Zone5_S	0.00	71.10	92.60	60.90	72.48	71.00	69.16	3.32	74.42	52.44

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VI	Residential	Zone6_R	0.00	69.36	110.10	42.70	72.56	66.65	63.33	9.23	78.59	70.25
	Commercial	Zone6_C	0.00	61.72	100.10	45.50	63.62	60.78	58.50	5.13	66.85	49.00
	Traffic	Zone6_T	52.60	61.62	97.00	38.90	63.16	61.30	58.43	4.73	66.35	47.36
	Sensitive	Zone6_S	0.00	58.76	102.70	44.30	59.75	57.02	54.17	5.58	64.34	46.49
Zone VII	Residential	Zone7_R	0.42	66.30	102.20	52.00	67.06	65.96	64.06	3.00	69.30	46.06
	Industrial	Zone7_I	7.74	71.02	101.10	52.30	72.62	70.77	69.10	3.52	74.54	53.19
	Traffic	Zone7_T	0.00	60.95	92.70	43.30	62.47	60.69	59.19	3.28	64.23	42.32
	Sensitive	Zone7_S	0.00	67.46	104.10	43.70	69.35	66.57	63.24	6.11	73.57	57.68
Zone VIII	Residential	Zone8_R	1.67	62.04	90.30	44.30	65.14	59.66	56.35	8.79	70.83	61.50
	Commercial	Zone8_C	4.79	59.48	98.20	44.50	63.38	56.33	52.89	10.49	69.97	64.84
	Traffic	Zone8_T	0.00	72.29	106.90	48.90	72.56	70.25	68.04	4.52	76.81	56.12
	Sensitive	Zone8_S	0.00	69.08	103.00	31.10	71.12	68.14	64.65	6.47	75.55	60.53
Zone IX	Residential	Zone9_R	0.00	62.73	94.00	45.20	65.72	61.70	57.50	8.22	70.95	60.40
	Commercial	Zone9_C	63.10	63.59	93.70	35.30	64.99	62.34	54.78	10.21	73.80	65.62
	Traffic	Zone9_T	0.00	68.81	100.00	49.80	70.33	68.82	65.89	4.44	73.24	53.65
	Sensitive	Zone9_S	0.96	60.98	95.10	45.20	62.48	60.42	58.52	3.95	64.93	44.34
Zone X	Residential	Zone10_R	0.00	65.13	92.60	44.10	67.18	62.33	58.34	8.84	73.97	63.70
	Commercial	Zone10_C	57.29	75.39	100.11	48.18	51.64	50.25	49.43	2.21	77.60	28.27
	Traffic	Zone10_T	51.56	69.02	97.80	36.50	70.55	68.65	66.48	4.08	73.09	52.78
	Sensitive	Zone10_S	0.00	74.10	110.10	42.10	75.11	65.29	61.59	13.53	87.63	85.69

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XI	Residential	Zone11_R	2.92	68.28	93.50	49.00	69.86	67.93	64.79	5.07	73.35	55.07
	Commercial	Zone11_C	0.00	68.26	98.90	30.00	69.85	67.87	65.78	4.07	72.34	52.07
	Traffic	Zone11_T	0.00	76.25	115.50	57.00	76.90	75.76	74.69	2.21	78.46	53.53
	Sensitive	Zone11_S	15.42	62.33	98.40	42.30	64.33	61.37	59.01	5.32	67.65	50.29
Zone XII	Residential	Zone12_R	0.00	65.64	95.40	46.60	67.53	65.23	62.55	4.98	70.62	52.46
	Commercial	Zone12_C	0.83	58.52	90.80	42.00	60.33	56.63	53.86	6.47	64.99	49.74
	Traffic	Zone12_T	0.00	65.24	95.60	46.10	67.34	64.99	61.92	5.42	70.66	53.61
	Sensitive	Zone12_S	6.46	59.18	96.60	42.70	60.94	57.36	54.67	6.27	65.45	49.74
Zone XIII	Residential	Zone13_R	5.83	63.51	90.00	46.40	66.48	62.45	57.22	9.26	72.77	64.25
	Industrial	Zone13_I	18.75	60.78	99.09	30.03	63.27	60.10	55.81	7.47	68.24	55.67
	Traffic	Zone13_T	24.17	66.62	97.33	30.03	69.29	66.12	62.09	7.20	73.82	60.88
	Sensitive	Zone13_S	26.04	51.37	92.21	30.28	53.55	48.70	47.43	6.12	57.49	41.89
Zone XIV	Residential	Zone14_R	0.42	57.69	94.20	42.50	60.31	55.86	51.96	8.35	66.04	55.36
	Commercial	Zone14_C	0.00	64.12	98.05	49.36	67.56	61.53	58.05	9.51	73.63	66.08
	Traffic	Zone14_T	0.00	65.91	98.20	53.00	67.00	65.50	64.56	2.44	68.35	44.30
	Sensitive	Zone14_S	0.42	67.35	102.20	45.29	69.49	62.07	55.01	14.48	81.83	82.94
Zone XV	Residential	Zone15_R	0.00	58.69	93.44	49.14	61.50	57.89	53.07	8.43	67.12	56.80
	Commercial	Zone15_C	14.79	67.18	93.40	48.90	68.01	67.10	66.07	1.95	69.12	43.86
	Traffic	Zone15_T	0.00	70.25	103.30	52.30	72.98	68.20	66.53	6.45	76.70	62.33
	Sensitive	Zone15_S	0.00	59.85	105.30	30.00	61.68	59.13	57.52	4.16	64.01	44.17

Table D.8 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for June – Night

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Residential	Zone1_R	0.00	57.11	97.70	41.40	59.52	55.13	50.61	8.92	66.02	56.27
	Industrial	Zone1_I	0.00	61.81	89.00	40.40	63.26	61.68	59.53	3.72	65.53	44.43
	Traffic	Zone1_T	0.00	54.12	86.70	41.40	57.20	52.61	49.57	7.64	61.75	50.11
	Sensitive	Zone1_S	0.00	64.65	100.40	40.60	68.64	59.49	52.13	16.51	81.16	88.15
Zone II	Residential	Zone2_R	0.00	57.71	80.90	36.60	64.95	53.12	46.44	18.51	76.22	90.47
	Industrial	Zone2_I	0.00	54.45	92.00	36.60	57.05	52.74	49.56	7.48	61.93	49.49
	Traffic	Zone2_T	0.00	60.32	99.50	36.20	64.29	57.50	53.31	10.98	71.29	67.21
	Sensitive	Zone2_S	9.58	53.43	98.66	48.82	53.87	50.22	49.48	4.39	57.82	37.05
Zone III	Residential	Zone3_R	3.75	56.12	92.90	37.10	59.46	54.01	50.18	9.28	65.40	57.30
	Industrial	Zone3_I	0.00	59.34	100.50	41.60	61.84	57.30	51.70	10.14	69.48	62.27
	Traffic	Zone3_T	0.00	68.57	101.60	38.60	69.12	62.25	58.59	10.53	79.10	70.71
	Sensitive	Zone3_S	0.00	55.41	89.80	37.70	58.28	54.44	51.05	7.24	62.65	49.99
Zone IV	Residential	Zone4_R	0.00	55.42	96.50	36.00	57.87	53.45	49.02	8.86	64.27	54.45
	Industrial	Zone4_I	0.00	55.35	99.46	45.59	58.73	50.88	47.67	11.06	66.41	61.92
	Traffic	Zone4_T	0.00	63.09	103.20	37.50	66.95	61.21	57.37	9.58	72.68	65.71
	Sensitive	Zone4_S	22.92	58.85	91.20	42.10	63.09	56.25	49.48	13.61	72.46	73.92
Zone V	Residential	Zone5_R	0.00	57.89	90.00	39.90	64.05	53.73	48.02	16.04	73.93	82.16
	Industrial	Zone5_I	29.17	57.76	97.12	46.13	61.92	55.23	52.26	9.66	67.42	60.91
	Traffic	Zone5_T	0.00	64.30	91.80	32.90	67.16	63.43	60.47	6.69	70.98	57.22
	Sensitive	Zone5_S	0.00	65.16	87.90	51.10	67.66	64.10	62.06	5.60	70.76	54.47

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VI	Residential	Zone6_R	0.00	71.46	106.90	38.90	75.46	66.14	55.24	20.23	91.69	106.14
	Commercial	Zone6_C	0.00	59.07	90.60	42.80	61.21	58.49	56.62	4.59	63.66	44.97
	Traffic	Zone6_T	52.08	56.92	93.10	39.30	60.40	55.65	47.96	12.44	69.36	67.72
	Sensitive	Zone6_S	0.00	53.81	91.10	40.00	55.51	51.70	47.32	8.19	61.99	50.07
Zone VII	Residential	Zone7_R	0.00	61.84	91.10	43.70	63.88	61.18	58.93	4.95	66.79	48.74
	Industrial	Zone7_I	8.33	66.24	98.10	36.90	68.22	65.73	61.87	6.35	72.59	57.26
	Traffic	Zone7_T	0.00	57.77	91.40	36.80	60.56	56.65	51.90	8.67	66.43	56.56
	Sensitive	Zone7_S	0.00	60.81	99.70	44.60	61.97	58.21	55.00	6.97	67.77	52.88
Zone VIII	Residential	Zone8_R	2.50	58.55	84.80	40.70	62.83	55.15	49.73	13.10	71.65	72.12
	Commercial	Zone8_C	4.17	56.95	96.00	42.70	61.07	53.52	50.05	11.03	67.98	64.15
	Traffic	Zone8_T	0.00	64.79	101.30	43.90	67.63	61.31	58.01	9.62	74.41	66.50
	Sensitive	Zone8_S	0.00	64.30	106.30	41.60	67.87	60.39	57.04	10.84	75.14	70.38
Zone IX	Residential	Zone9_R	0.00	57.81	86.70	39.40	61.13	52.89	48.17	12.96	70.76	70.00
	Commercial	Zone9_C	60.12	57.26	97.70	35.20	60.81	56.42	46.51	14.29	71.55	73.69
	Traffic	Zone9_T	0.00	62.51	94.80	44.10	65.26	61.49	58.02	7.24	69.74	56.97
	Sensitive	Zone9_S	0.00	54.98	87.60	40.10	58.27	53.64	49.58	8.69	63.67	54.35
Zone X	Residential	Zone10_R	0.00	52.56	83.70	41.40	55.45	50.49	48.26	7.19	59.75	47.01
	Commercial	Zone10_C	56.67	49.31	87.02	47.80	49.90	49.04	48.86	1.04	50.36	23.04
	Traffic	Zone10_T	53.57	63.46	98.00	43.40	65.97	62.01	57.90	8.08	71.54	60.21
	Sensitive	Zone10_S	0.00	66.25	110.70	39.10	64.54	57.30	50.42	14.12	80.37	76.90

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XI	Residential	Zone11_R	1.25	58.85	89.30	44.60	62.52	57.52	53.32	9.21	68.06	60.14
	Commercial	Zone11_C	0.00	63.81	94.50	30.00	66.67	62.45	57.47	9.21	73.02	64.30
	Traffic	Zone11_T	0.00	75.02	107.20	46.80	76.25	74.83	73.39	2.86	77.88	54.82
	Sensitive	Zone11_S	15.83	53.90	85.50	38.50	56.89	51.86	48.27	8.62	62.53	52.76
Zone XII	Residential	Zone12_R	0.00	56.85	89.20	43.90	60.17	54.96	49.84	10.33	67.18	61.16
	Commercial	Zone12_C	0.00	54.28	95.70	36.40	58.10	52.09	48.00	10.10	64.38	58.41
	Traffic	Zone12_T	0.00	64.09	96.60	42.60	66.47	63.65	60.44	6.03	70.12	54.55
	Sensitive	Zone12_S	6.67	52.67	90.30	38.00	56.03	51.13	47.94	8.09	60.76	50.30
Zone XIII	Residential	Zone13_R	10.83	55.21	88.90	42.60	60.48	50.38	47.29	13.19	68.39	70.04
	Industrial	Zone13_I	54.58	57.64	96.72	30.03	61.05	55.02	51.25	9.80	67.44	60.45
	Traffic	Zone13_T	93.33	60.90	96.91	30.03	64.43	56.18	47.29	17.14	78.04	85.83
	Sensitive	Zone13_S	25.42	48.16	86.63	31.22	49.60	47.53	46.87	2.73	50.89	27.80
Zone XIV	Residential	Zone14_R	0.00	50.90	88.90	41.80	53.24	49.79	47.42	5.83	56.72	40.72
	Commercial	Zone14_C	1.67	55.66	91.12	48.85	59.39	52.70	50.55	8.84	64.50	55.91
	Traffic	Zone14_T	0.00	64.64	99.40	41.80	67.53	63.34	60.84	6.70	71.33	57.62
	Sensitive	Zone14_S	0.00	58.76	100.40	43.75	62.02	54.17	47.88	14.14	72.90	74.43
Zone XV	Residential	Zone15_R	0.00	52.33	96.28	49.08	52.53	50.54	49.92	2.61	54.93	30.34
	Commercial	Zone15_C	15.83	63.67	97.60	43.00	65.57	63.26	61.16	4.41	68.07	48.79
	Traffic	Zone15_T	0.00	68.57	101.30	44.30	72.42	64.49	61.41	11.01	79.58	75.47
	Sensitive	Zone15_S	0.00	55.90	90.40	30.00	58.27	54.16	49.19	9.08	64.98	55.52

Table D.9 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for July – Day

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Residential	Zone1_R	0.40	60.04	96.80	30.00	61.97	59.16	57.08	4.89	64.93	46.63
	Industrial	Zone1_I	0.40	64.71	98.10	46.70	65.86	64.37	62.91	2.94	67.66	44.69
	Traffic	Zone1_T	20.16	62.16	93.00	45.60	65.03	61.11	56.72	8.32	70.47	59.98
	Sensitive	Zone1_S	0.20	66.69	108.50	39.90	69.81	64.57	59.09	10.72	77.41	71.97
Zone II	Residential	Zone2_R	0.40	60.48	101.20	41.40	62.24	60.18	57.45	4.79	65.27	46.61
	Industrial	Zone2_I	0.40	71.13	101.10	43.10	65.32	62.74	59.73	5.60	76.73	52.11
	Traffic	Zone2_T	4.64	68.45	102.20	30.00	70.56	67.85	65.92	4.64	73.09	54.49
	Sensitive	Zone2_S	3.43	70.07	101.62	48.79	74.05	61.52	52.17	21.89	91.96	109.72
Zone III	Residential	Zone3_R	1.21	70.17	101.20	45.30	72.01	64.58	61.99	10.02	80.18	72.06
	Industrial	Zone3_I	0.20	68.48	109.60	44.00	69.59	65.11	60.41	9.18	77.66	67.13
	Traffic	Zone3_T	0.20	72.22	118.20	51.50	72.51	70.70	68.43	4.08	76.30	54.76
	Sensitive	Zone3_S	0.20	60.83	100.60	43.10	62.05	60.37	58.45	3.60	64.43	42.84
Zone IV	Residential	Zone4_R	0.81	60.81	95.60	44.10	61.43	59.27	56.68	4.75	65.56	45.69
	Industrial	Zone4_I	0.40	63.24	100.46	36.90	67.14	55.81	44.94	22.20	85.44	103.74
	Traffic	Zone4_T	0.20	70.04	105.60	44.80	71.31	69.84	67.55	3.76	73.80	52.58
	Sensitive	Zone4_S	7.66	69.13	107.40	45.30	69.01	64.18	61.73	7.28	76.41	60.85
Zone V	Residential	Zone5_R	0.60	63.72	98.20	42.30	67.84	59.49	57.13	10.71	74.43	69.96
	Industrial	Zone5_I	8.27	65.39	100.98	45.76	67.93	64.87	60.19	7.74	73.13	61.15
	Traffic	Zone5_T	0.81	68.77	97.30	32.60	69.77	68.90	67.05	2.71	71.49	47.91
	Sensitive	Zone5_S	0.20	71.41	92.70	61.40	72.69	71.30	69.61	3.08	74.48	51.91

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VI	Residential	Zone6_R	3.23	68.56	109.80	43.60	70.78	66.99	64.39	6.39	74.95	59.96
	Commercial	Zone6_C	0.20	62.54	100.30	45.10	64.61	60.75	58.12	6.50	69.04	54.11
	Traffic	Zone6_T	2.62	62.09	98.20	43.90	63.72	61.73	60.09	3.64	65.72	44.63
	Sensitive	Zone6_S	0.60	58.68	99.40	42.80	60.13	57.24	53.55	6.58	65.25	49.86
Zone VII	Residential	Zone7_R	0.60	66.00	93.90	51.70	66.95	65.97	64.33	2.62	68.61	44.80
	Industrial	Zone7_I	44.06	71.02	103.40	52.40	72.45	70.79	69.13	3.32	74.34	52.41
	Traffic	Zone7_T	2.62	60.92	94.80	41.50	62.28	60.54	58.91	3.36	64.28	42.37
	Sensitive	Zone7_S	0.40	67.76	101.80	45.00	69.87	66.75	62.54	7.33	75.09	61.86
Zone VIII	Residential	Zone8_R	8.27	62.96	96.40	44.60	65.77	60.18	57.41	8.37	71.33	60.87
	Commercial	Zone8_C	7.86	60.34	91.20	44.70	64.05	56.74	53.29	10.76	71.10	66.33
	Traffic	Zone8_T	8.06	71.73	116.20	48.50	71.88	70.12	67.88	4.00	75.72	53.86
	Sensitive	Zone8_S	0.20	68.70	105.50	31.40	71.05	68.27	64.82	6.22	74.93	59.72
Zone IX	Residential	Zone9_R	0.20	63.10	92.70	44.70	66.57	61.83	57.16	9.41	72.51	64.81
	Commercial	Zone9_C	0.81	65.18	107.50	44.20	66.81	64.97	61.85	4.96	70.14	51.69
	Traffic	Zone9_T	0.20	68.95	103.60	51.60	70.50	69.02	65.82	4.68	73.63	54.53
	Sensitive	Zone9_S	1.01	61.17	95.00	45.10	62.85	60.71	58.86	3.99	65.16	44.82
Zone X	Residential	Zone10_R	0.20	64.22	93.40	42.20	64.76	60.44	57.31	7.44	71.66	57.08
	Commercial	Zone10_C	7.06	62.57	100.07	47.46	60.65	48.94	48.70	11.95	74.52	66.50
	Traffic	Zone10_T	0.81	69.57	101.00	48.50	71.11	69.12	66.80	4.31	73.88	54.03
	Sensitive	Zone10_S	0.20	67.43	113.20	42.90	67.63	63.91	61.28	6.35	73.77	56.67

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XI	Residential	Zone11_R	0.20	71.18	110.00	48.70	70.86	68.22	65.11	5.75	76.93	58.12
	Commercial	Zone11_C	0.20	68.49	98.70	30.00	69.96	68.25	65.80	4.16	72.65	52.44
	Traffic	Zone11_T	0.20	76.19	107.50	57.50	77.18	76.01	74.88	2.30	78.49	54.06
	Sensitive	Zone11_S	0.20	62.90	100.60	42.50	64.66	61.75	59.32	5.34	68.24	50.67
Zone XII	Residential	Zone12_R	0.20	67.87	99.00	47.00	69.55	66.44	63.60	5.95	73.82	57.40
	Commercial	Zone12_C	0.20	58.88	91.30	41.30	60.70	57.59	54.47	6.23	65.11	49.39
	Traffic	Zone12_T	0.60	65.58	102.30	46.80	67.61	64.81	61.97	5.63	71.21	54.51
	Sensitive	Zone12_S	1.61	60.37	99.50	43.00	61.82	57.34	54.83	6.99	67.36	52.80
Zone XIII	Residential	Zone13_R	11.09	64.73	92.40	45.90	66.79	62.70	57.31	9.48	74.21	65.23
	Industrial	Zone13_I	42.94	61.50	98.75	30.03	63.70	60.96	57.18	6.52	68.02	53.26
	Traffic	Zone13_T	34.48	66.76	98.00	30.03	69.26	66.34	61.86	7.39	74.16	61.44
	Sensitive	Zone13_S	8.27	52.91	98.55	30.28	55.70	48.54	47.08	8.61	61.52	51.54
Zone XIV	Residential	Zone14_R	0.20	57.29	100.40	42.40	59.03	55.26	52.25	6.77	64.07	49.34
	Commercial	Zone14_C	24.40	62.87	95.90	49.32	66.00	61.31	57.74	8.25	71.13	60.76
	Traffic	Zone14_T	0.20	65.61	95.10	52.30	66.45	65.41	64.56	1.89	67.50	42.13
	Sensitive	Zone14_S	1.01	67.15	102.22	44.97	71.59	61.87	52.89	18.70	85.85	97.69
Zone XV	Residential	Zone15_R	0.40	59.22	96.05	49.11	62.38	57.48	53.02	9.35	68.57	60.43
	Commercial	Zone15_C	0.20	67.63	109.90	52.10	68.49	67.42	66.40	2.09	69.72	44.75
	Traffic	Zone15_T	0.60	68.58	103.70	51.30	70.30	68.06	66.31	3.99	72.57	52.26
	Sensitive	Zone15_S	0.60	61.82	92.40	30.00	62.73	59.77	58.33	4.39	66.21	45.91

Table D.10 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for July – Night

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Residential	Zone1_R	0.00	56.70	97.00	30.00	58.33	54.28	49.98	8.35	65.05	53.38
	Industrial	Zone1_I	0.00	62.00	91.40	39.50	63.28	61.63	59.97	3.32	65.32	43.23
	Traffic	Zone1_T	21.77	57.56	82.10	40.30	62.61	54.13	49.12	13.49	71.04	73.06
	Sensitive	Zone1_S	0.00	66.40	105.40	37.80	70.36	60.06	52.39	17.97	84.37	94.28
Zone II	Residential	Zone2_R	0.00	57.61	90.70	35.60	64.64	51.70	46.30	18.34	75.95	89.65
	Industrial	Zone2_I	0.00	55.16	97.00	35.90	57.36	53.35	50.22	7.15	62.30	48.80
	Traffic	Zone2_T	3.23	60.57	98.30	30.00	63.99	57.69	52.56	11.43	71.99	68.28
	Sensitive	Zone2_S	4.03	68.90	102.33	48.73	70.00	58.46	49.75	20.25	89.15	100.74
Zone III	Residential	Zone3_R	4.84	56.88	91.90	36.30	59.71	54.91	50.44	9.27	66.15	57.54
	Industrial	Zone3_I	0.00	62.98	100.00	40.80	63.45	57.56	52.27	11.17	74.15	66.97
	Traffic	Zone3_T	0.00	71.98	98.30	37.50	71.39	64.18	59.28	12.11	84.09	77.72
	Sensitive	Zone3_S	0.00	56.31	92.00	33.80	59.48	55.15	51.21	8.27	64.58	54.29
Zone IV	Residential	Zone4_R	0.00	56.94	92.60	39.30	58.43	53.21	47.81	10.63	67.57	60.32
	Industrial	Zone4_I	2.42	59.40	97.64	36.54	62.91	50.06	44.96	17.95	77.34	86.76
	Traffic	Zone4_T	0.00	62.60	95.80	37.10	66.49	60.61	57.12	9.37	71.97	64.61
	Sensitive	Zone4_S	6.45	60.02	98.60	42.00	60.98	55.75	49.35	11.63	71.65	65.87
Zone V	Residential	Zone5_R	0.00	61.28	103.00	39.80	65.55	53.59	48.33	17.23	78.50	87.23
	Industrial	Zone5_I	6.45	58.26	95.03	45.33	62.17	56.01	52.58	9.59	67.85	60.92
	Traffic	Zone5_T	2.42	64.73	100.50	37.70	67.35	63.75	60.99	6.36	71.09	56.42
	Sensitive	Zone5_S	0.00	65.94	91.60	51.20	68.08	65.06	62.67	5.41	71.35	54.32

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VI	Residential	Zone6_R	3.23	70.18	105.60	38.60	74.29	65.94	56.73	17.56	87.74	96.96
	Commercial	Zone6_C	3.23	60.97	101.60	41.60	62.03	57.95	56.20	5.83	66.80	49.53
	Traffic	Zone6_T	4.44	57.21	89.70	38.70	60.29	56.15	51.45	8.84	66.05	56.83
	Sensitive	Zone6_S	0.81	52.44	86.80	39.70	55.04	51.46	47.77	7.27	59.71	46.83
Zone VII	Residential	Zone7_R	2.02	62.17	89.70	44.80	63.99	61.23	59.01	4.98	67.16	48.95
	Industrial	Zone7_I	38.87	65.62	103.90	40.40	67.67	64.98	61.92	5.75	71.37	54.92
	Traffic	Zone7_T	3.23	56.95	88.00	35.80	59.89	55.71	51.43	8.46	65.42	55.28
	Sensitive	Zone7_S	0.40	63.78	105.10	42.80	65.38	58.85	55.15	10.23	74.01	66.08
Zone VIII	Residential	Zone8_R	9.68	59.64	86.80	40.90	63.62	56.42	50.11	13.51	73.15	74.16
	Commercial	Zone8_C	13.31	57.45	92.70	41.70	62.19	52.53	49.05	13.14	70.58	71.60
	Traffic	Zone8_T	6.45	65.49	99.60	44.40	67.07	61.75	58.28	8.79	74.28	63.44
	Sensitive	Zone8_S	0.00	62.07	101.80	32.70	65.68	59.57	55.46	10.22	72.29	66.35
Zone IX	Residential	Zone9_R	0.00	58.28	81.70	39.60	63.80	52.81	47.59	16.22	74.50	82.46
	Commercial	Zone9_C	0.00	59.13	91.10	39.80	61.48	58.59	54.56	6.91	66.04	52.22
	Traffic	Zone9_T	0.00	62.26	97.60	43.50	65.74	60.33	56.26	9.48	71.74	64.18
	Sensitive	Zone9_S	0.00	55.72	88.90	39.70	58.43	54.16	50.18	8.25	63.97	53.19
Zone X	Residential	Zone10_R	0.00	54.21	89.00	38.60	55.71	50.63	47.84	7.87	62.09	49.32
	Commercial	Zone10_C	7.26	65.54	94.13	47.70	68.44	48.75	48.64	19.80	85.33	97.83
	Traffic	Zone10_T	0.00	63.22	98.40	43.80	66.49	61.35	57.03	9.46	72.67	64.85
	Sensitive	Zone10_S	0.00	60.40	99.30	35.90	63.22	56.62	50.17	13.06	73.46	72.39

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XI	Residential	Zone11_R	0.00	59.95	90.70	44.00	63.30	57.73	53.02	10.28	70.22	64.14
	Commercial	Zone11_C	0.00	64.68	95.10	30.00	67.45	63.85	60.30	7.14	71.82	58.88
	Traffic	Zone11_T	0.00	75.52	107.40	48.00	76.62	75.29	74.01	2.61	78.13	54.45
	Sensitive	Zone11_S	0.00	56.08	102.70	34.80	57.77	53.91	48.78	8.99	65.07	54.72
Zone XII	Residential	Zone12_R	0.00	59.93	93.90	41.00	62.00	56.95	51.88	10.12	70.05	62.36
	Commercial	Zone12_C	0.81	54.95	85.70	35.30	59.21	51.94	48.43	10.78	65.72	61.53
	Traffic	Zone12_T	0.00	64.78	98.60	42.80	66.59	63.53	60.74	5.85	70.64	54.15
	Sensitive	Zone12_S	0.00	53.47	91.70	40.40	56.52	51.93	48.50	8.01	61.49	50.56
Zone XIII	Residential	Zone13_R	20.97	57.13	83.20	41.90	60.07	52.48	48.18	11.89	69.02	65.74
	Industrial	Zone13_I	61.29	57.36	96.09	30.03	60.44	54.96	51.57	8.87	66.23	57.05
	Traffic	Zone13_T	95.56	61.56	91.21	30.03	63.70	60.09	56.39	7.31	68.87	55.63
	Sensitive	Zone13_S	10.48	49.42	95.41	30.03	50.48	47.40	46.55	3.93	53.34	32.26
Zone XIV	Residential	Zone14_R	0.00	55.92	101.10	40.10	54.21	50.74	48.33	5.88	61.80	41.87
	Commercial	Zone14_C	23.79	57.61	96.85	48.93	59.46	53.80	50.80	8.66	66.27	55.45
	Traffic	Zone14_T	0.00	62.96	93.20	42.20	64.29	62.63	61.13	3.16	66.12	43.77
	Sensitive	Zone14_S	0.00	61.38	100.66	43.48	64.92	52.91	47.44	17.48	78.86	87.36
Zone XV	Residential	Zone15_R	0.00	53.85	92.66	49.08	55.56	51.16	49.99	5.58	59.42	42.29
	Commercial	Zone15_C	0.00	63.94	92.80	42.30	65.95	63.48	61.59	4.36	68.30	49.04
	Traffic	Zone15_T	0.00	64.88	96.30	43.70	67.10	63.93	61.47	5.63	70.51	53.99
	Sensitive	Zone15_S	0.00	56.70	95.00	30.00	57.87	53.71	49.55	8.32	65.02	52.84

Table D.11 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for August – Day

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Residential	Zone1_R	4.84	67.31	104.70	30.00	64.53	58.80	56.92	7.61	74.92	57.36
	Industrial	Zone1_I	0.00	64.38	95.80	46.30	65.65	64.14	62.48	3.17	67.55	45.16
	Traffic	Zone1_T	0.00	61.43	92.80	46.60	63.82	60.26	56.45	7.36	68.80	55.91
	Sensitive	Zone1_S	0.00	67.18	108.20	39.40	69.27	64.47	58.72	10.55	77.73	70.90
Zone II	Residential	Zone2_R	0.00	63.74	107.60	39.30	67.11	60.37	56.56	10.55	74.29	68.76
	Industrial	Zone2_I	1.01	67.42	104.30	39.60	65.19	62.45	59.19	6.00	73.42	53.19
	Traffic	Zone2_T	28.23	71.08	116.50	30.00	75.03	68.22	65.20	9.83	80.91	74.52
	Sensitive	Zone2_S	21.17	70.87	101.85	48.58	73.72	63.70	51.87	21.85	92.72	109.27
Zone III	Residential	Zone3_R	0.20	79.29	112.80	43.10	83.83	64.53	61.88	21.94	101.23	119.66
	Industrial	Zone3_I	0.00	67.77	103.50	43.30	70.05	64.97	60.28	9.77	77.54	69.36
	Traffic	Zone3_T	0.00	71.41	117.60	50.20	72.84	70.19	68.03	4.82	76.23	57.29
	Sensitive	Zone3_S	0.00	61.76	107.10	41.50	62.21	60.29	58.08	4.13	65.88	44.58
Zone IV	Residential	Zone4_R	0.00	60.67	102.30	44.10	61.50	59.45	57.09	4.42	65.08	44.75
	Industrial	Zone4_I	2.82	56.62	96.58	33.02	58.37	49.01	47.38	10.99	67.61	61.32
	Traffic	Zone4_T	0.00	70.29	102.80	46.70	71.66	69.91	67.52	4.15	74.43	54.10
	Sensitive	Zone4_S	0.00	72.87	107.80	44.40	76.60	65.86	62.14	14.47	87.34	90.00
Zone V	Residential	Zone5_R	0.00	66.03	105.30	41.90	68.47	59.87	57.05	11.42	77.44	72.71
	Industrial	Zone5_I	0.40	65.37	97.20	46.32	68.10	64.64	59.80	8.30	73.67	63.00
	Traffic	Zone5_T	0.00	68.47	99.80	30.50	69.57	68.60	66.38	3.19	71.65	49.12
	Sensitive	Zone5_S	0.60	71.73	101.10	60.60	73.25	71.56	69.58	3.66	75.39	54.23

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VI	Residential	Zone6_R	0.20	69.49	108.30	41.60	72.06	68.16	65.39	6.67	76.16	62.07
	Commercial	Zone6_C	0.00	62.07	102.20	45.40	64.54	60.67	58.33	6.21	68.28	53.17
	Traffic	Zone6_T	4.23	62.13	95.50	45.40	63.47	61.89	60.28	3.19	65.32	43.03
	Sensitive	Zone6_S	0.40	58.73	104.20	43.50	60.71	57.03	53.67	7.05	65.78	51.85
Zone VII	Residential	Zone7_R	8.47	66.12	89.70	51.90	67.09	65.96	64.25	2.84	68.95	45.60
	Industrial	Zone7_I	60.08	71.16	101.90	52.40	72.89	70.80	68.94	3.95	75.11	54.75
	Traffic	Zone7_T	0.20	60.78	93.50	41.80	62.31	60.35	58.64	3.67	64.45	43.31
	Sensitive	Zone7_S	0.20	67.52	102.00	42.90	69.76	66.44	62.16	7.60	75.12	62.55
Zone VIII	Residential	Zone8_R	7.46	61.81	90.00	31.50	65.07	60.30	56.53	8.55	70.36	60.72
	Commercial	Zone8_C	2.22	59.23	87.10	44.20	63.72	57.00	53.12	10.59	69.82	65.49
	Traffic	Zone8_T	0.00	72.01	117.20	48.20	72.85	70.30	68.18	4.68	76.69	56.88
	Sensitive	Zone8_S	0.00	68.55	104.80	30.00	70.72	68.03	64.69	6.03	74.58	58.79
Zone IX	Residential	Zone9_R	0.00	62.61	105.60	44.50	63.92	61.75	57.82	6.11	68.71	52.24
	Commercial	Zone9_C	0.20	67.55	107.00	44.00	67.07	64.82	61.81	5.26	72.81	52.85
	Traffic	Zone9_T	0.00	68.84	100.60	50.00	70.53	68.85	65.75	4.78	73.62	54.87
	Sensitive	Zone9_S	0.00	62.37	96.80	45.70	63.69	61.17	59.01	4.68	67.05	47.71
Zone X	Residential	Zone10_R	0.60	67.15	92.90	42.10	69.16	61.37	57.13	12.03	79.18	75.25
	Commercial	Zone10_C	21.77	67.51	101.24	44.97	49.77	48.80	48.60	1.17	68.68	23.28
	Traffic	Zone10_T	0.00	69.26	102.40	48.20	70.95	68.98	66.36	4.58	73.85	54.70
	Sensitive	Zone10_S	0.00	69.96	115.40	43.00	71.58	64.52	61.19	10.39	80.35	72.75

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XI	Residential	Zone11_R	0.00	72.29	109.50	48.80	70.83	67.87	64.65	6.18	78.47	59.37
	Commercial	Zone11_C	0.00	70.64	105.50	30.00	71.98	67.98	65.63	6.35	76.99	61.03
	Traffic	Zone11_T	0.00	76.99	109.40	57.40	77.79	76.35	75.10	2.69	79.67	55.84
	Sensitive	Zone11_S	0.00	64.40	106.60	42.50	67.29	62.57	59.93	7.36	71.77	59.39
Zone XII	Residential	Zone12_R	0.60	67.62	99.10	32.80	69.03	66.52	62.36	6.67	74.29	59.05
	Commercial	Zone12_C	0.40	62.62	107.50	42.10	63.12	57.81	54.31	8.81	71.43	59.54
	Traffic	Zone12_T	0.00	65.30	99.10	46.40	67.52	64.96	61.38	6.14	71.43	55.92
	Sensitive	Zone12_S	17.71	67.91	95.50	41.50	71.08	57.37	54.53	16.55	84.46	90.73
Zone XIII	Residential	Zone13_R	10.89	63.00	99.70	45.90	65.46	61.54	56.63	8.83	71.82	61.94
	Industrial	Zone13_I	63.23	59.92	94.94	30.28	62.65	59.21	55.26	7.39	67.31	54.80
	Traffic	Zone13_T	38.51	66.65	99.24	30.03	69.47	65.83	62.07	7.40	74.04	61.66
	Sensitive	Zone13_S	15.32	51.00	99.25	34.04	52.29	47.91	46.76	5.53	56.53	38.87
Zone XIV	Residential	Zone14_R	0.00	57.69	92.60	41.00	58.46	54.55	51.61	6.85	64.54	49.01
	Commercial	Zone14_C	15.52	62.26	94.90	48.89	64.82	59.76	55.03	9.79	72.05	64.18
	Traffic	Zone14_T	0.40	66.29	109.00	52.90	67.22	65.54	64.59	2.63	68.92	45.10
	Sensitive	Zone14_S	0.00	62.18	101.11	44.74	65.69	57.74	49.86	15.83	78.01	83.16
Zone XV	Residential	Zone15_R	0.00	62.03	97.20	49.08	64.18	56.39	52.29	11.89	73.92	69.85
	Commercial	Zone15_C	0.00	68.36	101.80	51.20	70.17	67.55	66.32	3.86	72.22	51.74
	Traffic	Zone15_T	4.84	68.63	102.10	49.90	70.50	67.81	66.25	4.25	72.87	53.24
	Sensitive	Zone15_S	0.00	61.53	102.90	30.00	64.06	59.99	58.23	5.83	67.36	51.55

Table D.12 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for August – Night

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Residential	Zone1_R	6.45	59.33	99.30	30.00	58.80	54.17	48.92	9.88	69.21	58.44
	Industrial	Zone1_I	1.61	61.82	102.60	39.00	63.22	61.48	59.19	4.03	65.85	45.31
	Traffic	Zone1_T	0.00	57.16	93.60	40.80	59.97	53.54	49.42	10.55	67.71	61.62
	Sensitive	Zone1_S	0.00	71.03	114.50	38.30	74.72	61.14	51.32	23.40	94.43	114.92
Zone II	Residential	Zone2_R	0.00	60.40	105.70	33.80	64.29	52.02	45.75	18.54	78.94	89.92
	Industrial	Zone2_I	3.63	55.77	92.30	35.00	57.20	53.65	49.65	7.55	63.32	49.85
	Traffic	Zone2_T	29.03	64.53	100.50	30.00	65.01	57.62	52.35	12.66	77.19	72.97
	Sensitive	Zone2_S	19.35	65.92	100.82	48.58	66.68	54.64	49.44	17.23	83.15	88.37
Zone III	Residential	Zone3_R	0.00	69.47	110.90	35.90	62.70	56.18	50.46	12.25	81.71	69.45
	Industrial	Zone3_I	0.00	67.57	99.50	39.90	62.28	56.19	50.60	11.68	79.25	67.32
	Traffic	Zone3_T	0.00	67.44	96.20	38.20	69.19	63.57	58.44	10.76	78.20	71.46
	Sensitive	Zone3_S	0.00	57.91	106.90	35.80	59.88	55.27	50.61	9.28	67.19	57.71
Zone IV	Residential	Zone4_R	0.00	62.77	101.60	39.50	59.99	53.95	48.73	11.26	74.03	63.78
	Industrial	Zone4_I	7.26	55.64	98.99	30.28	57.00	48.51	47.32	9.68	65.32	56.03
	Traffic	Zone4_T	0.81	63.43	99.70	36.20	67.12	60.80	57.43	9.69	73.12	66.17
	Sensitive	Zone4_S	0.00	66.92	105.90	36.10	63.72	57.39	49.78	13.94	80.86	75.55
Zone V	Residential	Zone5_R	0.00	60.94	99.60	38.30	66.36	54.16	48.13	18.23	79.17	91.06
	Industrial	Zone5_I	0.00	57.97	96.45	45.59	61.64	55.31	52.25	9.39	67.36	59.80
	Traffic	Zone5_T	0.00	64.25	99.80	30.00	66.84	63.06	60.40	6.44	70.69	56.16
	Sensitive	Zone5_S	0.00	66.23	90.70	49.20	68.37	65.41	62.60	5.78	72.00	55.70

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VI	Residential	Zone6_R	0.00	69.77	105.50	37.40	73.86	63.51	55.58	18.29	88.06	98.72
	Commercial	Zone6_C	0.00	61.03	106.70	41.10	62.02	57.73	55.17	6.84	67.87	52.54
	Traffic	Zone6_T	4.03	56.54	87.70	37.50	60.06	55.31	49.81	10.25	66.79	60.81
	Sensitive	Zone6_S	0.00	55.91	96.30	37.80	56.00	50.44	46.31	9.69	65.60	55.08
Zone VII	Residential	Zone7_R	10.48	62.84	90.50	43.30	64.53	61.32	59.40	5.13	67.97	49.93
	Industrial	Zone7_I	63.71	65.51	98.40	39.50	68.10	64.64	61.62	6.49	72.00	57.56
	Traffic	Zone7_T	0.00	58.48	101.50	35.50	60.11	56.26	52.71	7.41	65.88	52.33
	Sensitive	Zone7_S	0.40	65.10	101.80	42.90	63.96	58.40	54.19	9.77	74.87	63.28
Zone VIII	Residential	Zone8_R	8.87	62.63	93.10	30.80	65.08	57.43	49.32	15.76	78.39	82.36
	Commercial	Zone8_C	6.45	56.60	86.90	42.30	59.79	51.87	49.22	10.56	67.16	61.48
	Traffic	Zone8_T	0.00	67.81	99.30	43.70	68.92	63.09	59.27	9.65	77.46	67.87
	Sensitive	Zone8_S	0.00	62.76	103.90	30.00	65.30	59.28	53.48	11.83	74.59	70.78
Zone IX	Residential	Zone9_R	0.00	61.92	93.40	38.70	61.37	53.07	47.72	13.65	75.56	72.32
	Commercial	Zone9_C	0.00	62.21	96.10	38.60	62.39	58.47	54.84	7.55	69.76	55.03
	Traffic	Zone9_T	0.00	63.49	100.10	42.60	66.65	61.20	56.97	9.68	73.17	65.69
	Sensitive	Zone9_S	0.00	57.69	104.40	39.50	59.42	54.49	50.11	9.32	67.00	57.37
Zone X	Residential	Zone10_R	0.00	56.98	89.30	39.50	56.01	50.84	47.24	8.77	65.75	52.32
	Commercial	Zone10_C	25.00	60.44	100.08	44.93	49.40	48.62	48.52	0.88	61.32	22.04
	Traffic	Zone10_T	0.00	63.39	109.90	43.80	65.83	61.70	57.07	8.76	72.15	62.13
	Sensitive	Zone10_S	0.00	67.18	109.00	38.50	64.06	56.14	49.19	14.87	82.05	78.66

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XI	Residential	Zone11_R	0.00	65.67	108.90	45.00	63.37	57.54	53.11	10.26	75.93	64.15
	Commercial	Zone11_C	0.00	64.57	101.10	30.00	66.51	63.51	59.38	7.13	71.70	57.91
	Traffic	Zone11_T	0.00	76.06	108.40	47.40	77.18	75.54	74.16	3.02	79.08	56.25
	Sensitive	Zone11_S	0.00	59.62	98.30	38.30	60.13	54.40	49.33	10.80	70.42	62.54
Zone XII	Residential	Zone12_R	0.00	58.71	93.60	31.60	61.14	55.44	50.53	10.61	69.32	62.97
	Commercial	Zone12_C	0.00	56.23	97.30	36.30	60.43	52.61	48.14	12.29	68.53	67.31
	Traffic	Zone12_T	0.00	65.45	110.00	41.60	66.21	63.46	60.62	5.58	71.03	52.96
	Sensitive	Zone12_S	13.36	61.57	107.80	39.00	57.30	50.08	46.51	10.79	72.36	59.67
Zone XIII	Residential	Zone13_R	8.87	58.48	93.10	41.30	57.02	49.70	46.37	10.65	69.13	58.97
	Industrial	Zone13_I	66.67	58.34	91.05	30.52	57.53	53.74	50.50	7.04	65.38	48.64
	Traffic	Zone13_T	99.60	60.16	87.59	30.03	60.16	60.16	60.16	0.00	60.16	30.16
	Sensitive	Zone13_S	16.13	53.08	97.59	32.46	52.19	46.94	46.41	5.78	58.86	39.53
Zone XIV	Residential	Zone14_R	0.00	59.95	99.80	38.70	54.05	50.00	46.99	7.06	67.01	45.24
	Commercial	Zone14_C	13.71	55.38	93.08	48.67	58.41	51.85	49.92	8.49	63.87	53.88
	Traffic	Zone14_T	0.00	63.17	98.10	41.30	64.54	62.66	61.06	3.48	66.65	44.98
	Sensitive	Zone14_S	0.00	57.38	99.98	44.01	58.25	49.40	46.98	11.27	68.65	62.06
Zone XV	Residential	Zone15_R	0.00	56.46	96.65	49.05	52.99	50.57	49.97	3.02	59.49	32.06
	Commercial	Zone15_C	0.00	64.05	95.10	42.10	65.88	63.63	61.83	4.06	68.10	48.06
	Traffic	Zone15_T	4.44	65.67	94.10	43.30	69.26	64.24	61.58	7.68	73.34	62.29
	Sensitive	Zone15_S	0.00	58.87	101.10	30.00	59.16	53.89	49.53	9.63	68.49	58.05

Table D.13 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for September – Day

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Residential	Zone1_R	0.00	59.04	94.20	30.00	61.00	58.45	56.72	4.28	63.32	43.85
	Industrial	Zone1_I	0.21	64.63	100.30	46.30	65.84	64.49	62.73	3.11	67.74	45.18
	Traffic	Zone1_T	0.00	60.20	92.20	47.40	61.73	59.45	56.01	5.73	65.93	48.91
	Sensitive	Zone1_S	0.42	66.58	111.20	40.70	69.81	64.46	58.62	11.18	77.76	73.35
Zone II	Residential	Zone2_R	0.00	58.93	106.00	40.30	60.67	57.81	54.35	6.32	65.25	49.64
	Industrial	Zone2_I	1.04	68.59	114.40	41.90	65.34	62.71	59.47	5.87	74.46	52.93
	Traffic	Zone2_T	0.00	65.80	111.90	30.00	66.74	64.66	62.94	3.80	69.60	48.15
	Sensitive	Zone2_S	33.75	65.23	100.70	48.52	69.39	60.72	52.40	17.00	82.23	90.39
Zone III	Residential	Zone3_R	0.00	65.95	102.30	43.20	67.13	63.48	61.21	5.92	71.88	54.91
	Industrial	Zone3_I	0.00	67.15	116.00	43.20	68.83	64.25	59.97	8.87	76.02	65.43
	Traffic	Zone3_T	0.00	71.22	116.00	50.70	72.90	69.88	67.58	5.32	76.55	58.87
	Sensitive	Zone3_S	0.21	60.49	102.20	43.40	61.82	60.09	57.81	4.00	64.49	43.83
Zone IV	Residential	Zone4_R	0.00	60.61	98.10	43.40	61.27	59.30	57.23	4.04	64.66	43.40
	Industrial	Zone4_I	6.31	75.11	99.98	45.59	53.46	48.52	47.97	5.49	80.61	39.94
	Traffic	Zone4_T	0.00	70.29	108.70	46.50	71.62	70.02	67.24	4.38	74.67	54.77
	Sensitive	Zone4_S	0.00	68.20	104.40	45.10	69.97	64.27	61.59	8.38	76.57	65.10
Zone V	Residential	Zone5_R	0.42	62.42	92.90	41.90	66.71	59.13	56.28	10.43	72.84	67.99
	Industrial	Zone5_I	0.00	65.78	97.57	45.88	68.44	65.05	59.70	8.74	74.52	64.65
	Traffic	Zone5_T	0.00	68.38	100.60	36.90	69.48	68.62	66.02	3.46	71.84	49.87
	Sensitive	Zone5_S	0.00	71.76	96.90	60.10	73.21	71.54	69.52	3.69	75.45	54.29

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VI	Residential	Zone6_R	0.00	68.97	107.70	40.50	71.04	68.08	65.29	5.75	74.73	58.30
	Commercial	Zone6_C	0.42	61.47	101.20	44.10	63.71	60.40	57.63	6.08	67.55	51.94
	Traffic	Zone6_T	32.71	61.75	93.80	44.60	62.88	61.59	60.19	2.69	64.43	40.94
	Sensitive	Zone6_S	0.42	60.58	92.70	42.60	62.36	56.54	53.08	9.28	69.86	60.19
Zone VII	Residential	Zone7_R	0.42	66.49	95.90	52.00	67.60	66.44	64.71	2.89	69.39	46.28
	Industrial	Zone7_I	20.09	71.83	103.60	52.70	73.27	70.99	68.84	4.43	76.26	56.54
	Traffic	Zone7_T	0.00	60.23	92.60	41.30	61.68	59.97	58.19	3.49	63.72	42.15
	Sensitive	Zone7_S	5.83	68.20	102.10	45.20	70.81	66.68	62.92	7.89	76.09	64.48
Zone VIII	Residential	Zone8_R	0.00	61.80	96.70	43.60	65.59	59.25	55.96	9.64	71.43	64.50
	Commercial	Zone8_C	0.63	60.08	90.00	43.70	64.25	57.48	53.36	10.89	70.97	66.93
	Traffic	Zone8_T	0.00	71.19	109.50	48.80	71.92	70.16	67.95	3.97	75.16	53.82
	Sensitive	Zone8_S	0.00	69.71	109.60	34.00	72.05	68.78	65.86	6.20	75.91	60.65
Zone IX	Residential	Zone9_R	28.54	63.68	92.50	45.40	67.05	62.38	58.20	8.84	72.53	63.58
	Commercial	Zone9_C	0.42	65.20	93.70	43.50	66.63	64.75	61.86	4.77	69.97	50.93
	Traffic	Zone9_T	0.00	69.07	103.30	49.30	70.49	69.12	66.17	4.33	73.40	53.47
	Sensitive	Zone9_S	0.00	60.80	93.30	45.40	62.26	60.54	58.65	3.61	64.41	43.10
Zone X	Residential	Zone10_R	0.00	64.46	94.40	39.90	65.85	61.53	57.54	8.31	72.77	60.78
	Commercial	Zone10_C	0.00	54.93	98.81	47.86	49.59	49.07	48.68	0.91	55.84	22.32
	Traffic	Zone10_T	0.00	70.87	100.40	50.10	72.62	70.50	67.87	4.75	75.62	56.85
	Sensitive	Zone10_S	0.00	68.62	111.10	42.60	69.58	64.02	60.99	8.59	77.21	65.34

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XI	Residential	Zone11_R	0.00	68.27	100.60	49.00	70.11	68.05	65.22	4.89	73.16	54.79
	Commercial	Zone11_C	0.00	70.86	102.90	30.00	72.81	69.00	66.57	6.23	77.09	61.51
	Traffic	Zone11_T	1.71	77.43	112.40	58.50	77.91	76.03	74.32	3.59	81.02	58.67
	Sensitive	Zone11_S	0.00	64.61	113.00	42.20	66.40	62.46	58.84	7.56	72.17	59.09
Zone XII	Residential	Zone12_R	0.00	67.15	98.20	45.60	69.14	66.42	63.48	5.66	72.81	56.11
	Commercial	Zone12_C	0.63	58.24	102.70	41.30	59.70	56.56	53.94	5.76	64.00	46.98
	Traffic	Zone12_T	0.00	65.69	107.20	45.30	67.38	65.19	61.91	5.47	71.16	53.80
	Sensitive	Zone12_S	7.11	65.51	99.50	42.30	64.12	56.82	53.91	10.22	75.73	64.77
Zone XIII	Residential	Zone13_R	7.29	62.63	89.60	44.90	65.43	61.34	57.52	7.90	70.54	59.14
	Industrial	Zone13_I	29.58	61.67	98.72	30.28	64.36	60.80	56.96	7.40	69.07	56.56
	Traffic	Zone13_T	47.71	66.34	98.13	30.03	68.99	65.80	61.92	7.07	73.41	60.20
	Sensitive	Zone13_S	40.42	70.89	101.06	33.55	56.08	48.90	47.03	9.05	79.94	53.25
Zone XIV	Residential	Zone14_R	0.00	59.00	95.60	40.70	59.66	55.30	51.85	7.81	66.80	53.07
	Commercial	Zone14_C	0.00	68.70	96.38	48.53	73.27	60.60	55.29	17.99	86.69	97.23
	Traffic	Zone14_T	0.00	65.36	101.90	52.90	66.21	65.14	64.26	1.95	67.31	42.07
	Sensitive	Zone14_S	0.42	61.78	101.52	43.53	65.56	56.52	50.32	15.24	77.02	81.29
Zone XV	Residential	Zone15_R	0.00	69.34	101.18	49.05	72.72	61.76	53.29	19.43	88.77	100.99
	Commercial	Zone15_C	0.00	67.70	95.40	50.30	68.88	67.42	66.13	2.75	70.46	47.14
	Traffic	Zone15_T	0.00	67.92	101.40	50.60	69.01	67.40	66.14	2.87	70.79	47.61
	Sensitive	Zone15_S	0.00	61.07	112.00	30.00	62.45	60.06	58.26	4.19	65.26	45.04

Table D.14 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for September – Night

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Residential	Zone1_R	0.00	58.39	101.30	30.00	60.10	54.10	50.01	10.09	68.48	60.36
	Industrial	Zone1_I	1.25	62.27	95.50	37.70	63.65	62.00	59.90	3.75	66.02	44.91
	Traffic	Zone1_T	0.00	56.55	103.90	40.50	56.71	52.53	48.67	8.05	64.59	50.85
	Sensitive	Zone1_S	0.00	70.06	107.30	36.60	73.66	64.35	53.73	19.93	89.99	103.45
Zone II	Residential	Zone2_R	0.00	54.72	90.60	33.20	55.60	50.01	45.89	9.71	64.44	54.74
	Industrial	Zone2_I	0.83	63.33	99.00	34.60	58.99	54.90	51.29	7.70	71.03	52.08
	Traffic	Zone2_T	0.00	61.47	95.60	35.10	61.35	55.47	50.53	10.82	72.28	63.79
	Sensitive	Zone2_S	33.33	64.87	100.73	48.49	68.57	53.27	49.52	19.05	83.91	95.71
Zone III	Residential	Zone3_R	0.42	56.51	92.70	36.20	58.86	54.08	49.57	9.30	65.80	56.75
	Industrial	Zone3_I	0.00	68.62	113.60	39.50	65.60	56.40	50.90	14.70	83.32	79.69
	Traffic	Zone3_T	0.00	64.71	99.10	38.90	67.58	61.74	57.27	10.30	75.01	68.48
	Sensitive	Zone3_S	0.00	56.47	100.00	35.10	57.76	53.90	49.68	8.09	64.56	52.02
Zone IV	Residential	Zone4_R	0.00	61.50	109.10	39.50	60.26	54.89	49.26	11.00	72.51	63.28
	Industrial	Zone4_I	8.00	79.24	99.94	32.84	49.49	48.29	47.61	1.88	81.13	25.14
	Traffic	Zone4_T	0.00	64.19	105.70	36.20	67.85	61.80	56.79	11.06	75.25	71.02
	Sensitive	Zone4_S	0.00	61.71	105.10	37.00	61.45	55.04	48.70	12.76	74.47	69.72
Zone V	Residential	Zone5_R	0.00	59.33	92.40	37.30	65.40	53.44	47.26	18.15	77.48	89.85
	Industrial	Zone5_I	0.00	58.58	97.23	43.53	62.14	55.74	52.57	9.56	68.14	60.83
	Traffic	Zone5_T	0.00	64.15	97.90	30.00	66.95	63.06	60.50	6.45	70.60	56.28
	Sensitive	Zone5_S	0.00	66.11	89.60	49.30	68.66	64.98	62.31	6.35	72.47	57.72

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VI	Residential	Zone6_R	0.00	67.48	103.80	36.20	71.56	60.56	53.58	17.98	85.46	95.50
	Commercial	Zone6_C	0.00	61.28	105.50	41.40	62.54	57.42	54.29	8.25	69.53	57.28
	Traffic	Zone6_T	33.33	56.56	94.80	38.10	59.25	54.51	49.44	9.82	66.37	58.70
	Sensitive	Zone6_S	0.00	56.13	95.00	38.20	55.18	50.35	46.60	8.57	64.70	50.89
Zone VII	Residential	Zone7_R	0.00	62.52	91.60	44.00	64.72	61.80	59.52	5.21	67.73	50.34
	Industrial	Zone7_I	17.13	65.87	101.10	39.00	68.58	64.52	61.58	7.01	72.88	59.60
	Traffic	Zone7_T	0.00	57.50	106.30	36.00	58.10	54.51	50.32	7.79	65.28	51.47
	Sensitive	Zone7_S	9.17	63.09	95.20	42.60	64.11	58.22	55.25	8.86	71.95	60.67
Zone VIII	Residential	Zone8_R	0.00	62.92	89.10	38.50	65.85	62.20	49.97	15.87	78.80	83.47
	Commercial	Zone8_C	0.00	58.01	86.80	41.20	63.56	50.96	48.15	15.41	73.42	79.80
	Traffic	Zone8_T	0.00	67.80	99.40	44.40	68.24	62.62	58.74	9.51	77.30	66.76
	Sensitive	Zone8_S	0.00	63.58	101.10	41.30	67.69	59.34	52.52	15.17	78.75	83.20
Zone IX	Residential	Zone9_R	26.67	60.67	86.60	39.50	64.73	54.43	47.69	17.04	77.71	85.85
	Commercial	Zone9_C	0.00	59.73	97.70	38.40	62.27	59.02	55.35	6.93	66.66	53.05
	Traffic	Zone9_T	0.00	62.25	96.10	43.50	65.88	60.52	57.10	8.78	71.03	62.22
	Sensitive	Zone9_S	0.00	57.62	96.10	38.20	58.84	54.89	49.84	9.00	66.62	55.84
Zone X	Residential	Zone10_R	0.00	56.90	88.40	39.60	58.48	51.38	48.23	10.25	67.15	59.24
	Commercial	Zone10_C	0.00	63.28	101.26	47.80	49.13	48.52	48.41	0.72	64.01	21.31
	Traffic	Zone10_T	0.00	67.79	103.40	44.70	70.77	64.82	59.20	11.57	79.36	75.49
	Sensitive	Zone10_S	0.00	63.48	104.90	35.80	65.05	56.90	50.39	14.66	78.14	79.04

Zone No.	Category	Station ID	% missing data	L _{req} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XI	Residential	Zone11_R	0.00	60.54	97.10	44.30	64.10	58.23	53.36	10.74	71.29	66.34
	Commercial	Zone11_C	0.00	65.21	97.60	30.00	67.18	64.72	60.93	6.25	71.46	55.93
	Traffic	Zone11_T	0.00	75.04	116.50	48.60	76.55	74.77	73.09	3.46	78.50	56.92
	Sensitive	Zone11_S	0.00	56.95	102.30	37.80	58.68	54.41	49.41	9.27	66.22	56.50
Zone XII	Residential	Zone12_R	0.00	59.85	94.60	42.40	61.95	56.91	50.87	11.07	70.93	65.17
	Commercial	Zone12_C	0.42	54.47	99.80	35.40	56.75	51.13	47.79	8.97	63.44	53.65
	Traffic	Zone12_T	0.00	64.21	103.80	41.50	66.21	63.30	60.96	5.26	69.46	51.98
	Sensitive	Zone12_S	6.84	62.18	101.40	37.40	56.17	50.79	46.55	9.62	71.79	55.02
Zone XIII	Residential	Zone13_R	11.30	57.50	90.50	40.90	57.19	49.80	45.97	11.22	68.73	60.85
	Industrial	Zone13_I	36.25	58.74	95.85	30.28	61.46	54.87	51.30	10.16	68.90	61.95
	Sensitive	Zone13_S	40.83	68.93	101.29	32.84	53.05	47.66	46.64	6.41	75.34	42.26
Zone XIV	Residential	Zone14_R	0.00	57.99	96.00	37.70	56.31	50.45	46.88	9.43	67.42	54.58
	Commercial	Zone14_C	0.00	62.63	97.02	48.58	62.33	53.16	50.22	12.11	74.75	68.67
	Traffic	Zone14_T	0.00	62.79	100.00	39.90	64.18	61.91	59.86	4.32	67.12	47.15
	Sensitive	Zone14_S	0.00	57.72	100.43	42.98	60.35	48.98	46.94	13.41	71.13	70.60
Zone XV	Residential	Zone15_R	0.00	62.79	100.88	47.43	63.07	53.21	50.27	12.80	75.59	71.47
	Commercial	Zone15_C	0.00	64.36	93.90	42.30	66.29	63.51	61.43	4.86	69.22	50.87
	Traffic	Zone15_T	0.00	64.72	96.30	42.30	66.83	64.20	61.58	5.25	69.97	52.59
	Sensitive	Zone15_S	0.00	55.41	93.40	30.00	58.15	53.58	48.66	9.49	64.90	56.62

Table D.15 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for October – Day

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Residential	Zone1_R	0.00	65.55	109.30	30.00	63.07	58.92	56.72	6.35	71.89	52.10
	Industrial	Zone1_I	19.35	64.66	102.80	33.00	65.75	64.04	50.25	15.50	80.16	82.26
	Traffic	Zone1_T	5.04	60.92	93.10	44.60	60.96	58.41	54.90	6.06	66.98	49.14
	Sensitive	Zone1_S	0.00	71.04	114.60	39.40	71.09	65.09	58.34	12.76	83.79	79.36
Zone II	Residential	Zone2_R	0.00	62.13	104.70	40.20	61.90	57.88	54.15	7.75	69.88	55.15
	Industrial	Zone2_I	0.00	73.63	113.40	41.30	72.89	62.58	59.05	13.84	87.47	84.41
	Traffic	Zone2_T	0.60	66.22	103.10	30.00	67.59	64.59	62.79	4.80	71.03	52.00
	Sensitive	Zone2_S	45.97	60.79	99.03	48.37	63.91	55.49	49.79	14.12	74.91	76.28
Zone III	Residential	Zone3_R	0.00	69.51	109.00	39.80	71.11	63.59	60.96	10.15	79.66	71.56
	Industrial	Zone3_I	5.85	68.90	110.50	41.00	70.42	65.47	60.51	9.91	78.81	70.15
	Traffic	Zone3_T	0.00	73.96	110.80	49.80	72.88	70.19	67.42	5.46	79.42	59.26
	Sensitive	Zone3_S	0.00	61.68	101.40	40.90	62.19	59.83	57.32	4.87	66.55	46.80
Zone IV	Residential	Zone4_R	0.00	64.94	113.10	35.10	63.46	59.29	56.19	7.27	72.20	55.25
	Industrial	Zone4_I	83.04	59.07	97.57	30.03	62.52	46.23	43.10	19.42	78.49	90.78
	Traffic	Zone4_T	5.85	71.10	109.10	45.90	72.08	70.10	67.67	4.41	75.51	55.32
	Sensitive	Zone4_S	0.00	69.76	112.10	42.70	71.06	64.19	61.52	9.54	79.30	69.68
Zone V	Residential	Zone5_R	0.00	63.92	101.50	40.50	67.49	59.26	55.73	11.76	75.68	72.77
	Industrial	Zone5_I	0.00	65.97	98.78	44.65	68.66	64.25	58.12	10.55	76.52	70.30
	Traffic	Zone5_T	0.00	67.63	94.90	45.90	69.17	67.44	65.03	4.15	71.77	51.61
	Sensitive	Zone5_S	0.60	70.32	93.00	58.40	72.07	70.06	67.76	4.31	74.62	54.99

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VI	Residential	Zone6_R	0.00	71.56	115.10	38.90	73.85	68.66	66.23	7.63	79.18	66.73
	Commercial	Zone6_C	0.00	63.14	105.90	41.30	64.15	59.04	54.99	9.16	72.30	61.63
	Traffic	Zone6_T	1.01	66.68	106.80	44.10	63.91	61.44	60.01	3.90	70.58	45.61
	Sensitive	Zone6_S	0.00	63.14	103.80	40.90	60.24	55.95	52.58	7.66	70.80	53.22
Zone VII	Residential	Zone7_R	17.74	67.82	96.90	30.00	69.17	66.87	64.78	4.39	72.21	52.35
	Industrial	Zone7_I	0.00	70.58	102.80	49.20	72.25	70.17	68.21	4.04	74.62	54.38
	Traffic	Zone7_T	0.00	64.01	110.70	38.60	63.14	60.25	58.22	4.92	68.93	47.90
	Sensitive	Zone7_S	19.15	67.15	97.90	39.60	69.67	65.18	61.43	8.24	75.39	64.39
Zone VIII	Residential	Zone8_R	0.40	60.88	92.30	32.70	63.44	58.32	55.47	7.98	68.85	57.37
	Commercial	Zone8_C	1.01	60.59	94.30	43.10	63.96	55.84	52.81	11.15	71.74	67.40
	Traffic	Zone8_T	0.00	74.79	115.50	47.20	73.54	70.12	67.97	5.57	80.36	60.25
	Sensitive	Zone8_S	0.00	70.29	114.60	36.10	72.62	68.41	64.97	7.66	77.95	65.59
Zone IX	Residential	Zone9_R	0.00	66.14	93.40	44.70	68.60	64.00	58.80	9.80	75.94	68.00
	Commercial	Zone9_C	0.00	68.46	115.70	42.90	67.05	64.69	61.18	5.88	74.33	54.68
	Traffic	Zone9_T	0.00	69.10	105.10	49.00	70.43	68.53	65.43	5.01	74.10	55.45
	Sensitive	Zone9_S	0.40	67.09	112.20	42.70	63.53	60.44	58.23	5.30	72.39	49.43
Zone X	Residential	Zone10_R	0.60	68.07	97.20	38.70	70.43	62.23	58.20	12.23	80.30	77.12
	Commercial	Zone10_C	0.00	55.95	98.00	47.76	51.46	49.01	48.65	2.82	58.76	29.91
	Traffic	Zone10_T	0.20	71.44	105.50	50.80	73.41	70.75	67.94	5.47	76.91	59.82
	Sensitive	Zone10_S	0.00	70.30	116.10	40.60	69.43	64.52	60.98	8.46	78.76	64.80

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XI	Residential	Zone11_R	0.00	71.71	104.60	46.80	71.26	68.24	64.96	6.31	78.01	60.18
	Commercial	Zone11_C	0.20	70.40	108.40	30.00	71.72	68.53	66.05	5.67	76.07	58.73
	Traffic	Zone11_T	0.00	69.95	108.40	43.00	68.57	65.29	62.64	5.94	75.88	56.38
	Sensitive	Zone11_S	0.00	66.50	112.50	40.80	66.20	62.63	58.87	7.33	73.84	58.21
Zone XII	Residential	Zone12_R	0.60	68.61	109.00	31.60	69.35	66.29	63.36	6.00	74.61	57.35
	Commercial	Zone12_C	0.00	61.45	102.90	39.50	61.93	56.50	53.86	8.07	69.52	56.14
	Traffic	Zone12_T	0.00	65.85	102.70	31.70	67.36	64.59	60.74	6.61	72.46	57.20
	Sensitive	Zone12_S	0.40	64.07	107.60	40.80	62.69	57.45	54.03	8.65	72.73	58.65
Zone XIII	Residential	Zone13_R	14.20	62.35	98.90	45.90	64.24	61.81	58.53	5.71	68.06	51.37
	Industrial	Zone13_I	16.94	61.14	98.12	30.03	64.17	59.74	55.49	8.67	69.81	60.19
	Traffic	Zone13_T	62.10	67.56	100.20	30.03	69.39	65.52	61.83	7.56	75.13	62.08
	Sensitive	Zone13_S	29.03	61.13	101.26	30.03	61.34	48.75	46.34	14.99	76.13	76.31
Zone XIV	Residential	Zone14_R	0.00	63.68	102.50	40.30	61.70	55.57	52.31	9.39	73.07	59.87
	Commercial	Zone14_C	1.41	73.27	98.03	48.16	79.71	59.68	49.16	30.55	103.82	141.36
	Traffic	Zone14_T	0.00	66.88	104.40	50.60	67.52	65.49	63.75	3.77	70.65	48.83
	Sensitive	Zone14_S	0.00	70.51	99.63	42.62	68.95	56.59	49.30	19.66	90.16	97.91
Zone XV	Residential	Zone15_R	0.00	68.62	100.43	48.97	72.38	61.99	53.59	18.80	87.42	98.77
	Commercial	Zone15_C	0.00	67.59	104.60	48.60	68.92	66.94	65.46	3.46	71.04	49.28
	Traffic	Zone15_T	0.00	67.73	107.30	47.90	69.38	66.96	65.39	3.99	71.72	51.35
	Sensitive	Zone15_S	0.00	64.10	107.70	30.00	62.98	59.78	57.70	5.28	69.38	48.80

Table D.16 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for October – Night

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Residential	Zone1_R	0.00	55.67	94.70	37.10	57.80	52.14	47.65	10.15	65.82	58.25
	Industrial	Zone1_I	19.76	61.65	97.30	33.00	63.58	61.31	39.77	23.81	85.46	105.01
	Traffic	Zone1_T	2.42	55.49	98.60	39.00	55.86	51.57	47.05	8.82	64.31	52.32
	Sensitive	Zone1_S	0.00	69.11	110.90	35.80	72.36	60.30	50.60	21.75	90.86	107.61
Zone II	Residential	Zone2_R	0.00	52.90	90.70	32.90	55.33	48.97	44.72	10.61	63.50	57.15
	Industrial	Zone2_I	0.00	61.96	105.60	34.10	59.06	53.36	49.36	9.71	71.66	58.19
	Traffic	Zone2_T	0.00	60.84	100.30	30.00	63.70	56.38	50.14	13.56	74.40	74.40
	Sensitive	Zone2_S	45.16	54.94	97.49	48.28	57.08	49.35	48.82	8.26	63.20	51.86
Zone III	Residential	Zone3_R	0.00	56.59	91.90	34.20	59.52	55.12	49.12	10.40	66.99	60.72
	Industrial	Zone3_I	6.45	66.37	105.70	37.20	69.36	57.36	49.59	19.77	86.14	98.66
	Traffic	Zone3_T	0.00	65.91	97.10	38.60	68.31	61.55	56.82	11.48	77.39	72.75
	Sensitive	Zone3_S	0.00	55.33	91.60	32.70	57.47	52.81	48.30	9.17	64.50	54.98
Zone IV	Residential	Zone4_R	0.00	58.94	105.00	30.40	59.38	52.96	46.70	12.68	71.62	67.40
	Industrial	Zone4_I	92.86	43.03	43.85	35.10	43.09	43.02	42.99	0.11	43.14	13.41
	Traffic	Zone4_T	6.45	63.52	105.20	35.90	67.12	60.40	56.00	11.12	74.64	70.48
	Sensitive	Zone4_S	0.00	60.08	97.90	39.90	61.21	55.04	47.36	13.85	73.94	72.77
Zone V	Residential	Zone5_R	0.00	61.90	103.60	34.80	65.85	52.75	46.55	19.30	81.19	93.74
	Industrial	Zone5_I	0.00	58.99	98.21	45.06	62.45	55.14	50.76	11.69	70.68	67.50
	Traffic	Zone5_T	0.00	62.78	94.10	39.70	65.92	61.73	59.16	6.76	69.54	56.19
	Sensitive	Zone5_S	0.81	64.53	90.00	47.90	67.40	63.50	60.69	6.71	71.23	57.51

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VI	Residential	Zone6_R	0.00	69.26	107.00	34.70	73.34	63.17	52.61	20.73	89.99	105.53
	Commercial	Zone6_C	0.00	59.82	102.50	38.60	62.29	55.35	49.59	12.70	72.52	70.37
	Traffic	Zone6_T	1.61	58.18	98.30	34.40	59.38	53.29	48.16	11.22	69.40	63.03
	Sensitive	Zone6_S	0.81	56.00	95.00	35.60	57.23	49.48	44.58	12.65	68.65	65.18
Zone VII	Residential	Zone7_R	12.90	63.05	91.30	44.50	65.50	62.16	59.61	5.89	68.94	53.17
	Industrial	Zone7_I	0.00	64.11	98.50	38.70	66.64	63.18	60.44	6.20	70.32	55.25
	Traffic	Zone7_T	0.00	56.94	94.60	33.90	58.86	54.07	49.58	9.28	66.23	56.71
	Sensitive	Zone7_S	19.35	63.67	95.90	36.60	64.02	57.37	52.20	11.82	75.49	69.48
Zone VIII	Residential	Zone8_R	0.00	59.86	87.80	38.20	63.29	55.86	49.07	14.22	74.08	75.95
	Commercial	Zone8_C	0.00	55.42	92.00	38.90	57.71	50.93	47.17	10.54	65.95	59.31
	Traffic	Zone8_T	0.00	68.15	107.30	42.40	72.11	63.31	58.41	13.70	81.85	83.21
	Sensitive	Zone8_S	0.00	64.91	108.30	40.40	68.22	60.36	53.00	15.22	80.12	83.86
Zone IX	Residential	Zone9_R	0.00	61.76	89.70	38.10	65.75	54.91	48.25	17.50	79.26	88.26
	Commercial	Zone9_C	0.00	59.85	96.30	36.50	60.94	57.02	52.27	8.67	68.52	56.96
	Traffic	Zone9_T	0.00	62.81	99.10	42.20	66.34	59.91	56.71	9.63	72.45	65.25
	Sensitive	Zone9_S	0.81	58.00	99.20	37.40	59.74	55.20	48.93	10.81	68.81	62.17
Zone X	Residential	Zone10_R	0.81	61.67	97.90	39.00	65.72	51.90	46.91	18.81	80.48	92.13
	Commercial	Zone10_C	0.00	50.92	95.30	47.66	50.65	48.49	48.36	2.29	53.21	27.52
	Traffic	Zone10_T	0.00	65.01	96.40	44.00	68.07	63.17	58.77	9.30	74.31	65.98
	Sensitive	Zone10_S	0.00	63.39	104.20	36.10	65.77	59.41	51.16	14.61	78.01	79.61

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XI	Residential	Zone11_R	0.00	63.88	109.90	42.60	64.80	58.95	53.21	11.60	75.47	69.60
	Commercial	Zone11_C	0.00	65.68	109.00	30.00	67.84	64.88	61.48	6.36	72.04	56.92
	Traffic	Zone11_T	0.00	61.09	99.90	38.20	63.31	57.50	53.02	10.30	71.39	64.20
	Sensitive	Zone11_S	0.00	59.38	103.70	36.30	62.31	53.86	48.61	13.70	73.08	73.41
Zone XII	Residential	Zone12_R	0.81	61.71	108.20	31.10	64.06	56.49	50.43	13.63	75.34	74.95
	Commercial	Zone12_C	0.00	53.90	91.50	34.20	56.49	50.71	45.59	10.90	64.80	59.18
	Traffic	Zone12_T	0.00	63.87	101.50	31.50	66.16	63.18	59.29	6.87	70.74	56.76
	Sensitive	Zone12_S	0.00	56.56	97.80	36.10	59.16	51.99	45.71	13.45	70.01	69.50
Zone XIII	Residential	Zone13_R	27.69	57.98	91.00	40.30	60.08	54.03	47.75	12.34	70.32	67.10
	Industrial	Zone13_I	24.60	57.94	97.49	30.28	61.00	53.99	49.96	11.05	68.99	64.15
	Sensitive	Zone13_S	29.84	54.08	97.34	30.03	56.53	46.82	45.94	10.59	64.67	58.32
Zone XIV	Residential	Zone14_R	0.00	61.27	95.30	35.70	63.30	50.57	46.23	17.07	78.34	84.51
	Commercial	Zone14_C	1.61	69.81	95.78	48.21	71.59	54.21	49.10	22.49	92.30	109.05
	Traffic	Zone14_T	0.00	62.67	106.10	41.20	64.06	61.62	59.29	4.77	67.44	48.37
	Sensitive	Zone14_S	0.00	76.53	100.24	43.20	66.08	48.94	46.58	19.50	96.03	94.58
Zone XV	Residential	Zone15_R	0.00	73.30	101.28	49.03	71.18	56.18	50.38	20.80	94.10	103.57
	Commercial	Zone15_C	0.00	63.16	97.70	41.90	65.72	62.11	59.27	6.45	69.61	55.06
	Traffic	Zone15_T	0.00	63.03	96.40	40.80	65.10	61.97	59.35	5.75	68.78	52.33
	Sensitive	Zone15_S	0.00	55.06	101.50	30.00	57.55	53.23	48.24	9.31	64.36	55.46

Table D.17 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for November – Day

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Residential	Zone1_R	0.00	60.57	95.80	30.00	62.12	59.22	56.95	5.17	65.74	47.63
	Industrial	Zone1_I	0.00	64.24	92.90	43.20	65.40	64.28	62.46	2.94	67.19	44.23
	Traffic	Zone1_T	9.58	59.66	88.40	44.90	61.57	59.50	54.61	6.96	66.62	52.44
	Sensitive	Zone1_S	0.00	68.38	102.80	39.80	72.36	65.23	57.85	14.51	82.89	85.90
Zone II	Residential	Zone2_R	0.00	58.18	92.00	38.80	60.48	57.35	53.55	6.94	65.12	51.29
	Industrial	Zone2_I	0.42	62.67	102.30	39.40	64.25	62.28	58.64	5.60	68.27	51.05
	Traffic	Zone2_T	0.00	65.18	97.60	30.00	66.82	64.52	62.58	4.24	69.42	49.55
	Sensitive	Zone2_S	18.13	68.84	100.96	48.25	73.63	61.38	51.39	22.24	91.08	110.35
Zone III	Residential	Zone3_R	0.21	65.48	97.60	41.90	68.16	64.09	61.75	6.41	71.89	57.39
	Industrial	Zone3_I	0.00	67.36	105.30	41.30	69.34	64.71	60.05	9.29	76.65	67.21
	Traffic	Zone3_T	0.00	71.52	116.70	49.60	72.33	70.15	67.42	4.91	76.43	57.07
	Sensitive	Zone3_S	0.00	61.61	94.00	40.30	63.63	59.98	57.36	6.27	67.87	52.43
Zone IV	Residential	Zone4_R	1.46	59.92	91.90	41.70	61.43	58.71	56.30	5.13	65.05	46.82
	Industrial	Zone4_I	95.42	75.97	95.18	31.44	63.88	42.64	37.03	26.85	102.82	114.42
	Traffic	Zone4_T	0.00	70.82	109.00	46.10	72.10	70.77	68.46	3.64	74.46	53.03
	Sensitive	Zone4_S	11.25	65.87	115.40	43.80	66.94	63.97	61.38	5.56	71.43	53.62
Zone V	Residential	Zone5_R	0.00	63.31	93.60	40.10	67.96	59.54	55.98	11.99	75.30	73.92
	Industrial	Zone5_I	0.42	64.73	97.93	46.25	67.88	63.48	58.84	9.03	73.77	64.98
	Traffic	Zone5_T	0.42	67.71	95.10	49.80	68.90	67.80	65.49	3.41	71.12	49.12
	Sensitive	Zone5_S	0.00	69.82	89.90	58.90	71.05	69.62	67.31	3.74	73.56	52.28

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VI	Residential	Zone6_R	0.21	70.24	107.00	39.10	72.55	68.52	66.20	6.34	76.58	61.58
	Commercial	Zone6_C	0.00	58.36	92.90	42.70	60.96	56.85	53.33	7.63	65.99	53.86
	Traffic	Zone6_T	2.50	62.33	96.40	43.60	63.64	61.66	60.29	3.36	65.69	43.71
	Sensitive	Zone6_S	0.00	57.85	91.60	41.30	61.27	56.15	52.17	9.11	66.95	58.59
Zone VII	Residential	Zone7_R	4.38	67.10	91.70	30.00	68.16	67.05	65.35	2.81	69.91	46.58
	Industrial	Zone7_I	22.08	71.22	105.00	51.90	72.91	71.08	68.79	4.11	75.33	55.25
	Traffic	Zone7_T	0.00	60.49	92.40	39.70	61.89	59.85	57.93	3.97	64.45	43.79
	Sensitive	Zone7_S	3.54	67.35	102.80	42.10	69.80	65.69	61.33	8.47	75.82	65.19
Zone VIII	Residential	Zone8_R	1.04	60.95	92.00	43.00	63.82	59.29	56.01	7.81	68.75	57.24
	Commercial	Zone8_C	38.96	68.65	91.80	43.30	70.00	55.99	52.20	17.80	86.46	93.41
	Traffic	Zone8_T	0.00	73.45	115.40	47.70	74.42	70.30	67.77	6.66	80.11	64.40
	Sensitive	Zone8_S	15.00	68.85	103.70	39.60	70.97	68.29	64.40	6.57	75.42	60.69
Zone IX	Residential	Zone9_R	0.00	63.30	100.40	43.50	65.61	62.37	58.18	7.44	70.74	57.92
	Commercial	Zone9_C	3.54	65.76	99.60	43.20	66.62	64.54	61.26	5.36	71.11	52.69
	Traffic	Zone9_T	0.42	69.38	112.80	48.40	70.43	68.96	65.92	4.51	73.89	53.97
	Sensitive	Zone9_S	6.67	61.44	93.20	41.90	62.61	60.34	58.31	4.30	65.74	45.52
Zone X	Residential	Zone10_R	0.00	68.96	93.90	41.10	67.67	63.43	59.63	8.04	77.00	61.79
	Commercial	Zone10_C	0.00	51.57	95.47	47.49	49.73	48.93	48.62	1.11	52.68	23.06
	Traffic	Zone10_T	1.25	70.31	99.70	50.20	71.73	70.06	67.56	4.17	74.49	54.25
	Sensitive	Zone10_S	19.79	65.55	103.60	41.20	68.14	64.57	61.04	7.11	72.66	59.47

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XI	Residential	Zone11_R	0.00	70.44	92.80	47.50	72.42	68.65	64.89	7.53	77.96	64.99
	Commercial	Zone11_C	46.88	70.89	102.20	30.00	71.17	68.82	66.13	5.04	75.93	56.31
	Traffic	Zone11_T	0.00	66.08	99.00	44.90	67.15	65.13	62.91	4.25	70.33	49.89
	Sensitive	Zone11_S	0.00	63.88	103.00	38.70	66.47	61.82	58.18	8.30	72.18	61.37
Zone XII	Residential	Zone12_R	0.00	67.21	95.00	46.10	69.09	66.84	63.88	5.21	72.41	54.70
	Commercial	Zone12_C	38.13	56.53	87.10	40.60	58.43	56.07	53.21	5.22	61.75	44.10
	Traffic	Zone12_T	7.50	65.01	104.30	45.50	66.73	64.71	62.33	4.40	69.42	49.93
	Sensitive	Zone12_S	11.04	60.43	96.50	41.20	62.47	58.90	55.47	7.00	67.43	53.47
Zone XIII	Residential	Zone13_R	0.63	61.20	91.80	45.10	63.81	60.29	56.58	7.23	68.44	55.52
	Industrial	Zone13_I	96.46	62.46	95.58	30.03	64.56	61.45	58.52	6.03	68.50	52.66
	Traffic	Zone13_T	69.79	67.56	98.69	30.03	70.02	66.25	63.08	6.94	74.50	60.84
	Sensitive	Zone13_S	20.83	51.40	96.30	30.03	54.02	48.31	46.48	7.54	58.94	46.65
Zone XIV	Residential	Zone14_R	0.00	58.42	104.80	40.40	60.45	55.90	52.95	7.50	65.91	52.93
	Commercial	Zone14_C	0.42	57.95	98.07	47.97	48.89	48.69	48.55	0.34	58.29	19.91
	Traffic	Zone14_T	3.75	65.77	97.20	52.30	66.74	65.54	64.37	2.37	68.14	43.85
	Sensitive	Zone14_S	14.17	88.23	101.13	43.26	93.83	70.67	52.29	41.54	129.78	188.46
Zone XV	Residential	Zone15_R	0.00	70.05	99.72	49.05	73.80	66.49	52.42	21.38	91.44	107.95
	Commercial	Zone15_C	0.00	68.32	97.00	49.60	69.32	68.14	66.86	2.46	70.78	46.70
	Traffic	Zone15_T	16.04	66.75	104.70	48.70	68.17	66.44	64.31	3.86	70.61	49.74
	Sensitive	Zone15_S	0.00	59.96	93.70	30.00	61.25	59.67	57.77	3.48	63.44	41.70

Table D.18 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for November – Night

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Residential	Zone1_R	0.00	54.21	87.50	39.20	57.10	52.57	48.39	8.71	62.92	53.24
	Industrial	Zone1_I	0.00	61.86	90.10	37.90	63.74	61.62	59.32	4.43	66.29	47.02
	Traffic	Zone1_T	9.17	52.10	85.20	38.70	54.26	50.76	47.42	6.84	58.94	44.76
	Sensitive	Zone1_S	0.00	69.00	110.30	36.30	70.61	56.94	48.83	21.78	90.78	105.95
Zone II	Residential	Zone2_R	0.00	49.93	89.00	33.80	52.45	48.87	45.23	7.22	57.14	44.09
	Industrial	Zone2_I	0.00	54.58	91.00	34.30	56.44	53.56	50.32	6.12	60.70	44.79
	Traffic	Zone2_T	0.00	58.38	92.80	30.00	61.15	54.79	51.00	10.15	68.53	61.59
	Sensitive	Zone2_S	17.50	59.66	99.53	48.22	63.08	52.28	48.88	14.20	73.86	75.67
Zone III	Residential	Zone3_R	0.00	56.50	94.10	35.00	59.51	54.55	49.36	10.15	66.65	59.95
	Industrial	Zone3_I	0.00	61.03	100.20	38.00	62.82	55.09	48.57	14.25	75.28	75.57
	Traffic	Zone3_T	0.00	63.23	96.70	38.50	67.31	59.73	56.82	10.49	73.72	68.78
	Sensitive	Zone3_S	0.00	55.18	89.70	32.60	56.91	50.95	47.19	9.72	64.90	56.07
Zone IV	Residential	Zone4_R	2.08	56.31	100.50	38.20	59.45	53.78	47.60	11.85	68.16	65.00
	Industrial	Zone4_I	96.67	44.47	77.00	39.74	45.04	42.82	42.51	2.53	47.00	22.62
	Traffic	Zone4_T	0.83	63.11	97.40	35.60	66.98	60.37	56.90	10.09	73.19	67.24
	Sensitive	Zone4_S	10.00	56.28	93.10	40.20	60.10	54.20	47.66	12.44	68.72	67.42
Zone V	Residential	Zone5_R	0.00	59.86	90.00	36.20	66.06	51.54	46.84	19.22	79.08	93.71
	Industrial	Zone5_I	0.00	57.27	97.08	45.88	61.27	54.64	51.61	9.66	66.93	60.26
	Traffic	Zone5_T	0.00	62.96	93.60	40.70	65.89	62.06	59.58	6.32	69.28	54.85
	Sensitive	Zone5_S	0.00	64.35	85.10	47.90	67.14	63.18	60.45	6.69	71.04	57.21

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VI	Residential	Zone6_R	0.42	68.98	106.80	34.90	72.80	63.17	52.59	20.21	89.19	103.42
	Commercial	Zone6_C	0.00	54.73	84.80	38.00	58.76	52.49	49.31	9.45	64.18	57.10
	Traffic	Zone6_T	0.83	56.47	93.60	35.90	59.78	54.42	48.83	10.96	67.43	62.66
	Sensitive	Zone6_S	0.00	50.19	84.40	35.80	53.35	48.78	45.59	7.76	57.96	46.64
Zone VII	Residential	Zone7_R	0.83	62.64	90.80	44.70	64.82	62.17	59.73	5.09	67.72	50.08
	Industrial	Zone7_I	20.83	65.02	97.90	38.20	67.43	64.22	61.26	6.17	71.20	55.95
	Traffic	Zone7_T	0.00	53.79	91.10	33.90	56.77	51.97	47.88	8.89	62.68	53.44
	Sensitive	Zone7_S	4.17	59.52	93.10	38.30	62.88	56.64	50.33	12.55	72.07	70.55
Zone VIII	Residential	Zone8_R	0.42	58.24	87.50	36.60	62.41	52.38	46.05	16.36	74.60	81.47
	Commercial	Zone8_C	42.92	53.80	82.50	39.30	54.14	50.09	46.93	7.21	61.02	45.78
	Traffic	Zone8_T	0.00	67.13	115.80	44.00	70.56	62.30	57.77	12.79	79.92	78.93
	Sensitive	Zone8_S	13.33	63.33	103.60	41.50	66.63	58.37	51.55	15.07	78.40	81.84
Zone IX	Residential	Zone9_R	0.00	58.70	84.40	37.00	62.76	54.92	48.70	14.06	72.76	74.94
	Commercial	Zone9_C	2.92	58.05	91.40	38.20	61.11	57.34	50.24	10.87	68.92	63.71
	Traffic	Zone9_T	0.00	62.17	99.40	42.80	65.81	60.48	56.81	9.01	71.18	62.83
	Sensitive	Zone9_S	5.42	55.70	89.10	37.00	58.82	54.74	48.65	10.18	65.88	59.35
Zone X	Residential	Zone10_R	0.00	56.65	87.10	39.20	59.18	53.07	48.00	11.18	67.83	62.72
	Commercial	Zone10_C	0.00	48.60	84.38	47.56	49.05	48.43	48.35	0.70	49.30	21.15
	Traffic	Zone10_T	0.42	64.62	99.60	44.70	67.28	62.98	59.25	8.03	72.66	61.38
	Sensitive	Zone10_S	17.50	60.99	99.00	37.40	64.32	57.51	51.20	13.12	74.10	73.66

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XI	Residential	Zone11_R	0.00	59.72	91.40	43.40	63.50	57.44	52.86	10.65	70.36	65.44
	Commercial	Zone11_C	49.17	65.02	94.10	42.00	67.27	64.96	60.87	6.40	71.43	56.48
	Traffic	Zone11_T	0.00	58.81	92.70	38.50	62.16	57.52	53.39	8.77	67.58	58.48
	Sensitive	Zone11_S	0.00	55.27	97.00	34.40	57.97	52.84	47.85	10.12	65.40	58.34
Zone XII	Residential	Zone12_R	0.00	57.46	92.40	40.50	61.09	55.46	50.10	10.99	68.45	64.05
	Commercial	Zone12_C	35.42	51.54	84.10	35.10	54.84	49.96	44.95	9.89	61.44	54.53
	Traffic	Zone12_T	6.67	64.04	124.90	41.10	66.20	63.76	59.72	6.47	70.51	55.62
	Sensitive	Zone12_S	10.83	55.58	84.80	36.50	58.75	54.52	48.23	10.52	66.10	60.30
Zone XIII	Residential	Zone13_R	8.33	53.67	81.30	39.60	56.77	50.69	46.81	9.96	63.63	56.65
	Industrial	Zone13_I	99.17	64.58	87.08	32.84	65.71	64.16	62.60	3.11	67.69	45.05
	Sensitive	Zone13_S	22.08	47.78	86.15	30.03	49.70	46.71	46.05	3.65	51.43	30.65
Zone XIV	Residential	Zone14_R	0.00	52.89	83.70	37.30	53.91	50.67	47.44	6.48	59.36	43.34
	Commercial	Zone14_C	0.83	58.21	98.14	48.11	48.65	48.60	48.50	0.15	58.36	19.11
	Traffic	Zone14_T	4.17	61.79	94.00	41.80	63.68	61.40	59.32	4.36	66.15	46.76
	Sensitive	Zone14_S	13.33	87.76	100.83	42.86	93.29	60.83	45.91	47.38	135.13	205.41
Zone XV	Residential	Zone15_R	0.00	71.33	100.70	49.03	75.58	66.79	61.33	14.26	85.58	88.35
	Commercial	Zone15_C	0.00	63.87	93.30	43.00	66.18	63.32	60.82	5.36	69.23	52.27
	Traffic	Zone15_T	15.00	61.93	94.20	41.50	64.04	61.02	58.75	5.29	67.22	49.91
	Sensitive	Zone15_S	0.00	53.74	88.40	30.00	56.76	52.63	47.85	8.92	62.65	53.52

Table D.19 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for December – Day

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Residential	Zone1_R	43.35	61.88	98.10	33.80	62.70	59.78	57.64	5.06	66.94	47.88
	Industrial	Zone1_I	53.23	65.28	106.50	46.50	66.15	64.29	62.90	3.25	68.53	45.90
	Traffic	Zone1_T	50.81	59.99	99.60	44.60	61.21	58.33	54.37	6.84	66.82	51.71
	Sensitive	Zone1_S	51.61	67.98	104.40	39.80	72.11	64.91	57.98	14.13	82.11	84.51
Zone II	Residential	Zone2_R	50.60	60.71	103.80	40.60	60.82	57.16	54.42	6.40	67.11	50.02
	Industrial	Zone2_I	50.40	64.24	102.40	39.50	65.63	61.95	57.86	7.77	72.02	58.96
	Traffic	Zone2_T	51.61	71.91	107.20	30.00	75.27	66.76	63.05	12.23	84.14	81.96
	Sensitive	Zone2_S	51.71	72.02	101.36	48.22	76.42	67.48	52.64	23.78	95.80	117.77
Zone III	Residential	Zone3_R	51.61	72.42	105.70	41.70	70.37	64.55	61.11	9.26	81.68	68.15
	Industrial	Zone3_I	50.60	68.19	107.50	39.50	70.55	65.06	59.71	10.83	79.02	73.05
	Traffic	Zone3_T	51.61	71.90	109.90	49.10	73.72	70.54	67.25	6.46	78.36	63.10
	Sensitive	Zone3_S	0.00	60.71	103.50	40.50	62.03	59.67	57.43	4.60	65.30	45.81
Zone IV	Residential	Zone4_R	52.02	60.92	95.40	38.90	63.51	58.55	54.82	8.70	69.62	59.60
	Industrial	Zone4_I	94.82	75.10	97.35	31.86	73.92	53.29	43.39	30.53	105.63	135.51
	Traffic	Zone4_T	48.39	70.22	101.20	47.30	71.82	70.25	67.31	4.51	74.73	55.35
	Sensitive	Zone4_S	58.47	66.29	101.80	42.80	68.46	64.76	61.64	6.82	73.10	58.90
Zone V	Residential	Zone5_R	51.61	63.01	92.60	41.50	67.55	59.90	55.99	11.56	74.58	72.24
	Industrial	Zone5_I	51.61	64.21	97.13	46.09	67.25	62.97	58.40	8.86	73.07	63.82
	Traffic	Zone5_T	51.61	67.62	92.50	46.50	68.88	67.69	65.43	3.45	71.07	49.24
	Sensitive	Zone5_S	43.35	70.47	91.70	58.50	72.22	70.13	67.59	4.63	75.10	56.11

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VI	Residential	Zone6_R	54.44	69.92	104.20	38.90	72.10	68.28	65.68	6.42	76.34	61.36
	Commercial	Zone6_C	51.61	58.81	96.00	41.90	61.30	56.86	52.44	8.86	67.67	57.86
	Traffic	Zone6_T	53.63	62.74	98.90	43.30	64.18	61.61	60.08	4.11	66.84	46.50
	Sensitive	Zone6_S	90.32	60.62	92.40	44.30	63.84	58.55	53.61	10.23	70.85	64.53
Zone VII	Residential	Zone7_R	98.19	66.80	86.10	57.90	67.52	66.58	66.18	1.33	68.14	41.51
	Industrial	Zone7_I	67.14	71.60	101.40	53.80	73.69	71.08	68.78	4.92	76.51	58.45
	Traffic	Zone7_T	50.60	61.31	94.20	39.50	62.76	60.21	58.47	4.29	65.60	45.63
	Sensitive	Zone7_S	43.95	66.90	102.10	41.50	69.46	65.63	62.00	7.46	74.35	61.83
Zone VIII	Residential	Zone8_R	68.75	62.11	84.60	42.10	64.60	60.88	56.53	8.07	70.19	58.82
	Commercial	Zone8_C	83.90	60.87	86.60	30.60	66.99	50.91	38.03	28.96	89.83	123.87
	Traffic	Zone8_T	50.20	70.99	105.10	48.40	73.17	69.70	67.51	5.67	76.66	60.17
	Sensitive	Zone8_S	45.16	68.48	104.10	30.90	70.60	67.73	63.76	6.84	75.32	61.12
Zone IX	Residential	Zone9_R	51.61	62.43	91.00	43.90	65.28	61.17	57.90	7.38	69.82	57.43
	Commercial	Zone9_C	52.42	64.62	93.50	40.50	66.45	64.37	61.01	5.44	70.06	52.77
	Traffic	Zone9_T	44.15	69.13	105.10	47.80	70.69	68.91	66.17	4.53	73.66	54.27
	Sensitive	Zone9_S	98.59	62.77	86.20	47.40	64.53	60.67	59.58	4.94	67.71	49.35
Zone X	Residential	Zone10_R	51.81	66.41	92.30	42.70	69.34	63.94	60.21	9.13	75.55	66.74
	Commercial	Zone10_C	51.61	51.58	92.81	47.53	53.29	49.70	48.67	4.63	56.21	37.17
	Traffic	Zone10_T	52.62	70.91	99.70	50.50	73.36	69.49	66.89	6.47	77.38	62.77

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XI	Residential	Zone11_R	71.98	68.27	98.20	46.90	70.19	67.38	64.25	5.94	74.21	58.01
	Commercial	Zone11_C	0.00	69.80	95.50	30.00	71.72	69.65	66.94	4.78	74.58	56.05
	Traffic	Zone11_T	51.21	65.29	94.40	44.40	66.91	64.93	62.55	4.36	69.65	49.97
	Sensitive	Zone11_S	51.61	62.58	96.40	38.20	64.90	61.36	58.82	6.09	68.66	53.16
Zone XII	Residential	Zone12_R	42.94	66.67	92.40	45.80	68.63	66.62	62.86	5.76	72.43	55.92
	Traffic	Zone12_T	41.85	64.92	102.60	32.00	66.84	64.39	59.02	7.83	72.74	60.32
	Sensitive	Zone12_S	55.85	60.88	95.70	42.30	62.60	59.85	57.25	5.35	66.22	48.64
	Residential	Zone13_R	83.30	62.41	84.50	45.00	66.36	59.94	56.21	10.15	72.56	66.82
Zone XIII	Industrial	Zone13_I	83.67	61.86	95.31	30.03	64.37	61.12	57.67	6.70	68.56	54.47
	Traffic	Zone13_T	91.53	66.30	96.26	30.03	69.19	65.59	62.34	6.85	73.15	59.73
	Sensitive	Zone13_S	52.92	53.30	99.85	30.03	46.20	45.72	45.29	0.91	54.21	18.92
	Residential	Zone14_R	49.19	60.54	105.80	31.00	63.33	55.51	53.53	9.80	70.34	62.72
Zone XIV	Commercial	Zone14_C	51.91	61.88	98.17	47.92	55.05	48.64	48.49	6.56	68.44	44.73
	Traffic	Zone14_T	50.70	66.44	96.80	52.10	67.87	65.90	64.40	3.47	69.91	48.27
	Sensitive	Zone14_S	50.60	70.38	100.76	43.03	75.20	61.77	49.43	25.76	96.15	122.49
	Residential	Zone15_R	51.61	73.53	100.68	49.55	80.58	50.65	50.20	30.38	103.92	141.74
Zone XV	Commercial	Zone15_C	50.60	68.36	97.00	51.20	69.46	68.31	66.98	2.48	70.84	46.89
	Sensitive	Zone15_S	45.16	60.13	92.70	30.00	61.55	59.83	57.85	3.70	63.83	42.65

Table D.20 Statistical summary of the noise data including the noise pollution parameters and noise pollution indices for December – Night

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone I	Residential	Zone1_R	42.74	55.81	93.90	38.00	58.63	52.74	48.75	9.89	65.70	58.29
	Industrial	Zone1_I	52.42	61.83	90.20	37.80	63.51	61.41	59.65	3.86	65.69	45.08
	Traffic	Zone1_T	49.19	53.59	84.60	38.80	55.25	50.59	47.17	8.08	61.67	49.49
	Sensitive	Zone1_S	50.40	67.67	107.20	36.00	72.58	59.95	51.25	21.32	89.00	106.55
Zone II	Residential	Zone2_R	49.19	52.07	83.10	35.40	54.46	50.03	45.80	8.67	60.74	50.46
	Industrial	Zone2_I	49.19	56.44	102.20	34.40	57.40	52.12	48.67	8.72	65.16	53.57
	Traffic	Zone2_T	51.61	62.30	97.00	30.00	65.36	55.58	51.87	13.49	75.79	75.82
	Sensitive	Zone2_S	50.61	70.09	101.05	48.18	75.29	51.65	48.92	26.36	96.46	124.37
Zone III	Residential	Zone3_R	49.19	57.15	95.40	35.90	60.15	54.79	49.61	10.54	67.69	61.77
	Industrial	Zone3_I	49.19	63.76	96.70	37.10	65.20	57.04	48.30	16.90	80.66	85.90
	Traffic	Zone3_T	52.02	64.24	107.60	36.50	67.21	60.11	55.92	11.29	75.52	71.06
	Sensitive	Zone3_S	0.00	53.93	88.40	33.20	56.76	51.52	47.52	9.24	63.17	54.47
Zone IV	Residential	Zone4_R	52.42	56.06	88.20	33.50	60.54	52.43	44.54	16.01	72.07	78.56
	Industrial	Zone4_I	96.69	71.35	78.20	30.28	74.14	70.58	57.39	16.75	88.10	94.38
	Traffic	Zone4_T	47.58	63.60	104.80	37.00	66.59	61.27	56.00	10.59	74.19	68.36
	Sensitive	Zone4_S	56.85	57.93	91.20	39.40	61.98	50.88	46.45	15.53	73.46	78.56
Zone V	Residential	Zone5_R	50.40	58.73	87.70	35.90	65.38	51.30	46.56	18.82	77.55	91.85
	Industrial	Zone5_I	50.81	56.15	92.44	44.41	59.40	54.31	49.69	9.70	65.85	58.50
	Traffic	Zone5_T	52.42	62.79	90.10	41.30	65.48	62.15	58.97	6.51	69.30	55.00
	Sensitive	Zone5_S	42.74	63.83	85.80	46.10	66.66	62.56	60.13	6.52	70.35	56.23

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone VI	Residential	Zone6_R	52.42	68.47	104.10	35.50	71.68	62.83	54.46	17.22	85.69	93.35
	Commercial	Zone6_C	51.21	56.16	87.90	37.70	58.58	51.33	47.35	11.23	67.39	62.27
	Traffic	Zone6_T	50.40	55.60	87.00	34.90	58.86	54.07	49.71	9.16	64.76	56.33
	Sensitive	Zone6_S	91.13	62.38	99.50	40.00	66.96	58.65	50.45	16.51	78.89	86.49
Zone VII	Residential	Zone7_R	98.79	63.65	82.00	52.90	64.27	63.48	62.96	1.31	64.96	38.21
	Industrial	Zone7_I	67.74	65.18	101.60	39.80	68.21	64.06	60.74	7.47	72.65	60.63
	Traffic	Zone7_T	49.19	56.04	95.80	33.20	58.25	52.58	46.84	11.42	67.45	62.50
	Sensitive	Zone7_S	42.34	61.55	98.50	38.00	64.72	55.70	51.07	13.65	75.20	75.67
Zone VIII	Residential	Zone8_R	70.97	56.88	86.20	36.10	63.31	49.87	44.12	19.19	76.08	90.89
	Commercial	Zone8_C	90.28	44.92	75.80	31.30	48.54	35.78	34.36	14.18	59.10	61.10
	Traffic	Zone8_T	49.19	68.29	104.00	43.70	70.89	63.25	57.87	13.02	81.31	79.95
	Sensitive	Zone8_S	43.15	67.53	103.90	33.00	73.16	58.95	49.61	23.55	91.08	113.81
Zone IX	Residential	Zone9_R	49.19	58.49	82.20	37.90	63.10	53.32	47.44	15.66	74.15	80.06
	Commercial	Zone9_C	52.02	56.95	92.00	36.90	60.21	54.91	48.43	11.78	68.73	65.55
	Traffic	Zone9_T	44.76	62.16	94.60	42.40	65.51	60.88	57.21	8.30	70.46	60.41
Zone X	Residential	Zone10_R	52.42	62.31	87.20	37.80	64.37	53.93	47.94	16.43	78.74	83.67
	Commercial	Zone10_C	49.60	49.55	90.15	47.60	50.24	48.56	48.26	1.98	51.52	26.16
	Traffic	Zone10_T	52.42	63.97	96.80	43.50	66.51	62.15	58.54	7.96	71.93	60.40

Zone No.	Category	Station ID	% missing data	L _{eq} (dB(A))	L _{max} (dB(A))	L _{min} (dB(A))	L ₁₀ (dB(A))	L ₅₀ (dB(A))	L ₉₀ (dB(A))	Noise Climate (NC) (dB(A))	Noise Pollution Level (L _{np}) (dB(A))	Traffic Noise Index (TNI) (dB(A))
Zone XI	Residential	Zone11_R	71.77	59.39	88.60	41.60	62.98	57.56	52.01	10.97	70.36	65.91
	Commercial	Zone11_C	0.00	68.51	97.80	30.00	71.11	67.79	63.46	7.65	76.16	64.07
	Traffic	Zone11_T	49.19	59.56	90.40	41.00	62.52	58.21	53.75	8.77	68.33	58.83
	Sensitive	Zone11_S	50.40	56.14	93.30	33.70	58.66	53.89	48.98	9.68	65.82	57.68
Zone XII	Residential	Zone12_R	42.74	57.90	91.40	39.70	61.34	55.29	49.20	12.14	70.04	67.76
	Traffic	Zone12_T	39.27	63.52	96.20	31.20	65.96	63.05	55.88	10.08	73.60	66.21
	Sensitive	Zone12_S	52.42	57.25	93.30	38.40	59.66	56.36	53.57	6.10	63.35	47.95
	Residential	Zone13_R	85.02	59.27	78.90	37.60	61.71	53.99	47.84	13.87	73.14	73.32
Zone XIII	Industrial	Zone13_I	95.97	56.71	94.08	32.07	60.27	53.53	50.10	10.17	66.88	60.77
	Traffic	Zone13_T	99.60	52.00	69.38	32.84	52.00	52.00	52.00	0.00	52.00	22.00
	Sensitive	Zone13_S	58.30	46.11	90.50	30.28	45.65	45.39	45.11	0.54	46.65	17.26
	Residential	Zone14_R	47.98	55.53	83.50	31.20	56.29	50.61	47.08	9.21	64.75	53.93
Zone XIV	Commercial	Zone14_C	52.63	67.53	98.06	47.82	58.70	48.51	48.43	10.27	77.80	59.51
	Traffic	Zone14_T	48.99	62.68	101.90	40.10	64.25	61.23	58.63	5.62	68.30	51.09
	Sensitive	Zone14_S	49.19	58.92	97.75	43.03	62.60	47.03	46.02	16.58	75.50	82.34
	Residential	Zone15_R	52.42	72.69	99.54	49.53	79.64	50.53	50.20	29.44	102.14	137.97
Zone XV	Commercial	Zone15_C	49.19	64.11	91.50	43.20	66.62	63.54	60.72	5.90	70.01	54.32
	Sensitive	Zone15_S	43.15	57.15	95.90	30.00	58.55	53.34	48.34	10.21	67.36	59.18

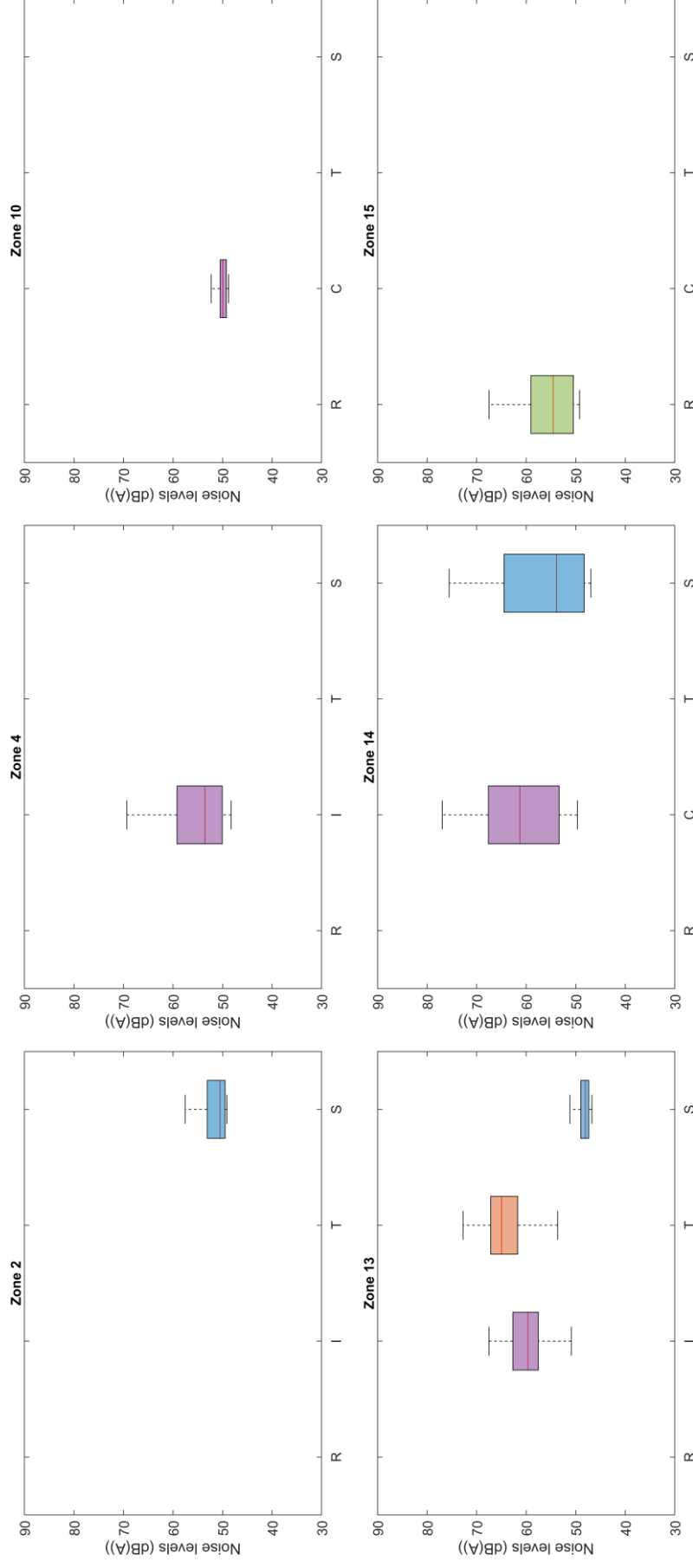


Figure D.1 Box plot showing variations in noise levels – March 2025

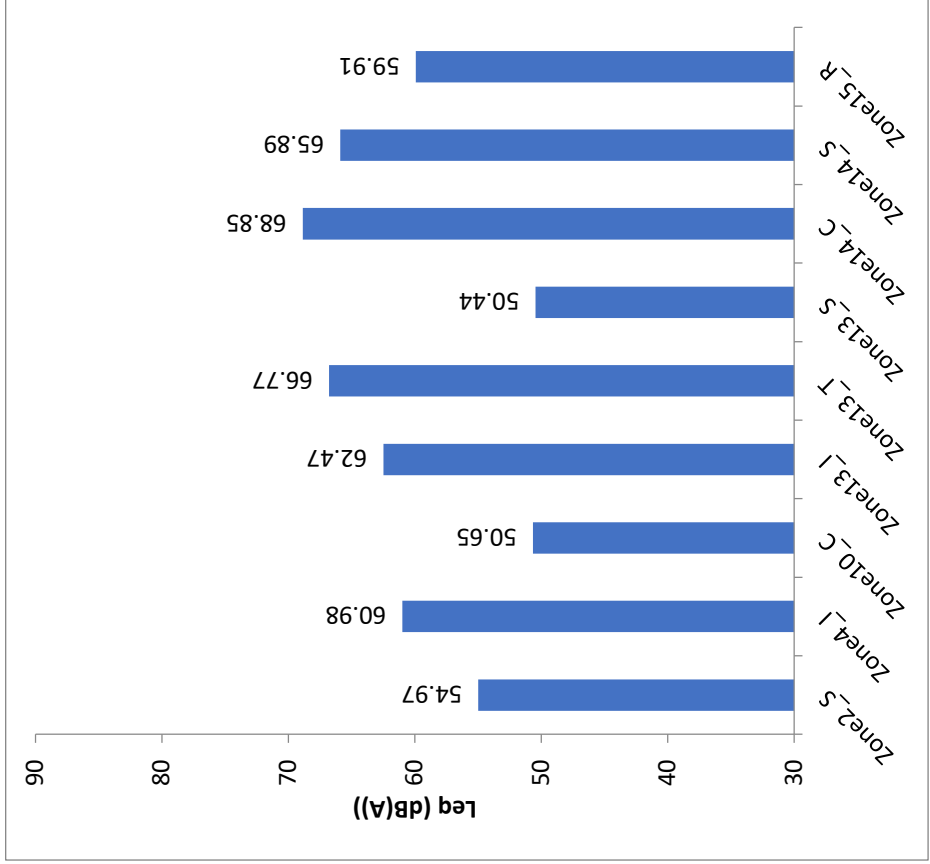


Figure D.2 Comparison of noise levels across all the zones during
March 2025 – Day

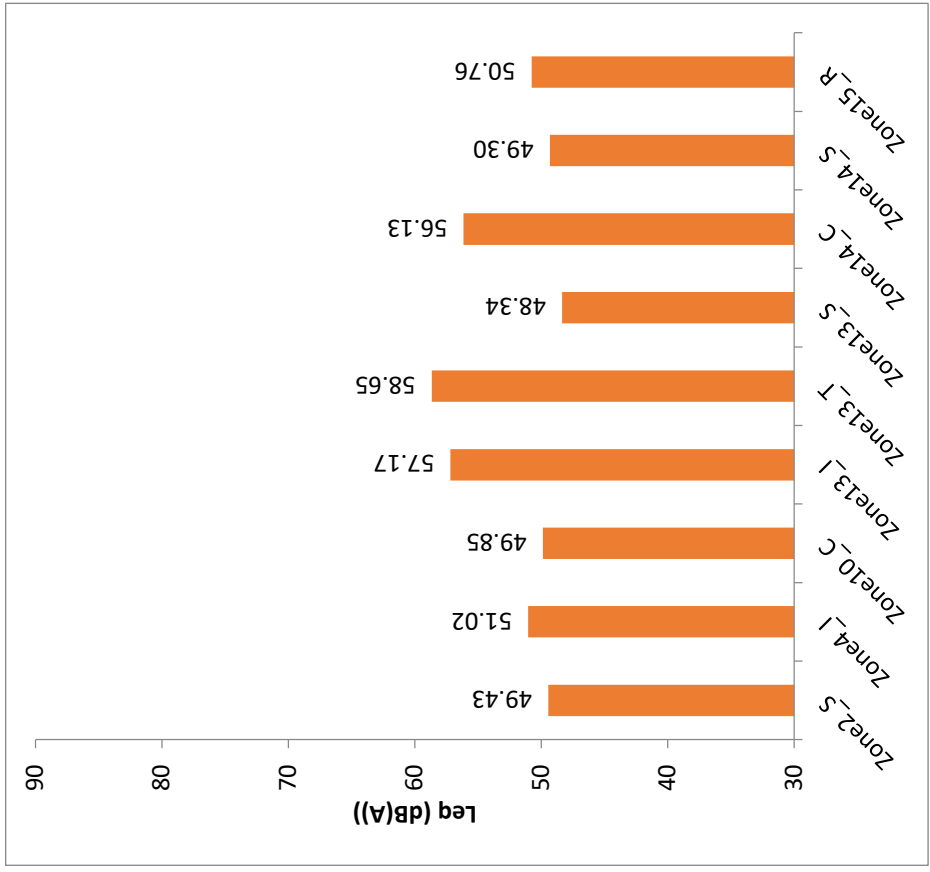


Figure D.3 Comparison of noise levels across all the zones during
March 2025 – Night

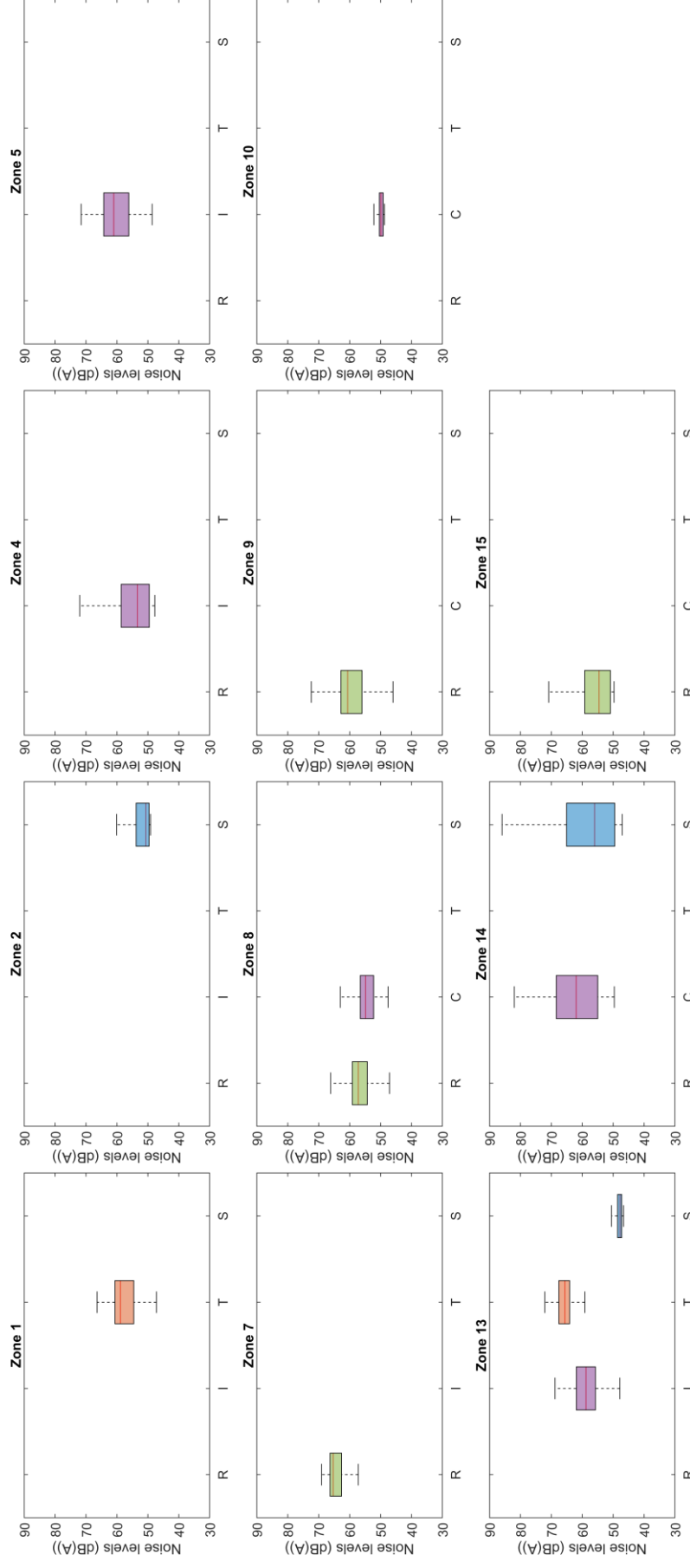


Figure D.4 Box plot showing variations in noise levels – April 2025

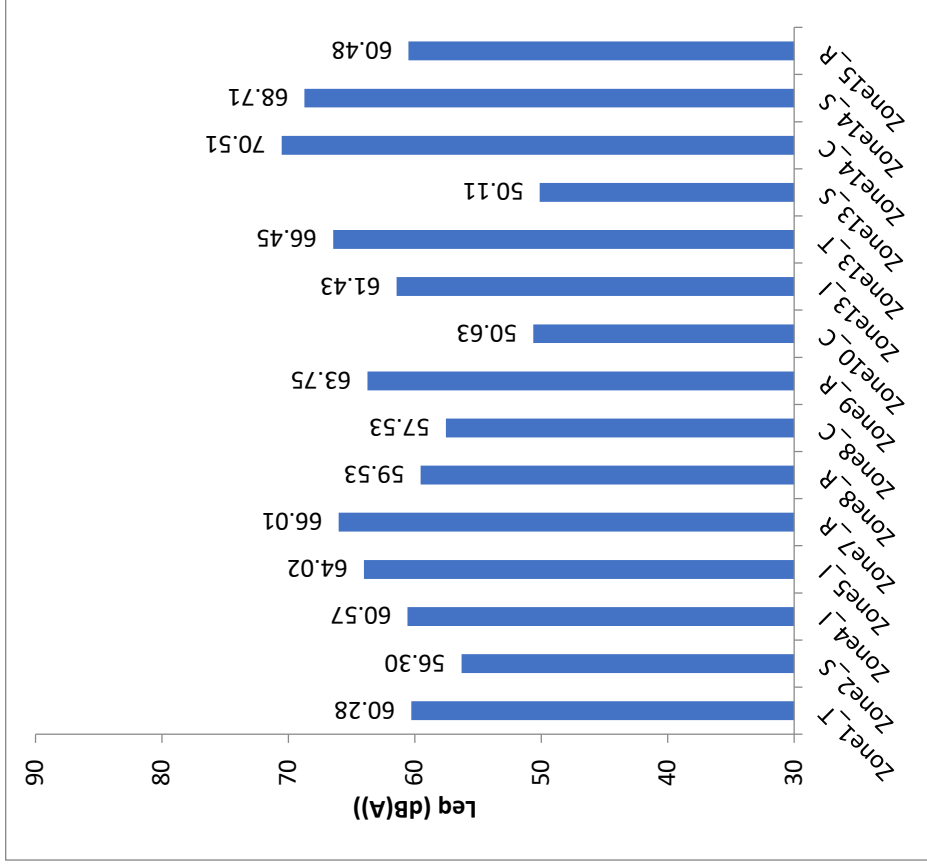


Figure D.5 Comparison of noise levels across all the zones during
April 2025 – Day

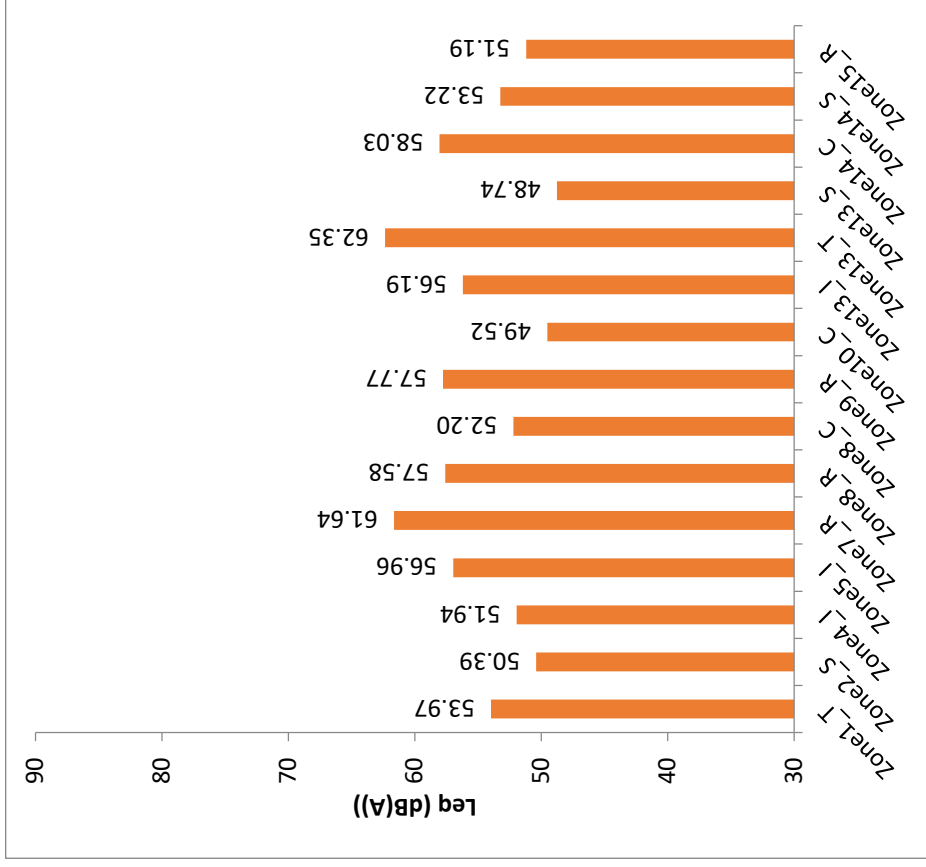


Figure D.6 Comparison of noise levels across all the zones during
April 2025 – Night

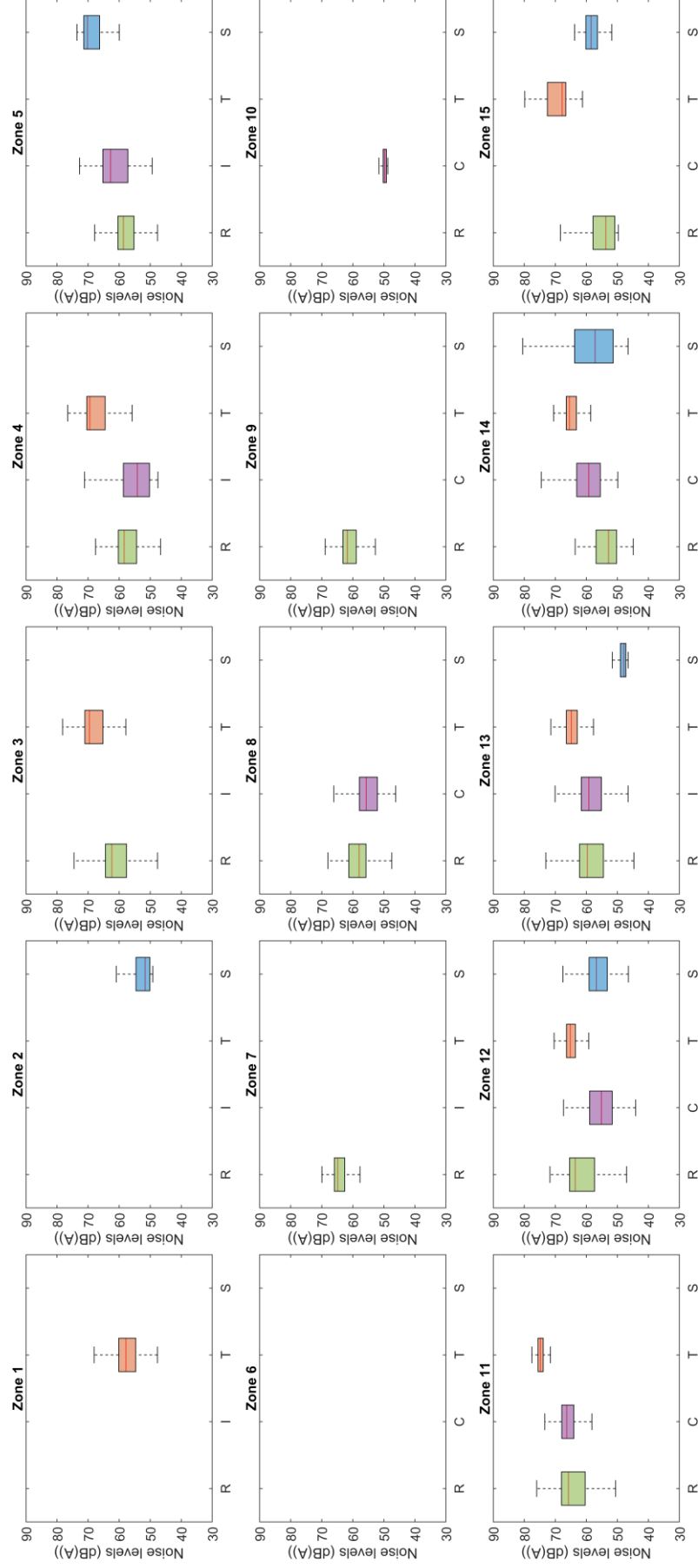


Figure D.7 Box plot showing variations in noise levels – May 2025

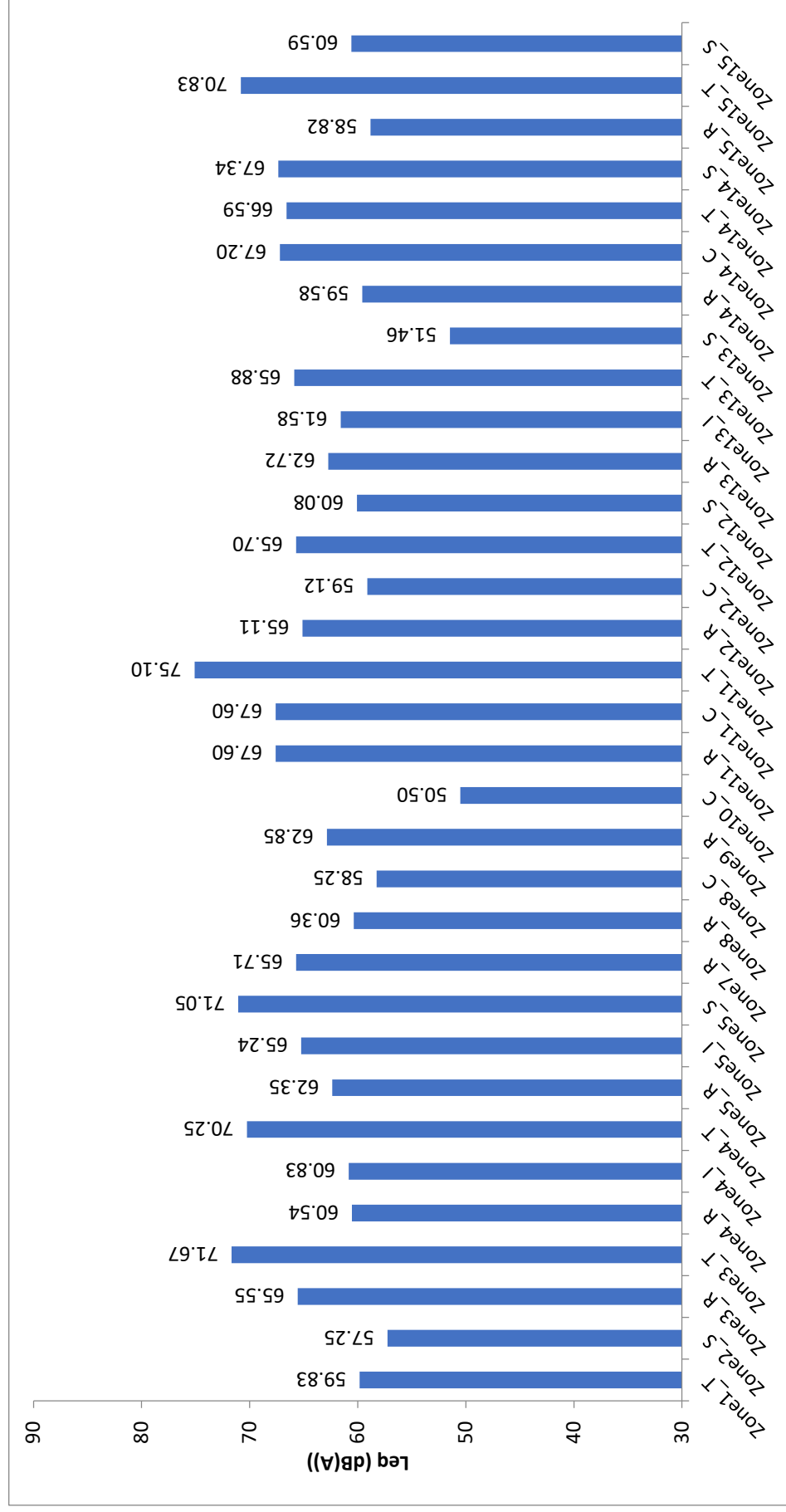


Figure D.8 Comparison of noise levels across all the zones during May 2025 – Day

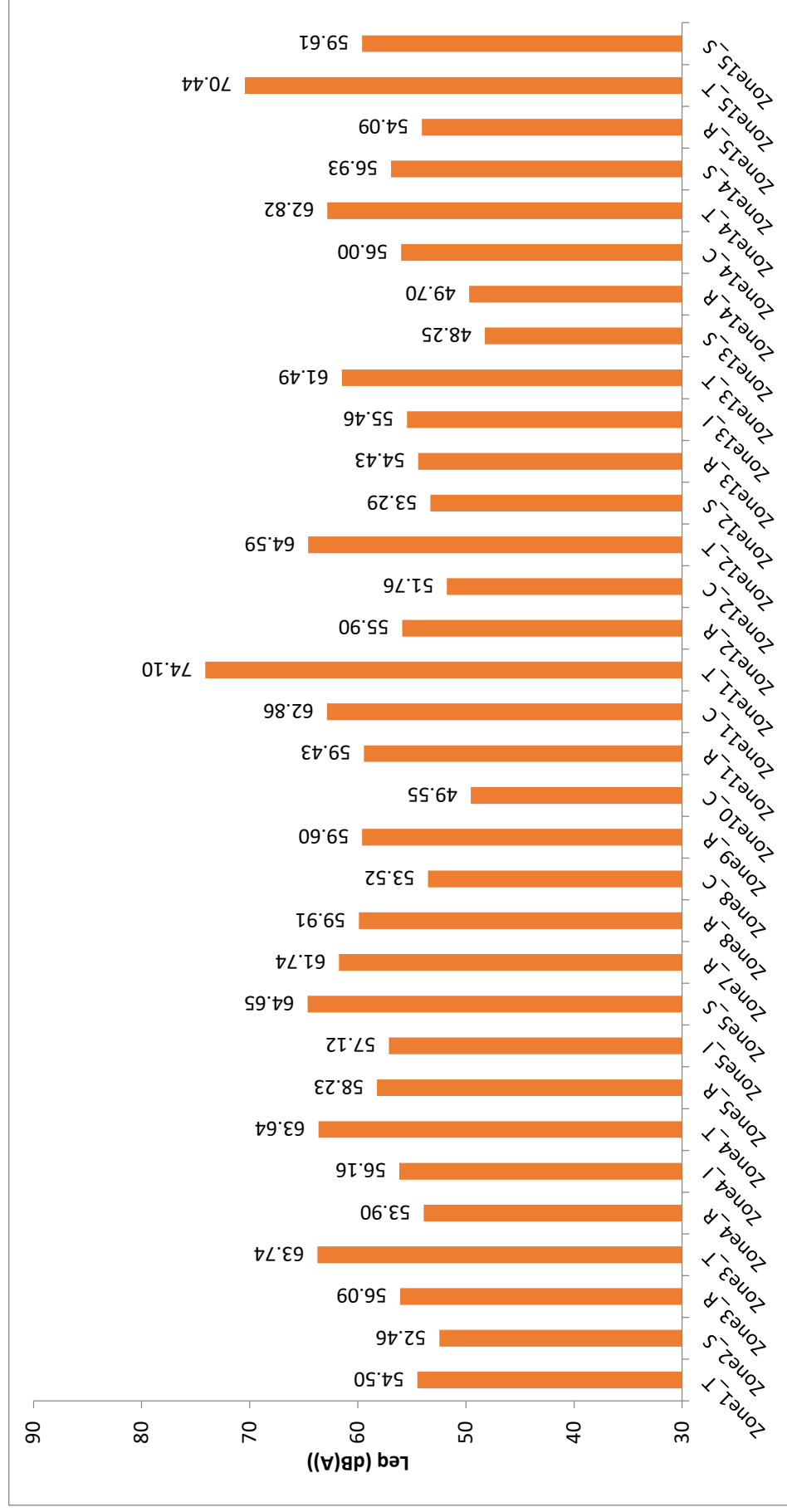


Figure D.9 Comparison of noise levels across all the zones during May 2025 – Night

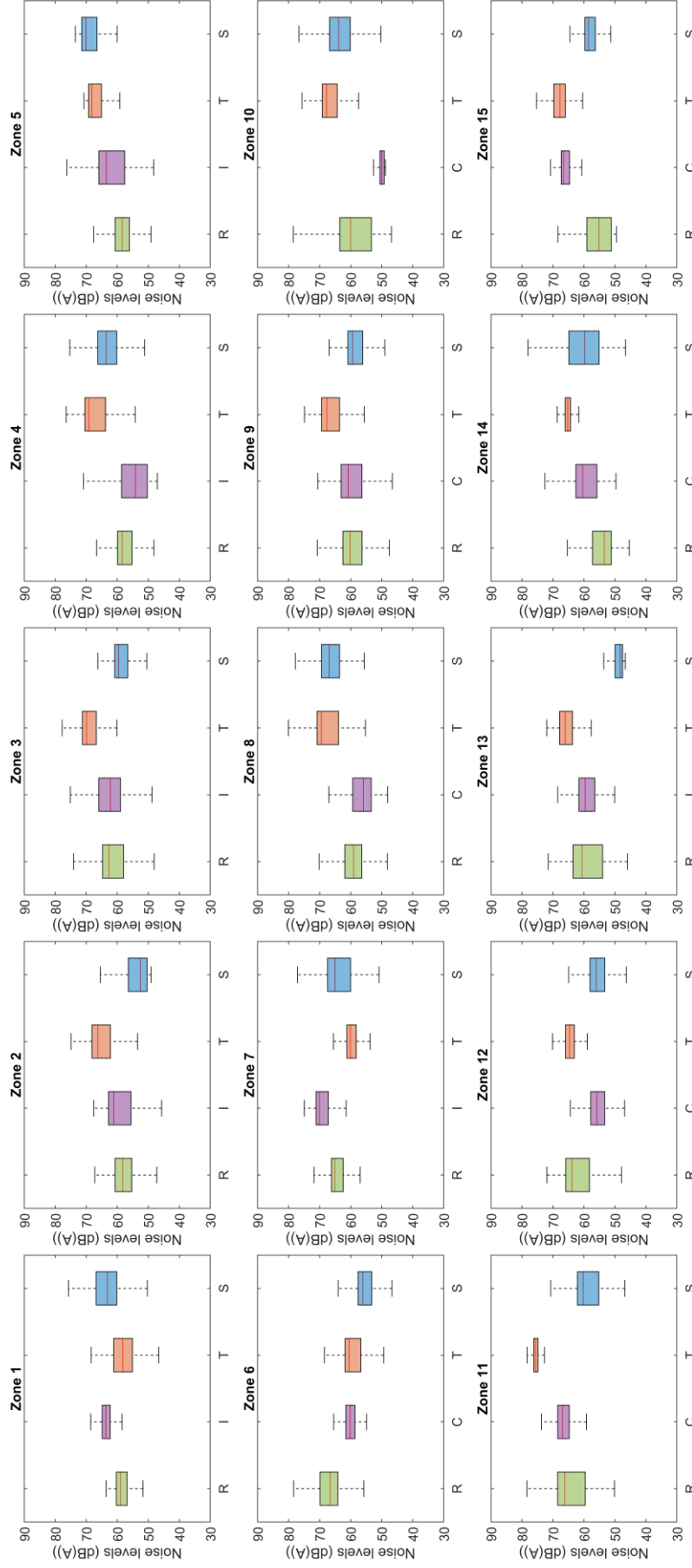


Figure D.10 Box plot showing variations in noise levels — June 2025

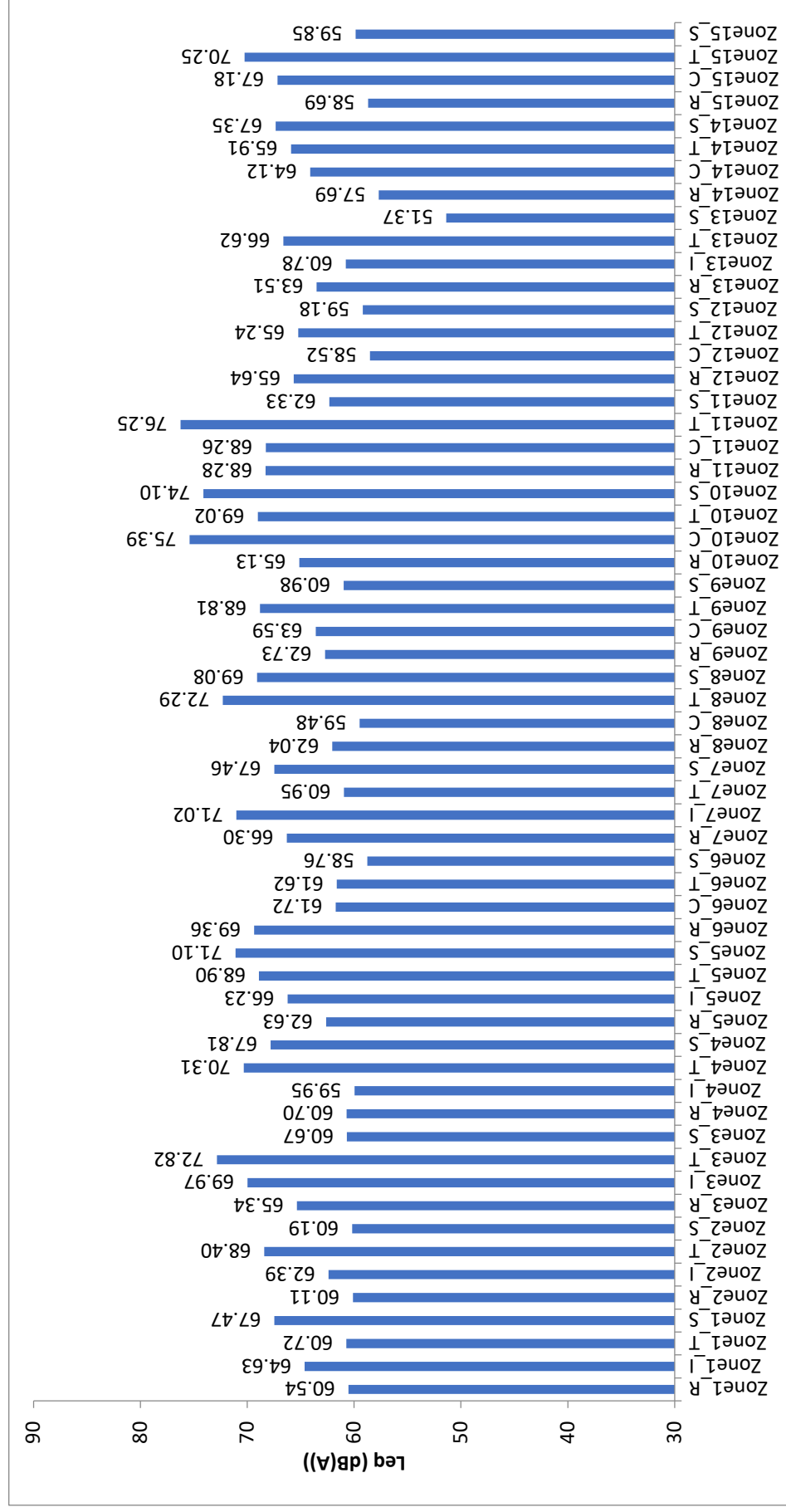


Figure D.11 Comparison of noise levels across all the zones during June 2025 – Day

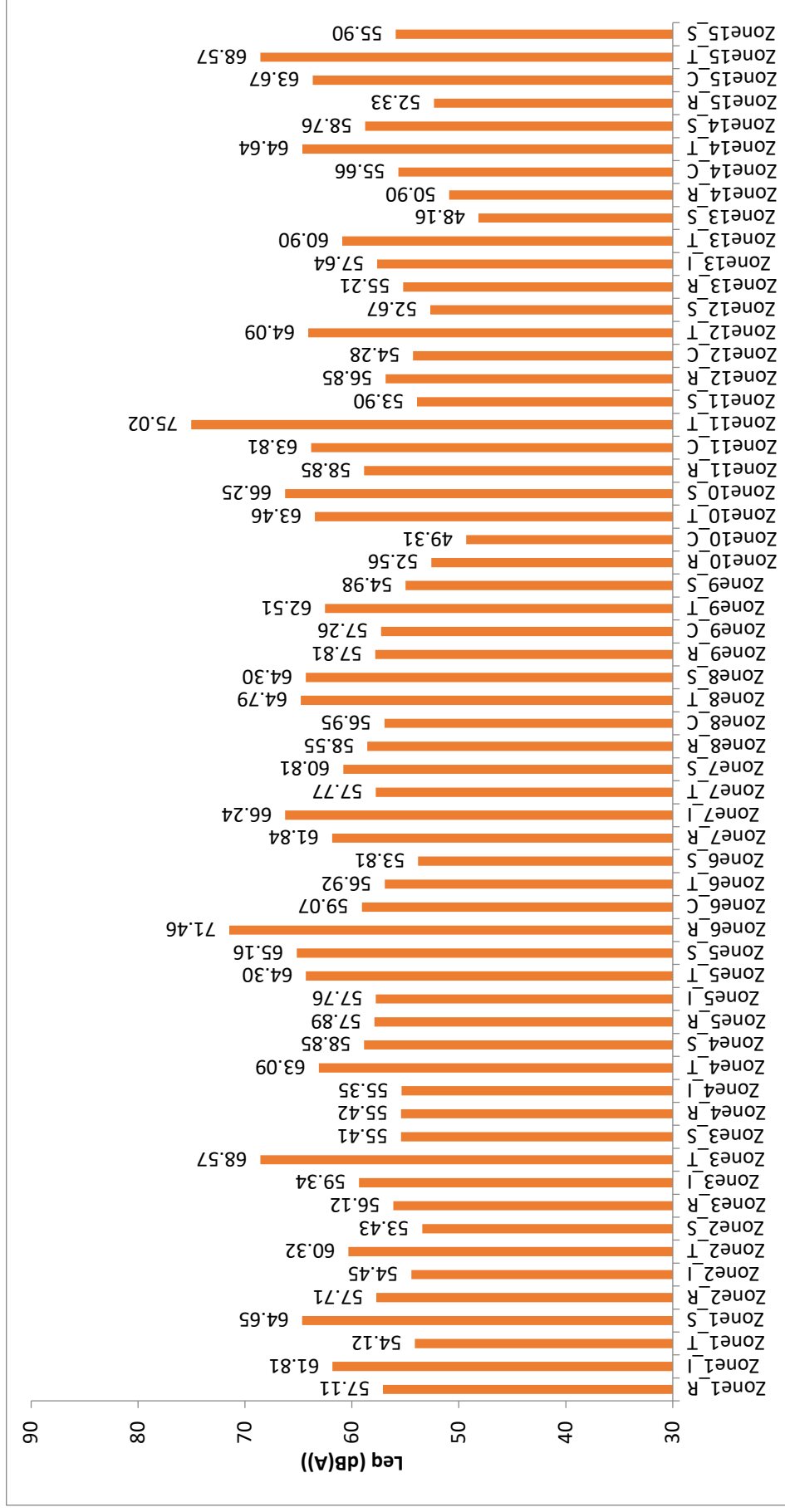


Figure D.12 Comparison of noise levels across all the zones during June 2025 – Night

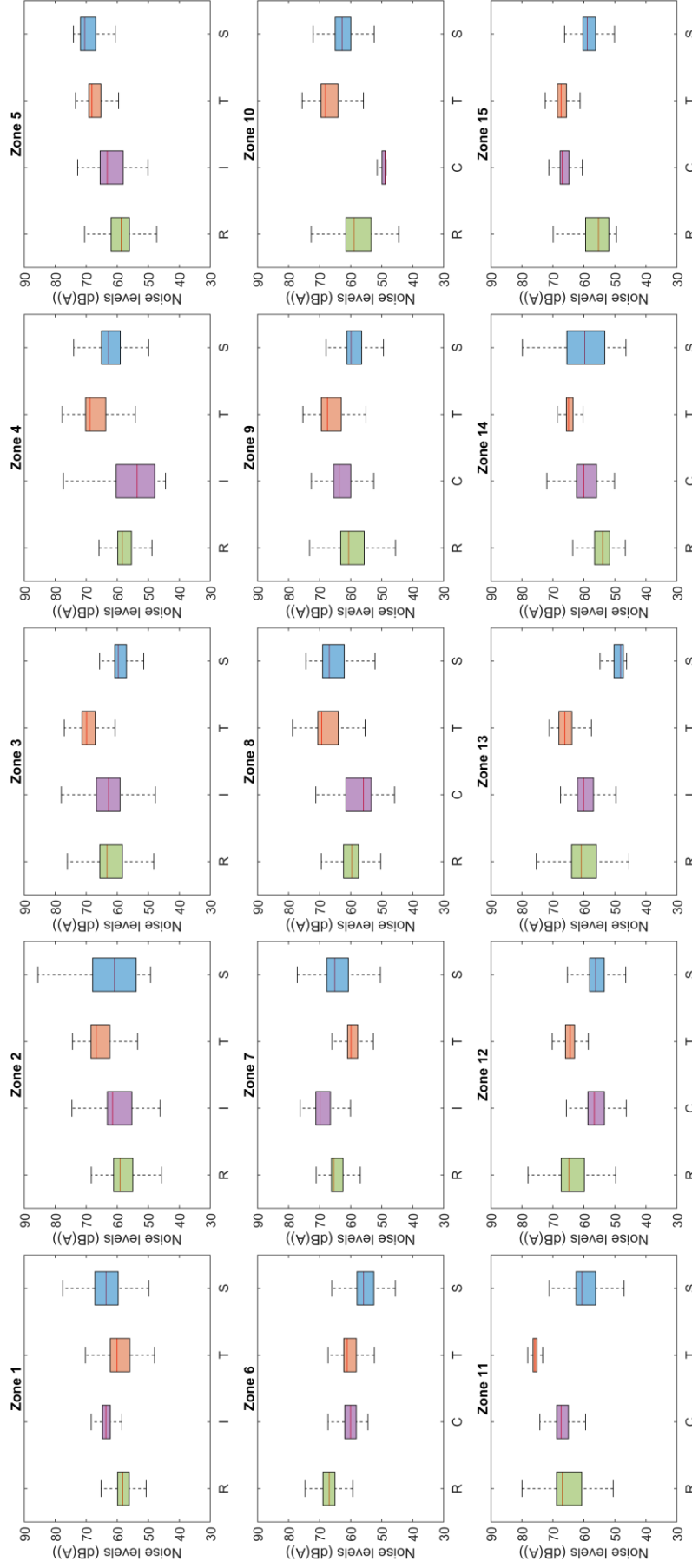


Figure D.13 Box plot showing variations in noise levels – July 2025

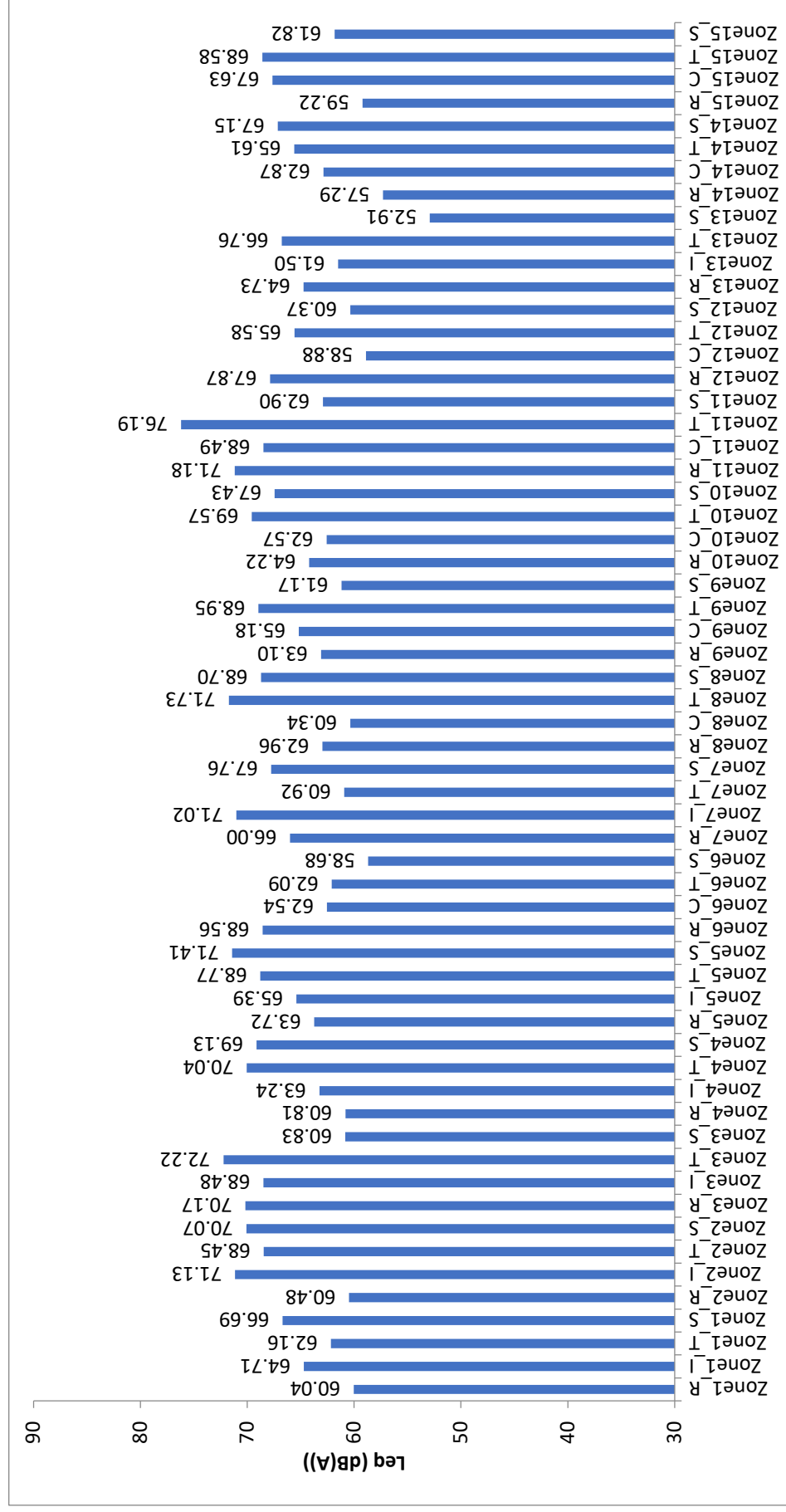


Figure D.14 Comparison of noise levels across all the zones during July 2025 – Day

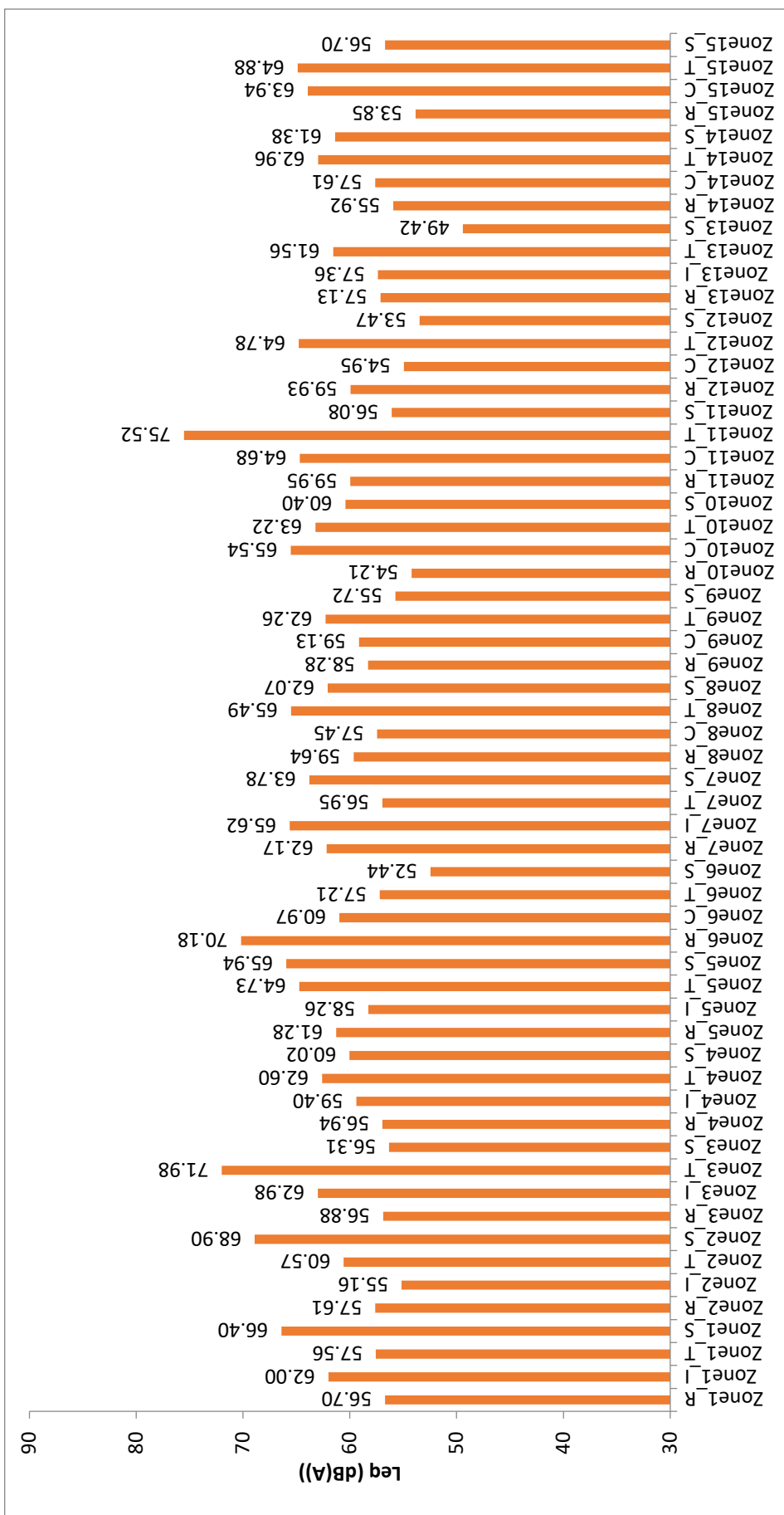


Figure D.15 Comparison of noise levels across all the zones during July 2025 – Night

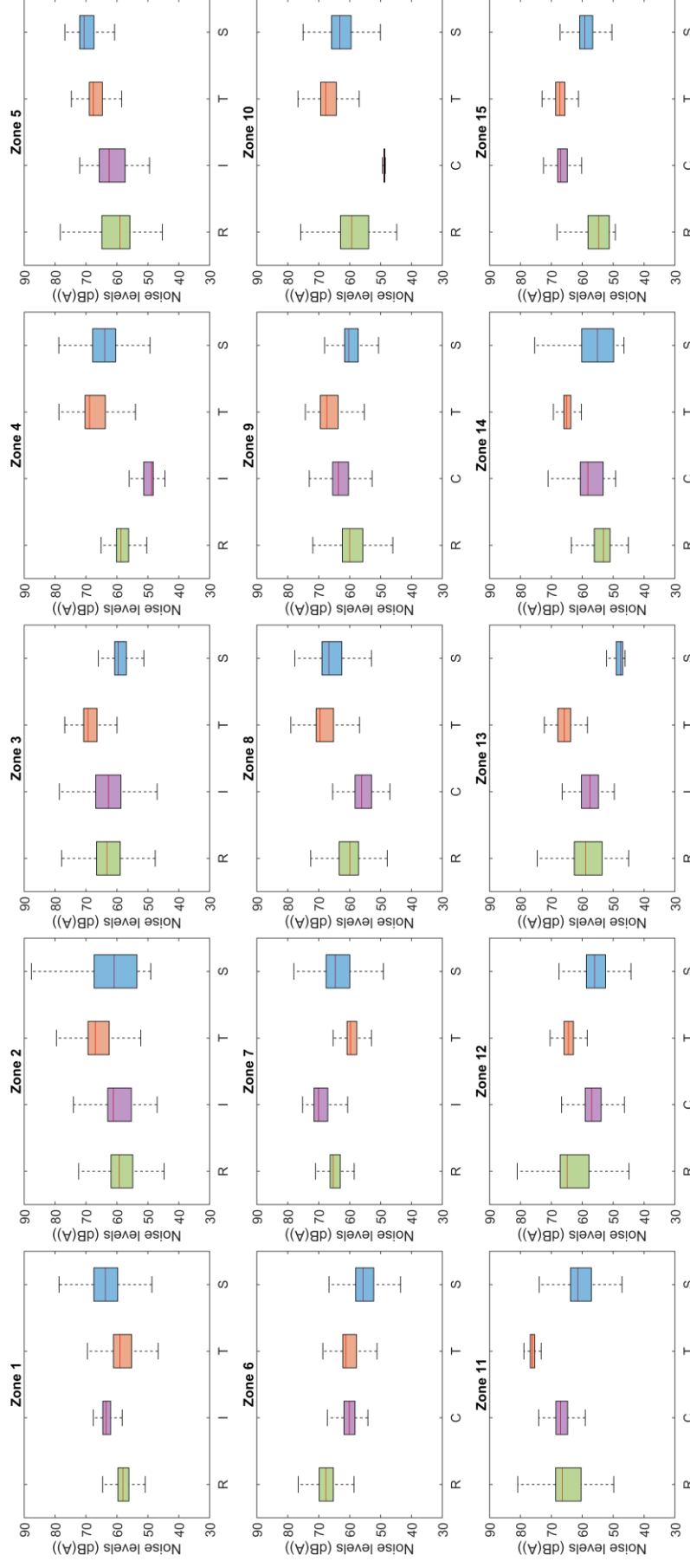


Figure D.16 Box plot showing variations in noise levels – August 2025

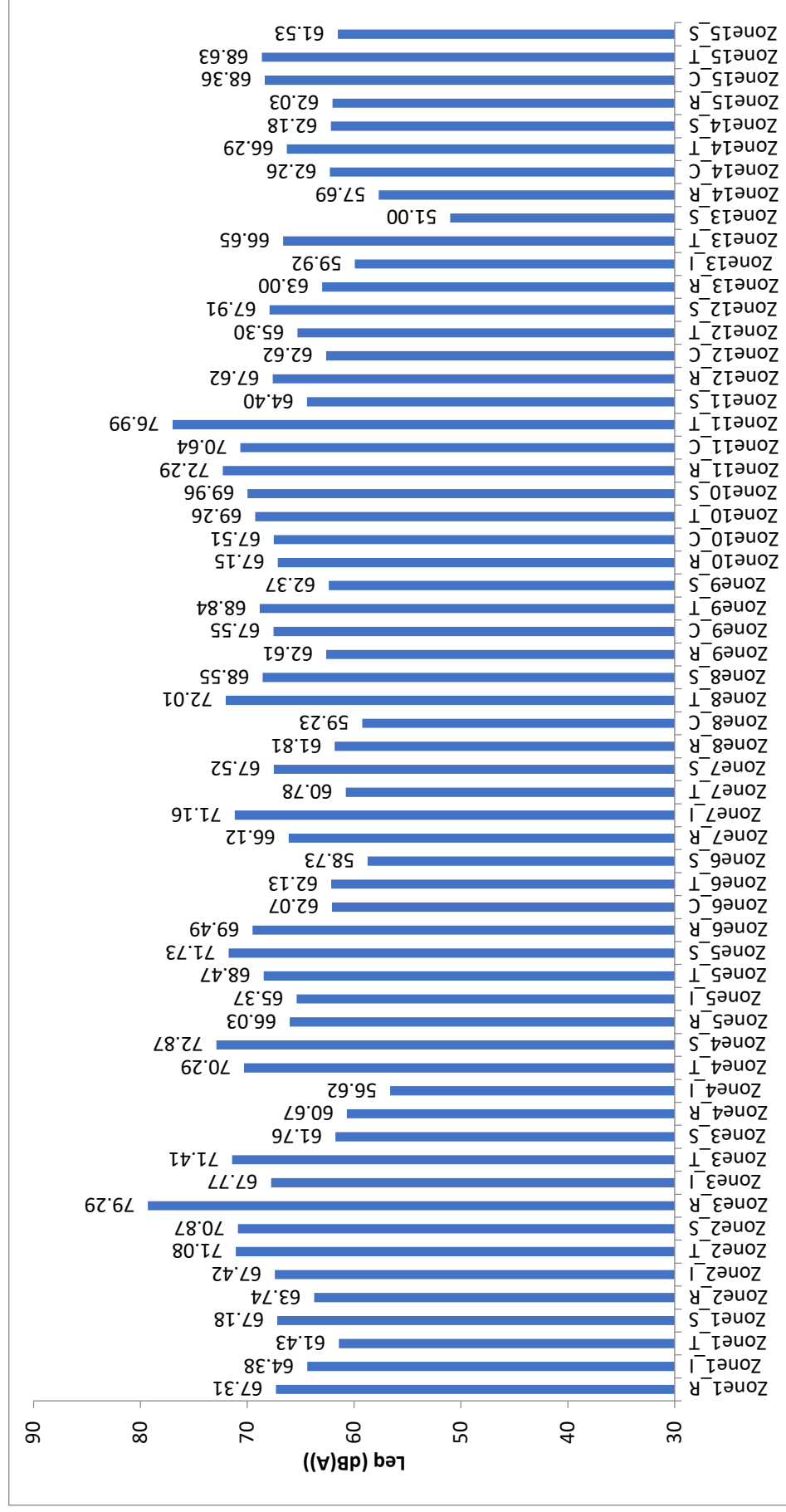


Figure D.17 Comparison of noise levels across all the zones during August 2025 – Day

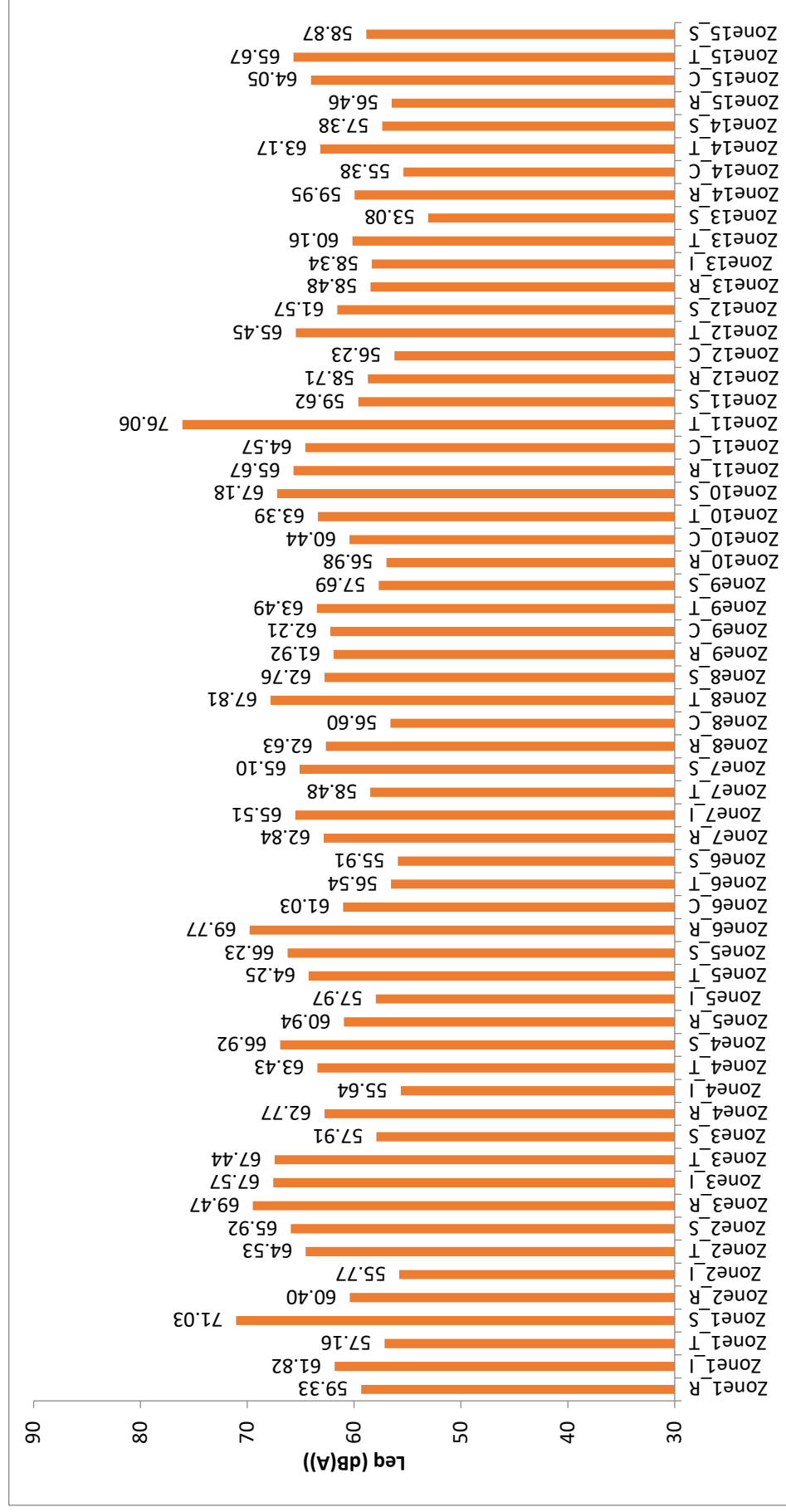


Figure D.18 Comparison of noise levels across all the zones during August 2025 – Night

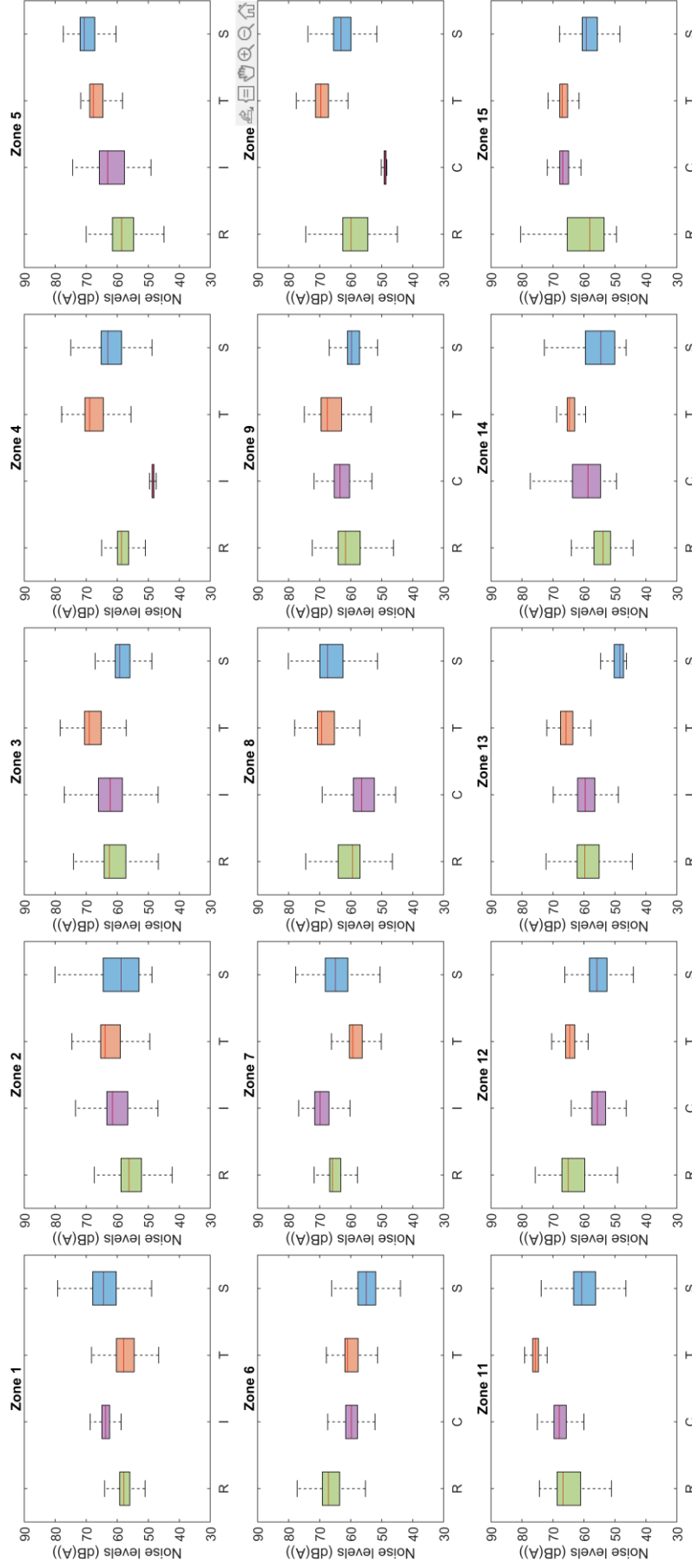


Figure D.19 Box plot showing variations in noise levels – September 2025

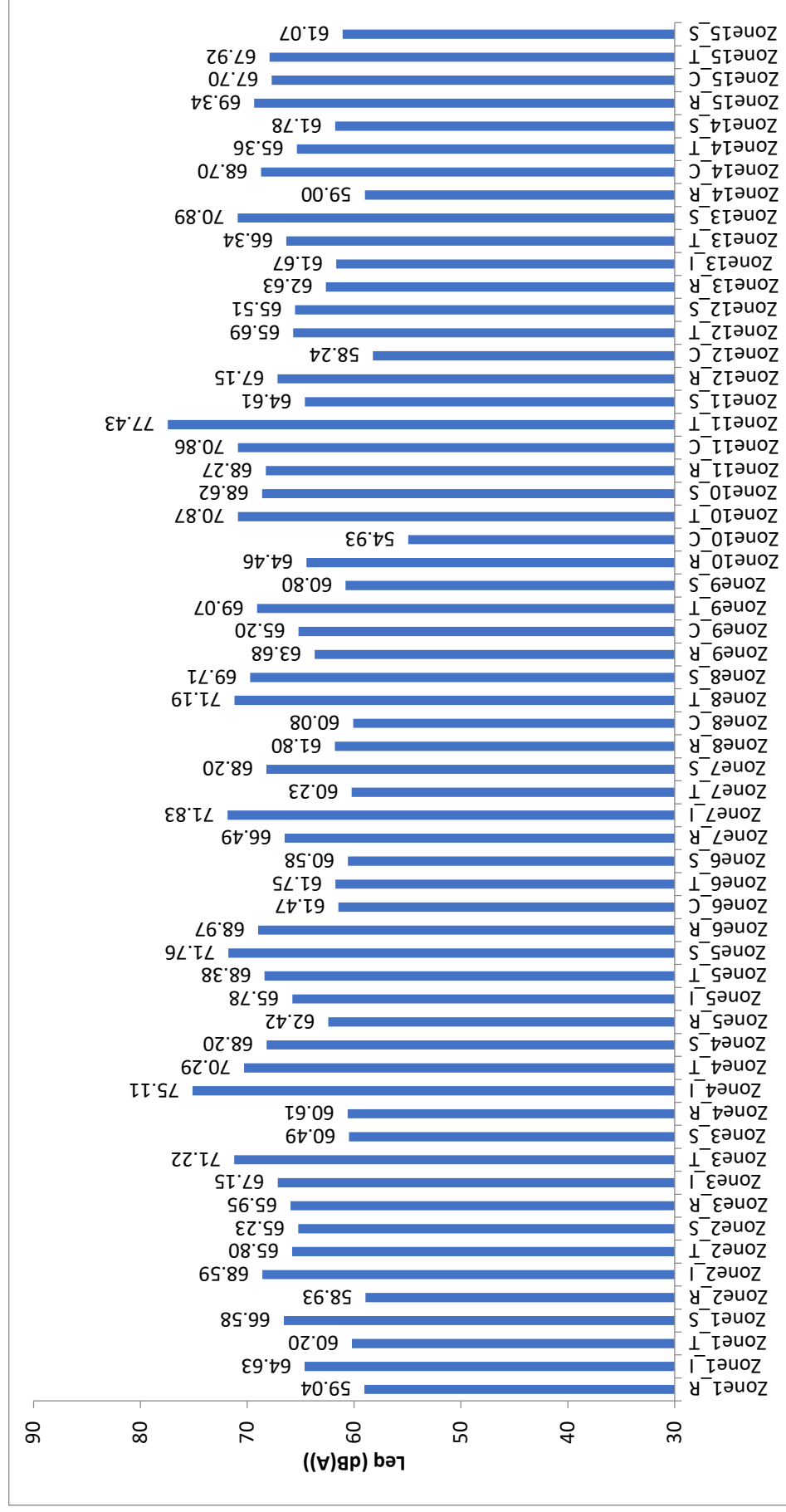


Figure D.20 Comparison of noise levels across all the zones during September 2025 – Day

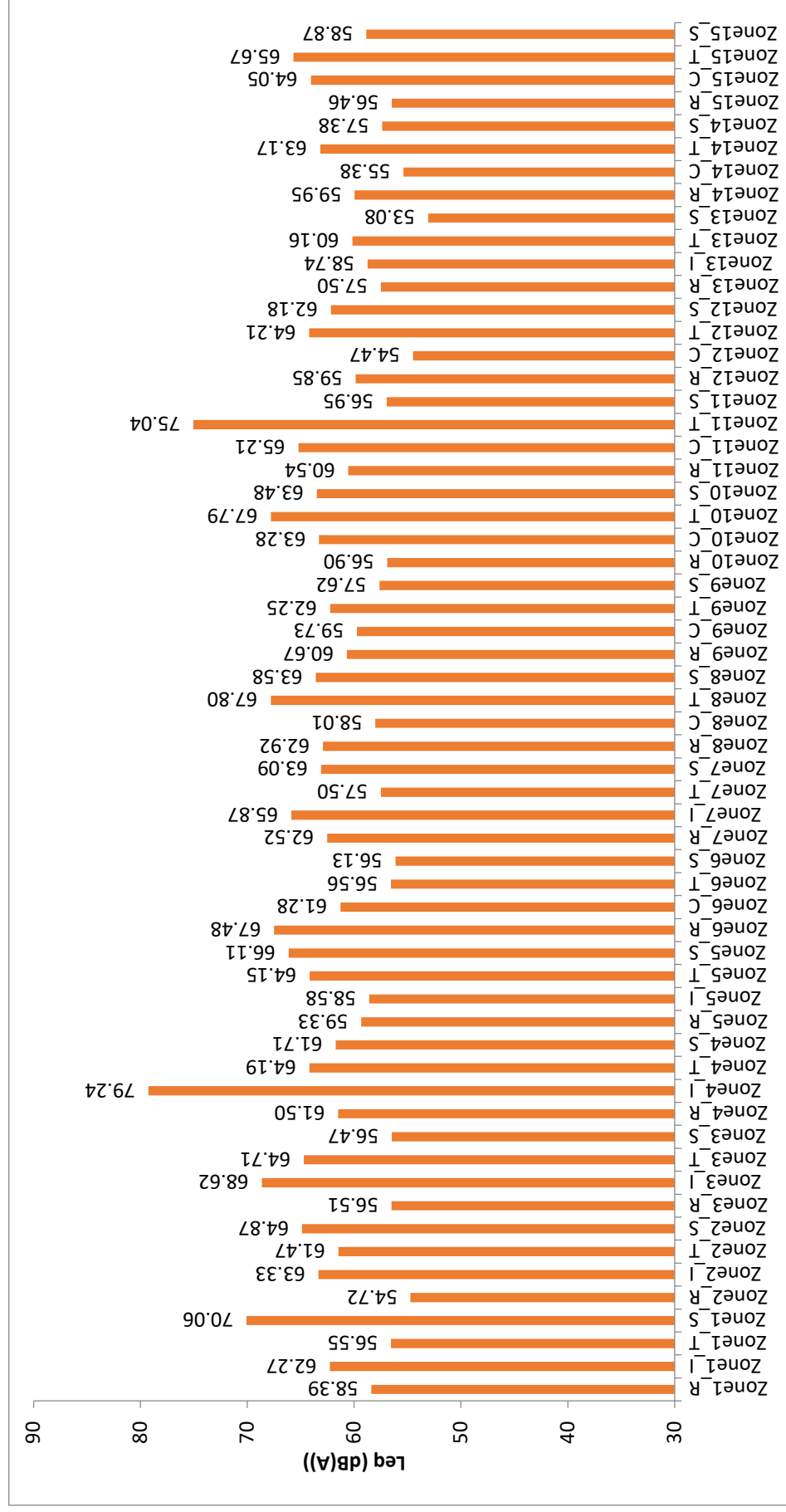


Figure D.21 Comparison of noise levels across all the zones during September 2025 – Night

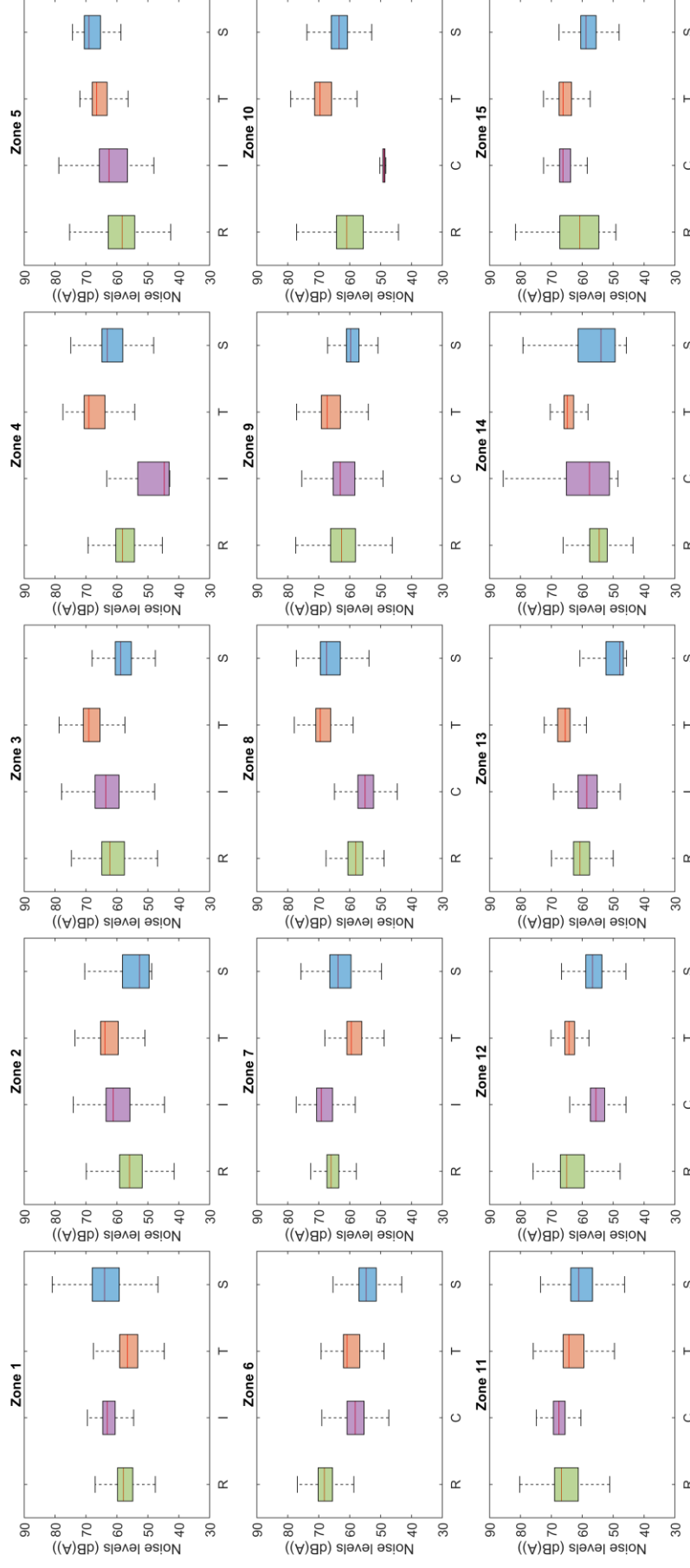


Figure D.22 Box plot showing variations in noise levels – October 2025

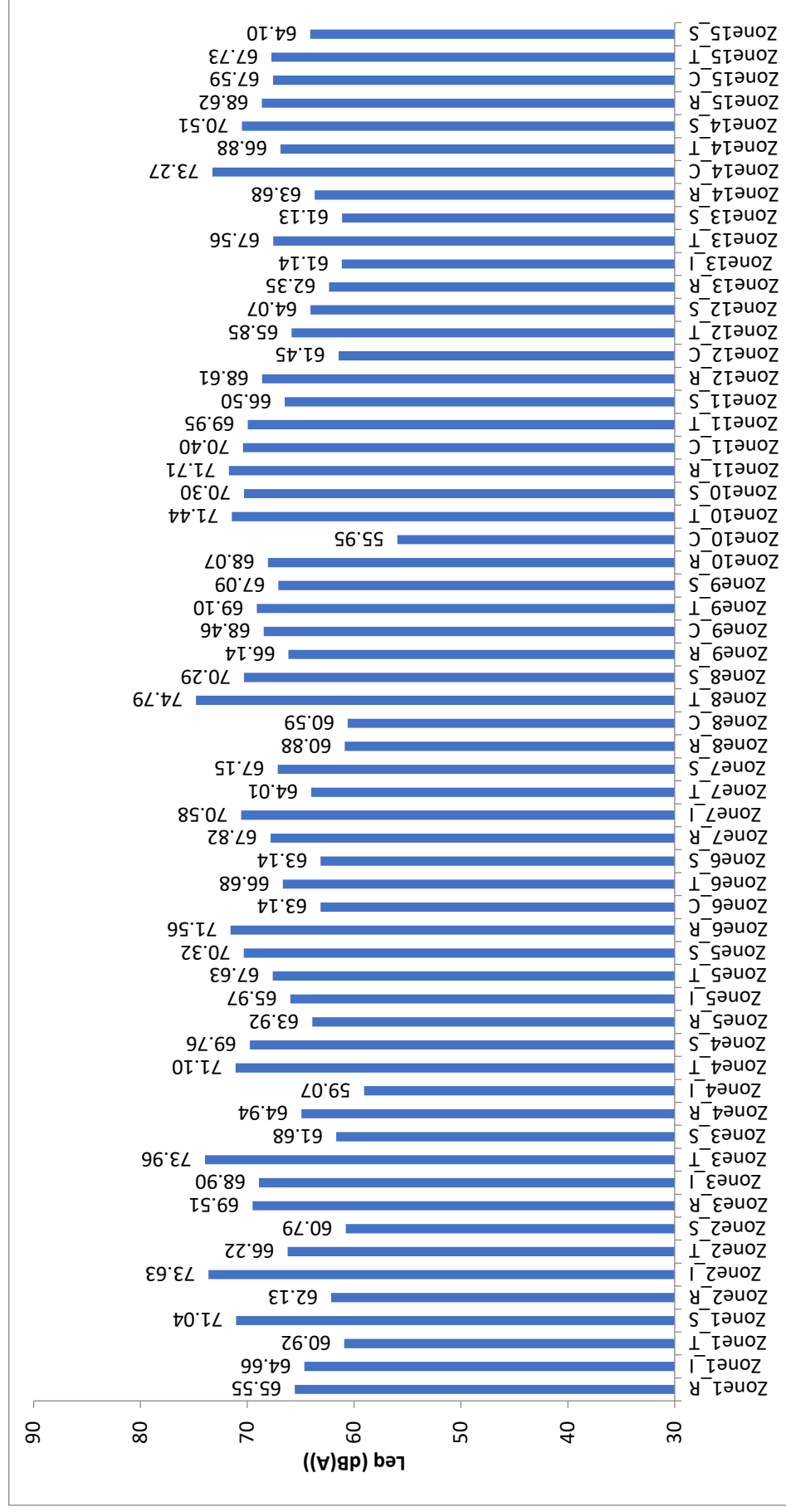


Figure D.23 Comparison of noise levels across all the zones during October 2025 – Day

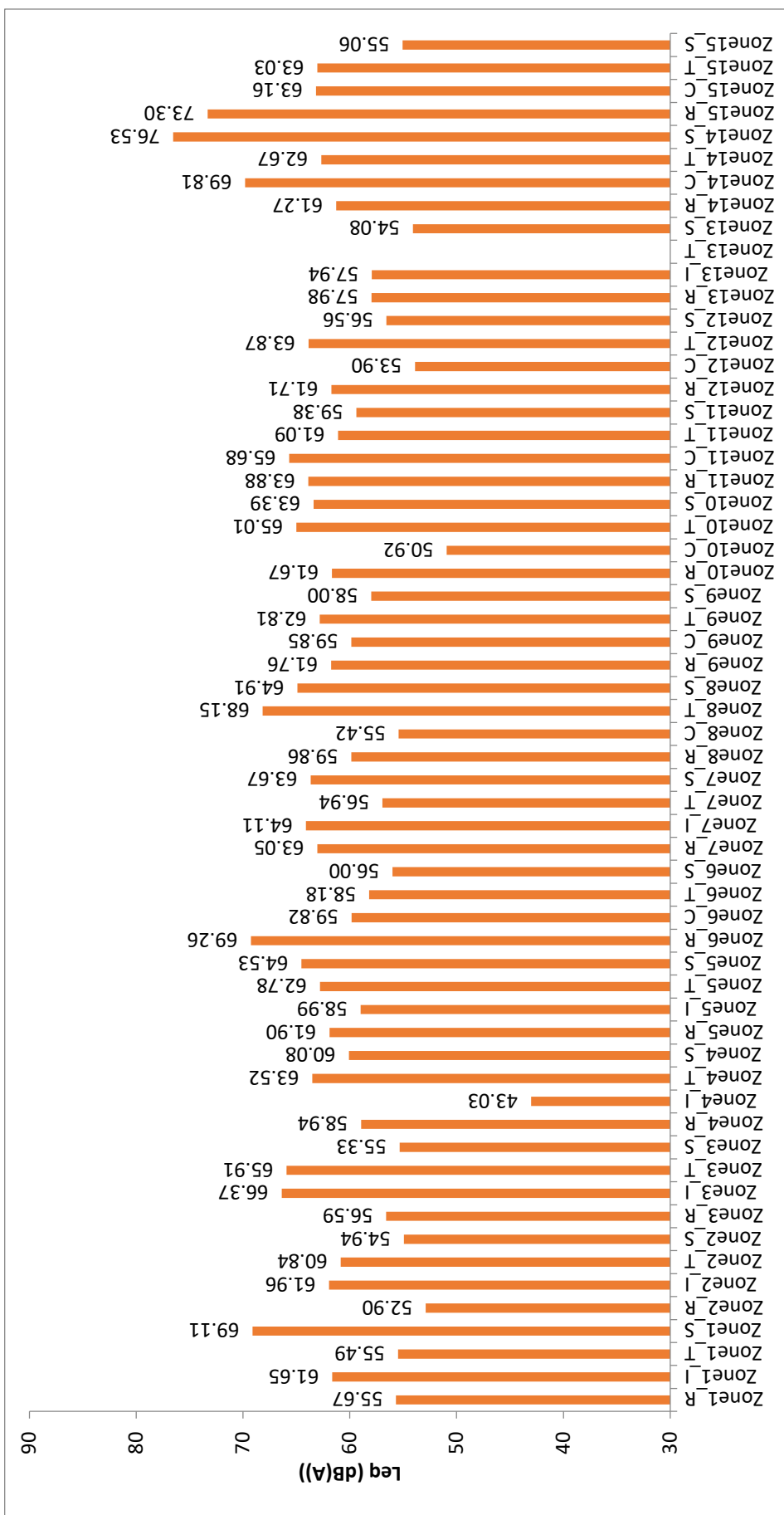


Figure D.24 Comparison of noise levels across all the zones during October 2025 – Night

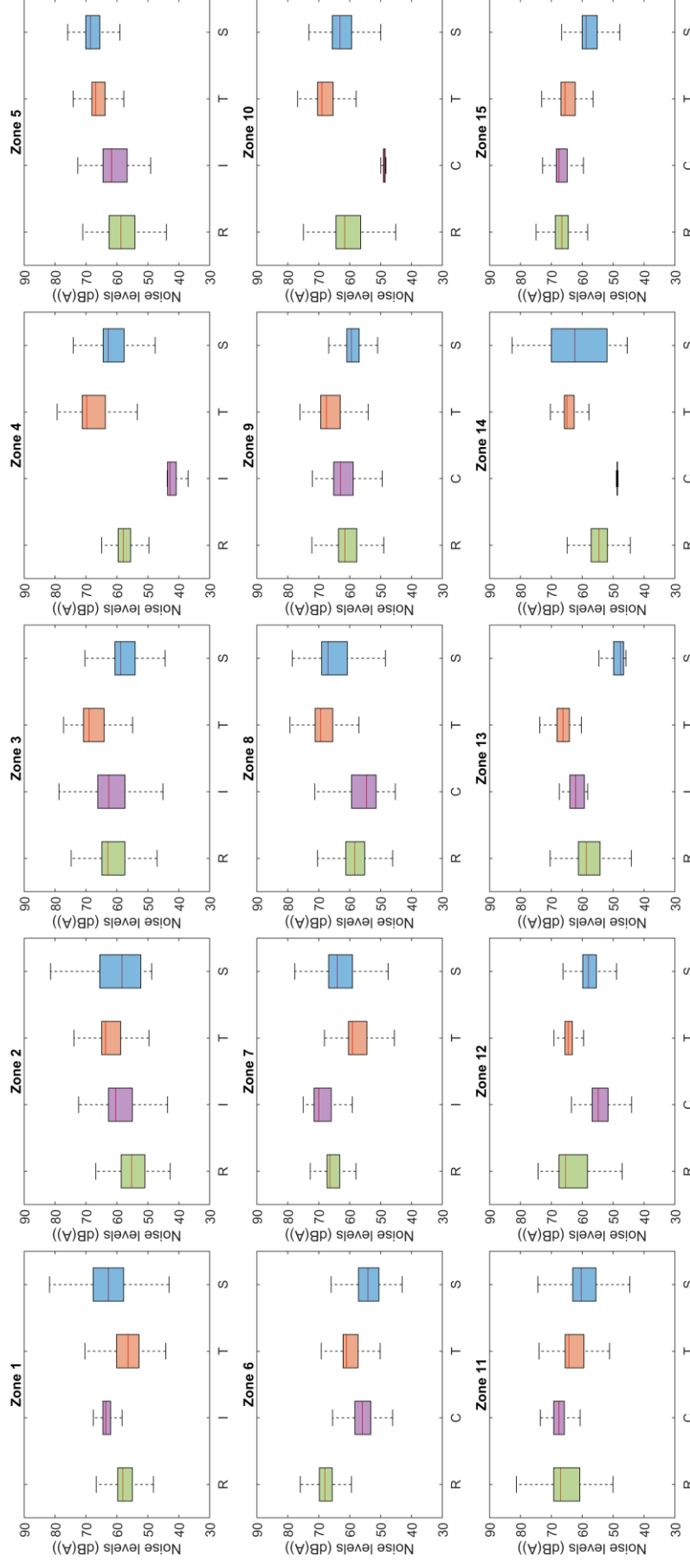


Figure D.25 Box plot showing variations in noise levels – November 2025

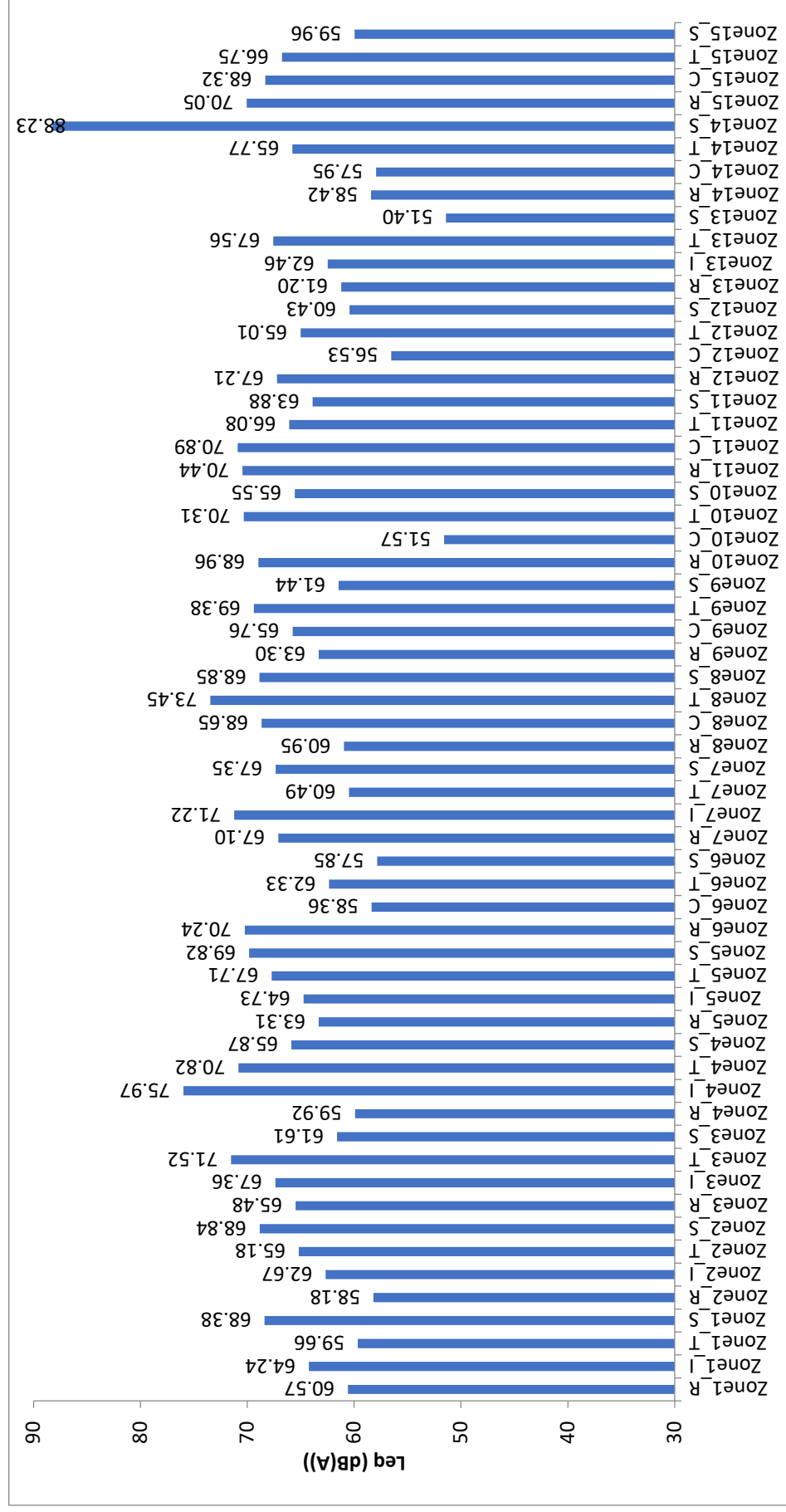


Figure D.26 Comparison of noise levels across all the zones during November 2025 – Day

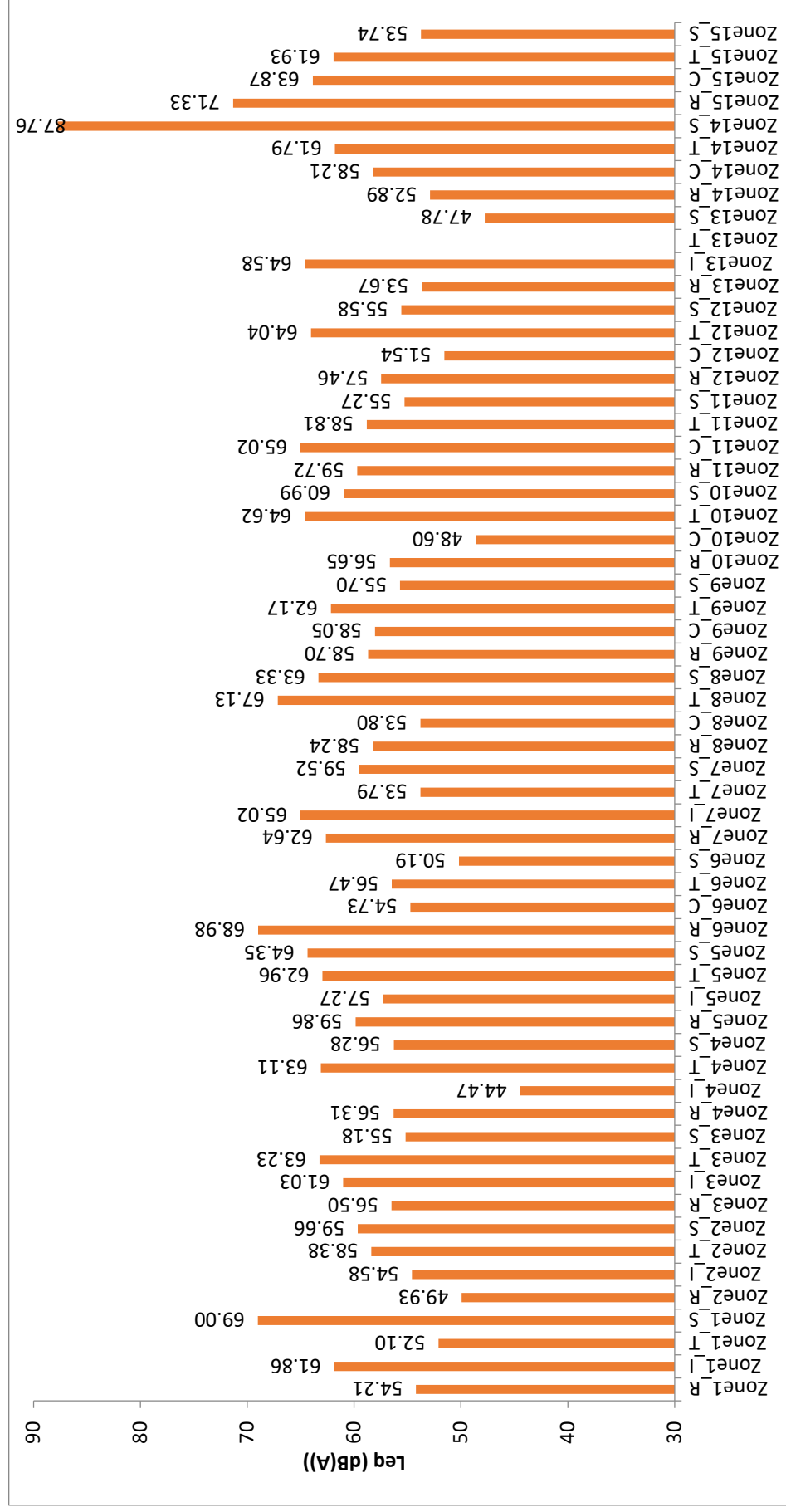


Figure D.27 Comparison of noise levels across all the zones during November 2025 – Night

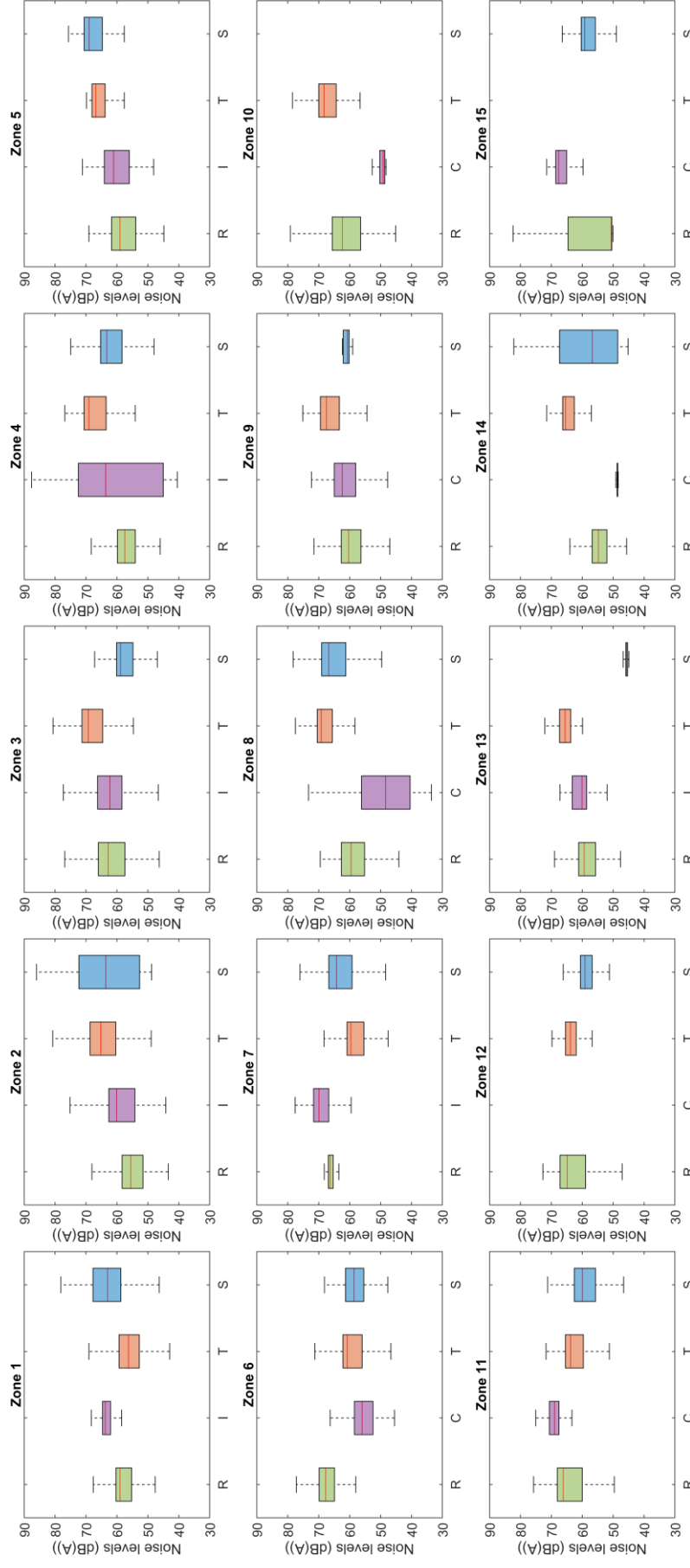


Figure D.28 Box plot showing variations in noise levels – December 2025

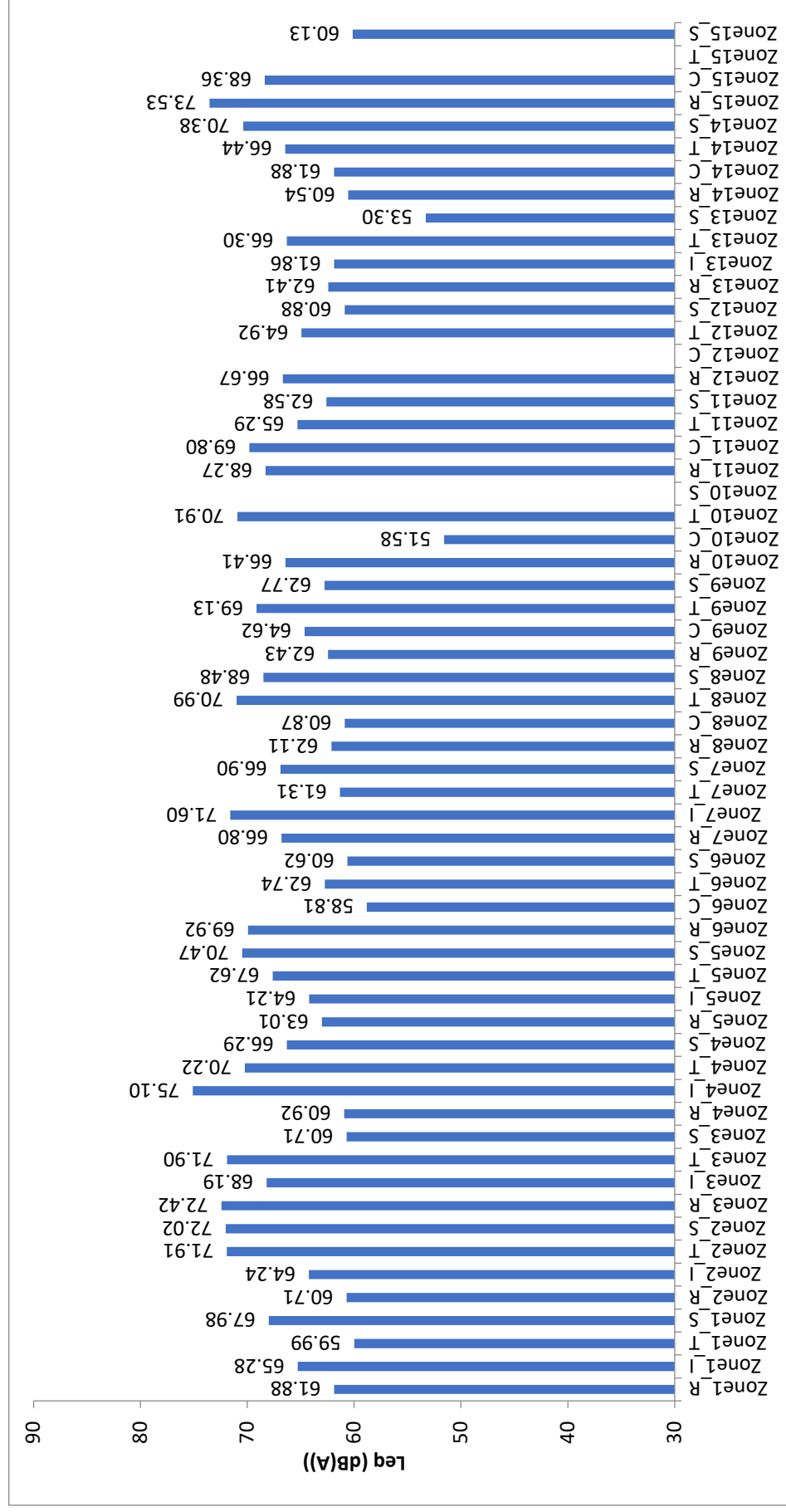


Figure D.29 Comparison of noise levels across all the zones during December 2025 – Day

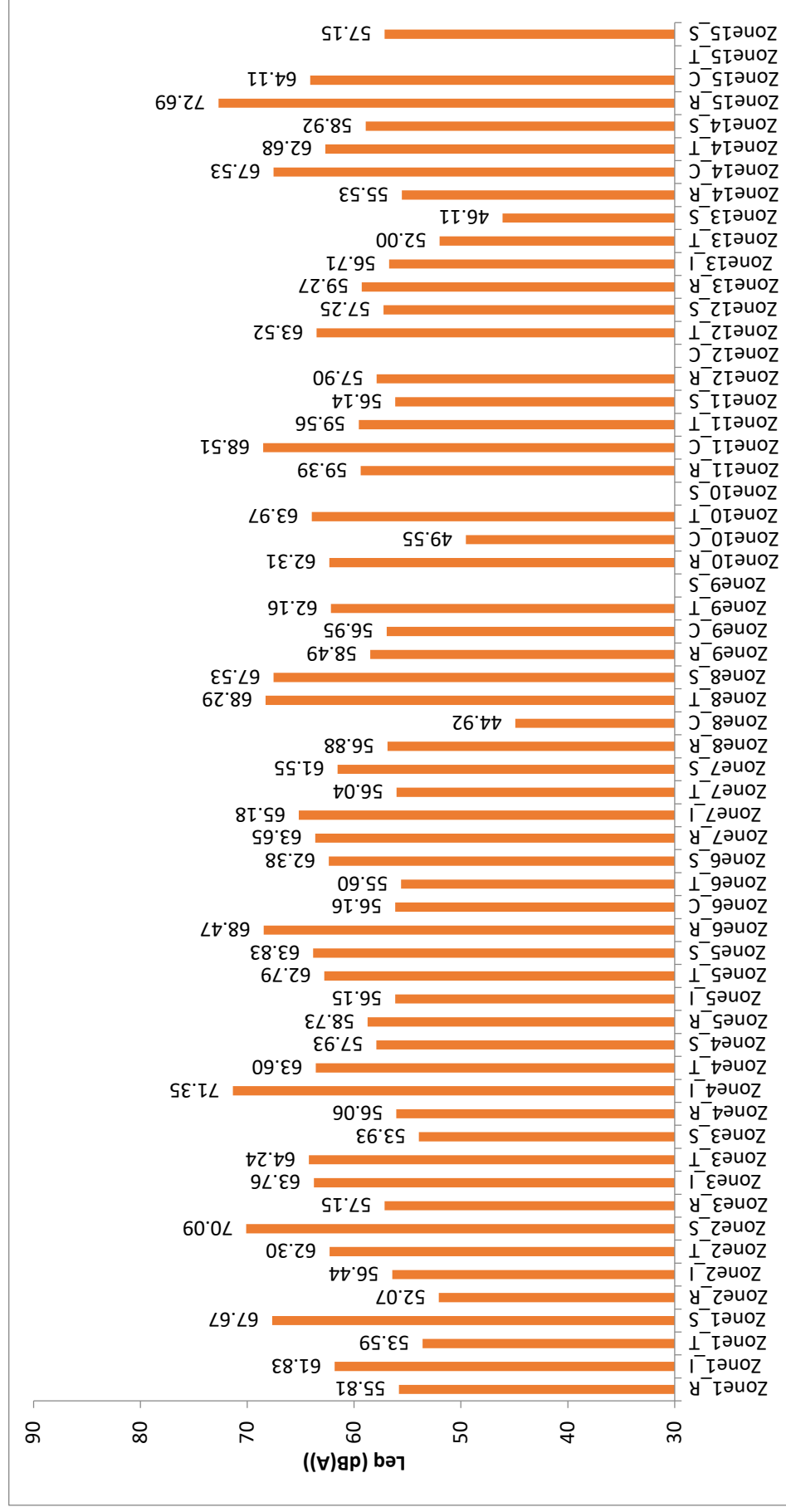


Figure D.30 Comparison of noise levels across all the zones during December 2025 – Night

Table D.21 Exceedance of noise levels with respect to CPCB standards – March 2025⁵

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone2_S	64	56	87.50	32	32	100.00
Zone4_I	48	0	0.00	24	0	0.00
Zone10_C	112	0	0.00	56	1	1.79
Zone13_I	160	0	0.00	80	0	0.00
Zone13_T	216	136	62.96	62	33	53.23
Zone13_S	147	25	17.01	75	75	100.00
Zone14_C	160	86	53.75	80	21	26.25
Zone14_S	270	229	84.81	136	136	100.00
Zone15_R	96	65	67.71	48	48	100.00

Table D.22 Exceedance of noise levels with respect to CPCB standards – April 2025⁶

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone1_T	192	2	1.04	91	17	18.68
Zone2_S	480	410	85.42	240	240	100.00
Zone4_I	480	0	0.00	240	0	0.00
Zone5_I	464	0	0.00	232	1	0.43
Zone7_R	240	240	100.00	120	120	100.00
Zone8_R	320	297	92.81	160	155	96.88
Zone8_C	159	1	0.63	79	7	8.86
Zone9_R	320	315	98.44	160	155	96.88
Zone10_C	446	1	0.22	217	3	1.38
Zone13_I	463	0	0.00	226	0	0.00
Zone13_T	366	220	60.11	7	6	85.71
Zone13_S	464	40	8.62	235	235	100.00
Zone14_C	467	260	55.67	238	88	36.97
Zone14_S	478	443	92.68	240	240	100.00
Zone15_R	480	335	69.79	240	240	100.00

Table D.23 Exceedance of noise levels with respect to CPCB standards – May 2025⁷

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone1_T	489	6	1.23	248	60	24.19
Zone2_S	440	408	92.73	217	217	100.00
Zone3_R	277	277	100.00	138	138	100.00
Zone3_T	281	281	100.00	144	144	100.00
Zone4_R	153	150	98.04	80	80	100.00
Zone4_I	480	1	0.21	232	1	0.43

⁵ Stations with 100% exceedance are highlighted in red

⁶ Stations with 100% exceedance are highlighted in red

⁷ Stations with 100% exceedance are highlighted in red

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone4_T	169	169	100.00	88	88	100.00
Zone5_R	169	165	97.63	88	88	100.00
Zone5_I	489	0	0.00	248	0	0.00
Zone5_S	249	249	100.00	128	128	100.00
Zone7_R	489	489	100.00	248	248	100.00
Zone8_R	471	444	94.27	235	234	99.57
Zone8_C	478	5	1.05	242	37	15.29
Zone9_R	489	485	99.18	248	248	100.00
Zone10_C	462	0	0.00	240	2	0.83
Zone11_R	302	302	100.00	155	155	100.00
Zone11_C	327	308	94.19	168	163	97.02
Zone11_T	292	280	95.89	152	144	94.74
Zone12_R	393	393	100.00	200	200	100.00
Zone12_C	121	6	4.96	62	8	12.90
Zone12_T	137	87	63.50	72	72	100.00
Zone12_S	136	136	100.00	68	68	100.00
Zone13_R	404	401	99.26	207	204	98.55
Zone13_I	313	0	0.00	137	0	0.00
Zone13_T	399	206	51.63	45	34	75.56
Zone13_S	473	103	21.78	245	245	100.00
Zone14_R	185	105	56.76	96	95	98.96
Zone14_C	437	119	27.23	216	86	39.81
Zone14_T	183	162	88.52	96	96	100.00
Zone14_S	489	449	91.82	248	248	100.00
Zone15_R	489	298	60.94	248	248	100.00
Zone15_T	80	80	100.00	40	40	100.00
Zone15_S	48	48	100.00	24	24	100.00

Table D.24 Exceedance of noise levels with respect to CPCB standards – June 2025⁸

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone1_R	208	208	100.00	104	104	100.00
Zone1_I	272	0	0.00	136	0	0.00
Zone1_T	480	12	2.50	240	72	30.00
Zone1_S	272	272	100.00	136	136	100.00
Zone2_R	208	208	100.00	104	100	96.15
Zone2_I	256	0	0.00	128	0	0.00
Zone2_T	208	194	93.27	104	80	76.92
Zone2_S	438	420	95.89	217	217	100.00
Zone3_R	478	478	100.00	231	231	100.00
Zone3_I	288	5	1.74	144	0	0.00
Zone3_T	480	480	100.00	240	240	100.00
Zone3_S	192	192	100.00	96	96	100.00
Zone4_R	480	470	97.92	240	240	100.00
Zone4_I	480	2	0.42	240	0	0.00
Zone4_T	480	479	99.79	240	239	99.58

⁸ Stations with 100% exceedance are highlighted in red

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone4_S	378	378	100.00	185	185	100.00
Zone5_R	480	468	97.50	240	240	100.00
Zone5_I	323	1	0.31	170	0	0.00
Zone5_T	304	303	99.67	152	152	100.00
Zone5_S	480	480	100.00	240	240	100.00
Zone6_R	416	416	100.00	208	208	100.00
Zone6_C	416	16	3.85	208	205	98.56
Zone6_T	182	5	2.75	92	51	55.43
Zone6_S	368	368	100.00	184	184	100.00
Zone7_R	478	478	100.00	240	240	100.00
Zone7_I	310	0	0.00	154	7	4.55
Zone7_T	320	2	0.63	160	103	64.38
Zone7_S	320	320	100.00	160	160	100.00
Zone8_R	472	457	96.82	234	234	100.00
Zone8_C	457	19	4.16	230	95	41.30
Zone8_T	320	317	99.06	160	160	100.00
Zone8_S	336	336	100.00	168	168	100.00
Zone9_R	480	475	98.96	240	240	100.00
Zone9_C	124	11	8.87	67	39	58.21
Zone9_T	448	426	95.09	224	223	99.55
Zone9_S	412	412	100.00	208	208	100.00
Zone10_R	176	176	100.00	88	88	100.00
Zone10_C	205	5	2.44	104	0	0.00
Zone10_T	217	211	97.24	104	104	100.00
Zone10_S	448	448	100.00	224	224	100.00
Zone11_R	466	466	100.00	237	237	100.00
Zone11_C	480	464	96.67	240	234	97.50
Zone11_T	480	480	100.00	240	240	100.00
Zone11_S	406	406	100.00	202	202	100.00
Zone12_R	480	480	100.00	240	240	100.00
Zone12_C	476	15	3.15	240	61	25.42
Zone12_T	480	238	49.58	240	240	100.00
Zone12_S	449	449	100.00	224	224	100.00
Zone13_R	452	445	98.45	214	214	100.00
Zone13_I	390	0	0.00	109	0	0.00
Zone13_T	364	232	63.74	16	9	56.25
Zone13_S	355	120	33.80	179	179	100.00
Zone14_R	478	265	55.44	240	240	100.00
Zone14_C	480	104	21.67	236	81	34.32
Zone14_T	480	349	72.71	240	240	100.00
Zone14_S	478	468	97.91	240	240	100.00
Zone15_R	480	355	73.96	240	240	100.00
Zone15_C	409	409	100.00	202	202	100.00
Zone15_T	480	480	100.00	240	240	100.00
Zone15_S	480	480	100.00	240	240	100.00

Table D.25 Exceedance of noise levels with respect to CPCB standards – July 2025⁹

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone1_R	494	493	99.80	248	248	100.00
Zone1_I	494	0	0.00	248	0	0.00
Zone1_T	396	40	10.10	194	81	41.75
Zone1_S	495	495	100.00	248	248	100.00
Zone2_R	494	494	100.00	248	240	96.77
Zone2_I	494	26	5.26	248	0	0.00
Zone2_T	473	457	96.62	240	169	70.42
Zone2_S	479	472	98.54	238	238	100.00
Zone3_R	490	490	100.00	236	236	100.00
Zone3_I	495	11	2.22	248	9	3.63
Zone3_T	495	495	100.00	248	248	100.00
Zone3_S	495	495	100.00	248	248	100.00
Zone4_R	492	484	98.37	248	248	100.00
Zone4_I	494	5	1.01	242	4	1.65
Zone4_T	495	490	98.99	248	246	99.19
Zone4_S	458	458	100.00	232	232	100.00
Zone5_R	493	481	97.57	248	248	100.00
Zone5_I	455	0	0.00	232	1	0.43
Zone5_T	492	489	99.39	242	242	100.00
Zone5_S	495	495	100.00	248	248	100.00
Zone6_R	480	480	100.00	240	240	100.00
Zone6_C	495	43	8.69	240	239	99.58
Zone6_T	483	11	2.28	237	146	61.60
Zone6_S	493	493	100.00	246	246	100.00
Zone7_R	493	493	100.00	243	243	100.00
Zone7_I	278	1	0.36	151	3	1.99
Zone7_T	483	5	1.04	240	139	57.92
Zone7_S	494	494	100.00	247	247	100.00
Zone8_R	455	446	98.02	224	224	100.00
Zone8_C	457	20	4.38	215	69	32.09
Zone8_T	456	449	98.46	232	232	100.00
Zone8_S	495	495	100.00	248	248	100.00
Zone9_R	495	494	99.80	248	248	100.00
Zone9_C	492	241	48.98	248	211	85.08
Zone9_T	495	465	93.94	248	248	100.00
Zone9_S	491	491	100.00	248	248	100.00
Zone10_R	495	489	98.79	248	246	99.19
Zone10_C	461	33	7.16	230	30	13.04
Zone10_T	492	492	100.00	248	242	97.58
Zone10_S	495	495	100.00	248	248	100.00
Zone11_R	495	495	100.00	248	248	100.00
Zone11_C	495	478	96.57	248	248	100.00
Zone11_T	495	495	100.00	248	248	100.00
Zone11_S	495	495	100.00	248	248	100.00
Zone12_R	495	495	100.00	248	245	98.79
Zone12_C	495	9	1.82	246	64	26.02
Zone12_T	493	237	48.07	248	248	100.00
Zone12_S	488	488	100.00	248	248	100.00

⁹ Stations with 100% exceedance are highlighted in red

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone13_R	441	433	98.19	196	196	100.00
Zone13_I	283	0	0.00	96	0	0.00
Zone13_T	325	219	67.38	11	10	90.91
Zone13_S	455	153	33.63	222	222	100.00
Zone14_R	495	262	52.93	248	248	100.00
Zone14_C	375	51	13.60	189	80	42.33
Zone14_T	495	356	71.92	248	248	100.00
Zone14_S	491	471	95.93	248	248	100.00
Zone15_R	494	359	72.67	248	248	100.00
Zone15_C	495	495	100.00	248	248	100.00
Zone15_T	493	493	100.00	248	248	100.00
Zone15_S	493	493	100.00	248	248	100.00

Table D.26 Exceedance of noise levels with respect to CPCB standards – August 2025¹⁰

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone1_R	472	471	99.79	232	232	100.00
Zone1_I	496	0	0.00	244	1	0.41
Zone1_T	496	25	5.04	248	87	35.08
Zone1_S	496	496	100.00	248	248	100.00
Zone2_R	496	480	96.77	248	237	95.56
Zone2_I	491	22	4.48	239	1	0.42
Zone2_T	356	322	90.45	176	125	71.02
Zone2_S	391	383	97.95	200	200	100.00
Zone3_R	495	495	100.00	248	248	100.00
Zone3_I	496	10	2.02	248	13	5.24
Zone3_T	496	496	100.00	248	246	99.19
Zone3_S	496	496	100.00	248	248	100.00
Zone4_R	496	493	99.40	248	248	100.00
Zone4_I	482	0	0.00	230	1	0.43
Zone4_T	496	488	98.39	246	245	99.59
Zone4_S	496	496	100.00	248	248	100.00
Zone5_R	496	474	95.56	248	248	100.00
Zone5_I	494	0	0.00	248	0	0.00
Zone5_T	496	492	99.19	248	248	100.00
Zone5_S	493	493	100.00	248	248	100.00
Zone6_R	495	495	100.00	248	248	100.00
Zone6_C	496	40	8.06	248	230	92.74
Zone6_T	475	9	1.89	238	124	52.10
Zone6_S	494	494	100.00	248	248	100.00
Zone7_R	454	454	100.00	222	222	100.00
Zone7_I	198	1	0.51	90	2	2.22
Zone7_T	495	8	1.62	248	162	65.32
Zone7_S	495	495	100.00	247	247	100.00
Zone8_R	459	439	95.64	226	220	97.35
Zone8_C	485	11	2.27	232	58	25.00
Zone8_T	496	493	99.40	248	248	100.00

¹⁰ Stations with 100% exceedance are highlighted in red

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone8_S	496	496	100.00	248	248	100.00
Zone9_R	496	495	99.80	248	248	100.00
Zone9_C	495	224	45.25	248	221	89.11
Zone9_T	496	464	93.55	248	247	99.60
Zone9_S	496	496	100.00	248	248	100.00
Zone10_R	493	485	98.38	248	247	99.60
Zone10_C	388	8	2.06	186	5	2.69
Zone10_T	496	490	98.79	248	244	98.39
Zone10_S	496	496	100.00	248	248	100.00
Zone11_R	496	496	100.00	248	248	100.00
Zone11_C	496	473	95.36	248	247	99.60
Zone11_T	496	496	100.00	248	248	100.00
Zone11_S	496	496	100.00	248	248	100.00
Zone12_R	493	479	97.16	248	245	98.79
Zone12_C	494	39	7.89	248	84	33.87
Zone12_T	496	241	48.59	248	248	100.00
Zone12_S	409	409	100.00	214	214	100.00
Zone13_R	442	428	96.83	226	225	99.56
Zone13_I	182	0	0.00	83	2	2.41
Zone13_T	305	188	61.64	1	1	100.00
Zone13_S	420	82	19.52	208	208	100.00
Zone14_R	496	223	44.96	248	248	100.00
Zone14_C	419	38	9.07	214	47	21.96
Zone14_T	494	371	75.10	248	248	100.00
Zone14_S	496	441	88.91	248	248	100.00
Zone15_R	496	329	66.33	248	248	100.00
Zone15_C	496	495	99.80	248	248	100.00
Zone15_T	472	466	98.73	237	237	100.00
Zone15_S	496	496	100.00	248	248	100.00

Table D.27 Exceedance of noise levels with respect to CPCB standards – September 2025¹¹

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone1_R	480	476	99.17	240	240	100.00
Zone1_I	479	0	0.00	237	1	0.42
Zone1_T	480	10	2.08	240	58	24.17
Zone1_S	478	478	100.00	240	240	100.00
Zone2_R	480	406	84.58	240	223	92.92
Zone2_I	475	10	2.11	238	6	2.52
Zone2_T	480	200	41.67	240	124	51.67
Zone2_S	318	309	97.17	160	160	100.00
Zone3_R	480	480	100.00	239	239	100.00
Zone3_I	480	8	1.67	240	18	7.50
Zone3_T	480	478	99.58	240	236	98.33
Zone3_S	479	479	100.00	240	240	100.00
Zone4_R	480	477	99.38	240	240	100.00
Zone4_I	282	14	4.96	138	7	5.07

¹¹ Stations with 100% exceedance are highlighted in red

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone4_T	480	470	97.92	240	234	97.50
Zone4_S	480	480	100.00	240	240	100.00
Zone5_R	478	450	94.14	240	239	99.58
Zone5_I	480	0	0.00	240	1	0.42
Zone5_T	480	467	97.29	240	240	100.00
Zone5_S	480	480	100.00	240	240	100.00
Zone6_R	480	480	100.00	240	240	100.00
Zone6_C	478	21	4.39	240	203	84.58
Zone6_T	323	3	0.93	160	67	41.88
Zone6_S	478	478	100.00	240	240	100.00
Zone7_R	478	478	100.00	240	240	100.00
Zone7_I	354	4	1.13	167	120	71.86
Zone7_T	480	3	0.63	240	101	42.08
Zone7_S	452	452	100.00	218	218	100.00
Zone8_R	480	455	94.79	240	238	99.17
Zone8_C	477	32	6.71	240	63	26.25
Zone8_T	480	477	99.38	240	240	100.00
Zone8_S	480	480	100.00	240	240	100.00
Zone9_R	343	343	100.00	176	176	100.00
Zone9_C	478	206	43.10	240	219	91.25
Zone9_T	480	455	94.79	240	239	99.58
Zone9_S	480	480	100.00	240	240	100.00
Zone10_R	480	471	98.13	240	239	99.58
Zone10_C	480	2	0.42	240	3	1.25
Zone10_T	480	479	99.79	240	240	100.00
Zone10_S	480	480	100.00	240	240	100.00
Zone11_R	480	480	100.00	240	240	100.00
Zone11_C	480	475	98.96	240	239	99.58
Zone11_T	403	403	100.00	206	206	100.00
Zone11_S	480	480	100.00	240	240	100.00
Zone12_R	480	480	100.00	240	240	100.00
Zone12_C	477	8	1.68	239	42	17.57
Zone12_T	480	256	53.33	240	239	99.58
Zone12_S	442	353	79.86	220	220	100.00
Zone13_R	445	444	99.78	212	204	96.23
Zone13_I	338	0	0.00	153	1	0.65
Zone13_T	251	147	58.57	-	-	-
Zone13_S	286	86	30.07	142	142	100.00
Zone14_R	480	255	53.13	240	238	99.17
Zone14_C	480	138	28.75	240	83	34.58
Zone14_T	480	279	58.13	240	240	100.00
Zone14_S	478	437	91.42	240	240	100.00
Zone15_R	480	384	80.00	240	240	100.00
Zone15_C	480	478	99.58	240	240	100.00
Zone15_T	480	477	99.38	240	240	100.00
Zone15_S	480	480	100.00	240	240	100.00

Table D.28 Exceedance of noise levels with respect to CPCB standards – October 2025¹²

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone1_R	496	490	98.79	248	246	99.19
Zone1_I	400	2	0.50	199	3	1.51
Zone1_T	471	13	2.76	242	36	14.88
Zone1_S	496	496	100.00	248	248	100.00
Zone2_R	496	404	81.45	248	214	86.29
Zone2_I	496	46	9.27	248	8	3.23
Zone2_T	493	209	42.39	248	140	56.45
Zone2_S	268	235	87.69	136	136	100.00
Zone3_R	496	496	100.00	248	248	100.00
Zone3_I	467	16	3.43	232	21	9.05
Zone3_T	496	494	99.60	248	242	97.58
Zone3_S	496	496	100.00	248	248	100.00
Zone4_R	496	472	95.16	248	235	94.76
Zone4_I	26	0	0.00	20	1	5.00
Zone4_T	467	460	98.50	232	223	96.12
Zone4_S	496	496	100.00	248	248	100.00
Zone5_R	496	462	93.15	248	238	95.97
Zone5_I	496	4	0.81	248	1	0.40
Zone5_T	496	447	90.12	248	248	100.00
Zone5_S	493	493	100.00	246	246	100.00
Zone6_R	496	496	100.00	248	248	100.00
Zone6_C	496	36	7.26	248	129	52.02
Zone6_T	491	31	6.31	244	90	36.89
Zone6_S	496	493	99.40	246	246	100.00
Zone7_R	408	408	100.00	216	216	100.00
Zone7_I	486	4	0.82	246	131	53.25
Zone7_T	496	29	5.85	248	93	37.50
Zone7_S	401	401	100.00	200	200	100.00
Zone8_R	494	459	92.91	248	242	97.58
Zone8_C	490	33	6.73	246	45	18.29
Zone8_T	496	489	98.59	248	247	99.60
Zone8_S	496	496	100.00	248	248	100.00
Zone9_R	496	494	99.60	248	246	99.19
Zone9_C	448	189	42.19	230	171	74.35
Zone9_T	496	454	91.53	248	242	97.58
Zone9_S	494	494	100.00	246	246	100.00
Zone10_R	493	487	98.78	246	240	97.56
Zone10_C	496	9	1.81	248	10	4.03
Zone10_T	495	488	98.59	248	248	100.00
Zone10_S	496	496	100.00	248	248	100.00
Zone11_R	496	496	100.00	248	248	100.00
Zone11_C	491	474	96.54	246	239	97.15
Zone11_T	291	77	26.46	150	150	100.00
Zone11_S	496	496	100.00	248	248	100.00
Zone12_R	493	485	98.38	246	246	100.00
Zone12_C	496	24	4.84	248	40	16.13

¹² Stations with 100% exceedance are highlighted in red

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone12_T	496	212	42.74	248	240	96.77
Zone12_S	494	494	100.00	248	248	100.00
Zone13_R	392	293	74.74	206	206	100.00
Zone13_I	412	0	0.00	187	1	0.53
Zone13_T	188	111	59.04	-	-	-
Zone13_S	352	141	40.06	174	174	100.00
Zone14_R	496	282	56.85	248	241	97.18
Zone14_C	489	148	30.27	244	105	43.03
Zone14_T	496	321	64.72	248	247	99.60
Zone14_S	494	425	86.03	246	246	100.00
Zone15_R	496	408	82.26	248	248	100.00
Zone15_C	496	469	94.56	248	248	100.00
Zone15_T	496	468	94.35	248	248	100.00
Zone15_S	496	496	100.00	248	248	100.00

Table D.29 Exceedance of noise levels with respect to CPCB standards – November 2025¹³

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone1_R	480	479	99.79	240	240	100.00
Zone1_I	480	0	0.00	240	0	0.00
Zone1_T	434	7	1.61	218	14	6.42
Zone1_S	480	480	100.00	240	240	100.00
Zone2_R	480	363	75.63	240	219	91.25
Zone2_I	478	0	0.00	240	0	0.00
Zone2_T	480	165	34.38	240	117	48.75
Zone2_S	393	375	95.42	198	198	100.00
Zone3_R	479	479	100.00	240	239	99.58
Zone3_I	480	11	2.29	240	5	2.08
Zone3_T	480	478	99.58	240	239	99.58
Zone3_S	480	480	100.00	240	240	100.00
Zone4_R	473	465	98.31	235	233	99.15
Zone4_I	22	2	9.09	8	0	0.00
Zone4_T	480	479	99.79	238	237	99.58
Zone4_S	426	426	100.00	216	216	100.00
Zone5_R	480	446	92.92	240	237	98.75
Zone5_I	478	0	0.00	240	0	0.00
Zone5_T	478	452	94.56	240	240	100.00
Zone5_S	480	480	100.00	240	240	100.00
Zone6_R	479	479	100.00	239	239	100.00
Zone6_C	480	8	1.67	240	58	24.17
Zone6_T	468	18	3.85	238	110	46.22
Zone6_S	480	473	98.54	240	240	100.00
Zone7_R	459	459	100.00	238	238	100.00
Zone7_I	374	0	0.00	190	3	1.58
Zone7_T	480	6	1.25	240	50	20.83
Zone7_S	463	463	100.00	230	230	100.00
Zone8_R	475	453	95.37	239	227	94.98

¹³ Stations with 100% exceedance are highlighted in red

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone8_C	293	66	22.53	137	8	5.84
Zone8_T	480	474	98.75	240	239	99.58
Zone8_S	408	408	100.00	208	208	100.00
Zone9_R	480	472	98.33	240	240	100.00
Zone9_C	463	183	39.52	233	158	67.81
Zone9_T	478	457	95.61	240	238	99.17
Zone9_S	448	448	100.00	227	227	100.00
Zone10_R	480	480	100.00	240	239	99.58
Zone10_C	480	4	0.83	240	0	0.00
Zone10_T	474	473	99.79	239	239	100.00
Zone10_S	385	385	100.00	198	198	100.00
Zone11_R	480	480	100.00	240	240	100.00
Zone11_C	255	249	97.65	122	122	100.00
Zone11_T	480	259	53.96	240	181	75.42
Zone11_S	480	480	100.00	240	240	100.00
Zone12_R	480	480	100.00	240	240	100.00
Zone12_C	297	0	0.00	155	15	9.68
Zone12_T	444	182	40.99	224	222	99.11
Zone12_S	427	427	100.00	214	214	100.00
Zone13_R	477	461	96.65	220	218	99.09
Zone13_I	17	0	0.00	2	0	0.00
Zone13_T	145	96	66.21	-	-	-
Zone13_S	380	119	31.32	187	187	100.00
Zone14_R	480	302	62.92	240	239	99.58
Zone14_C	478	4	0.84	238	9	3.78
Zone14_T	462	335	72.51	230	230	100.00
Zone14_S	296	274	92.57	146	146	100.00
Zone15_R	480	409	85.21	240	240	100.00
Zone15_C	480	479	99.79	240	240	100.00
Zone15_T	403	331	82.13	204	204	100.00
Zone15_S	480	480	100.00	240	240	100.00

Table D.30 Exceedance of noise levels with respect to CPCB standards – December 2025¹⁴

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone1_R	281	280	99.64	142	142	100.00
Zone1_I	232	2	0.86	118	0	0.00
Zone1_T	244	9	3.69	126	15	11.90
Zone1_S	240	240	100.00	123	123	100.00
Zone2_R	245	203	82.86	126	118	93.65
Zone2_I	246	2	0.81	126	1	0.79
Zone2_T	240	176	73.33	120	68	56.67
Zone2_S	240	234	97.50	122	122	100.00
Zone3_R	240	240	100.00	126	126	100.00
Zone3_I	245	10	4.08	126	5	3.97
Zone3_T	240	238	99.17	119	111	93.28
Zone3_S	234	234	100.00	118	118	100.00

¹⁴ Stations with 100% exceedance are highlighted in red

Station ID	Day time			Night time		
	No. of observations	No. of exceedance	% exceedance	No. of observations	No. of exceedance	% exceedance
Zone4_R	238	211	88.66	118	101	85.59
Zone4_I	19	0	0.00	15	2	13.33
Zone4_T	256	253	98.83	130	126	96.92
Zone4_S	206	206	100.00	107	107	100.00
Zone5_R	240	224	93.33	123	122	99.19
Zone5_I	240	0	0.00	122	0	0.00
Zone5_T	240	227	94.58	118	118	100.00
Zone5_S	281	281	100.00	142	142	100.00
Zone6_R	226	226	100.00	118	118	100.00
Zone6_C	240	8	3.33	121	42	34.71
Zone6_T	230	13	5.65	123	50	40.65
Zone6_S	48	48	100.00	22	22	100.00
Zone7_R	9	9	100.00	3	3	100.00
Zone7_I	163	7	4.29	80	1	1.25
Zone7_T	245	10	4.08	126	38	30.16
Zone7_S	278	278	100.00	143	143	100.00
Zone8_R	155	150	96.77	72	61	84.72
Zone8_C	80	10	12.50	24	0	0.00
Zone8_T	247	238	96.36	126	125	99.21
Zone8_S	272	272	100.00	141	141	100.00
Zone9_R	240	238	99.17	126	123	97.62
Zone9_C	236	84	35.59	119	58	48.74
Zone9_T	277	267	96.39	137	135	98.54
Zone9_S	7	7	100.00	-	-	-
Zone10_R	239	239	100.00	118	118	100.00
Zone10_C	240	0	0.00	125	1	0.80
Zone10_T	235	234	99.57	118	117	99.15
Zone11_R	139	139	100.00	70	70	100.00
Zone11_C	272	266	97.79	139	139	100.00
Zone11_T	242	118	48.76	126	99	78.57
Zone11_S	240	240	100.00	123	123	100.00
Zone12_R	283	283	100.00	142	142	100.00
Zone12_T	289	110	38.06	150	138	92.00
Zone12_S	219	219	100.00	118	118	100.00
Zone13_R	83	78	93.98	37	35	94.59
Zone13_I	81	0	0.00	10	0	0.00
Zone13_T	42	24	57.14	-	-	-
Zone13_S	234	10	4.27	103	103	100.00
Zone14_R	252	154	61.11	129	126	97.67
Zone14_C	239	17	7.11	117	14	11.97
Zone14_T	245	193	78.78	126	126	100.00
Zone14_S	245	218	88.98	126	126	100.00
Zone15_R	240	61	25.42	118	118	100.00
Zone15_C	245	245	100.00	126	126	100.00
Zone15_S	272	272	100.00	141	141	100.00

APPENDIX E. MONTH-WISE NOISE MAPS

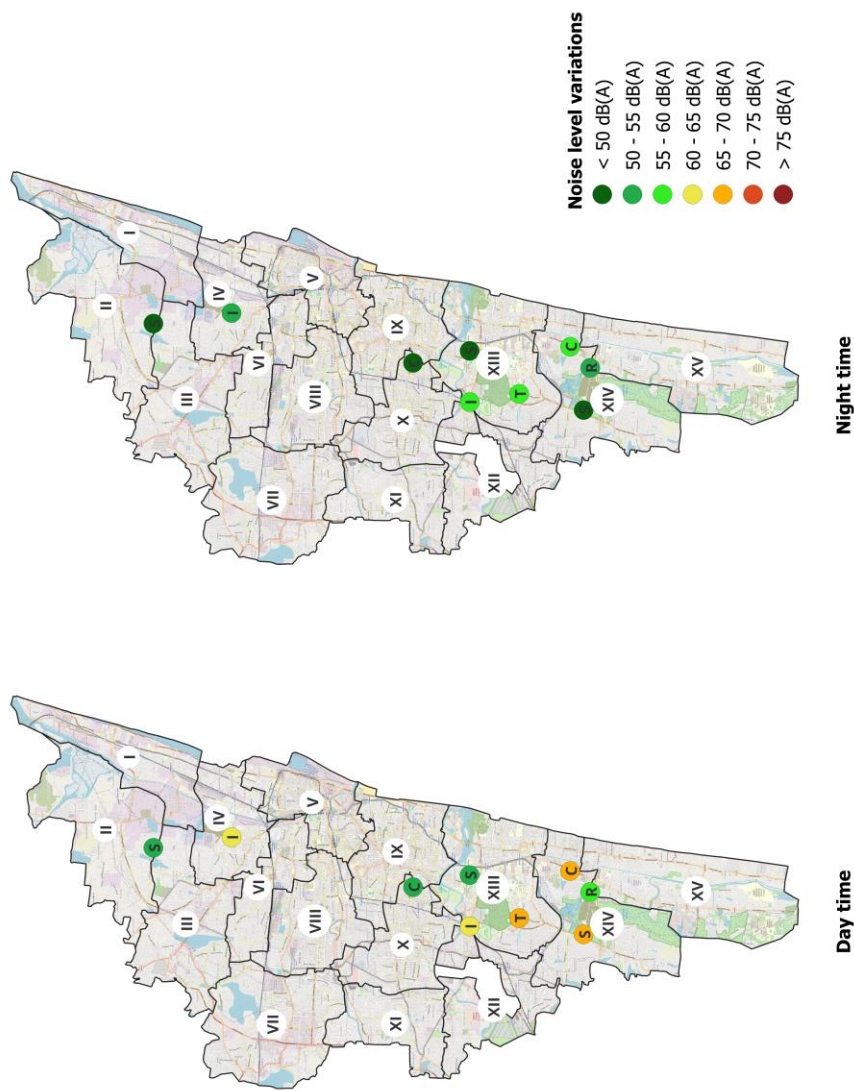


Figure E.1 Spatial noise maps for day and night time – March 2025

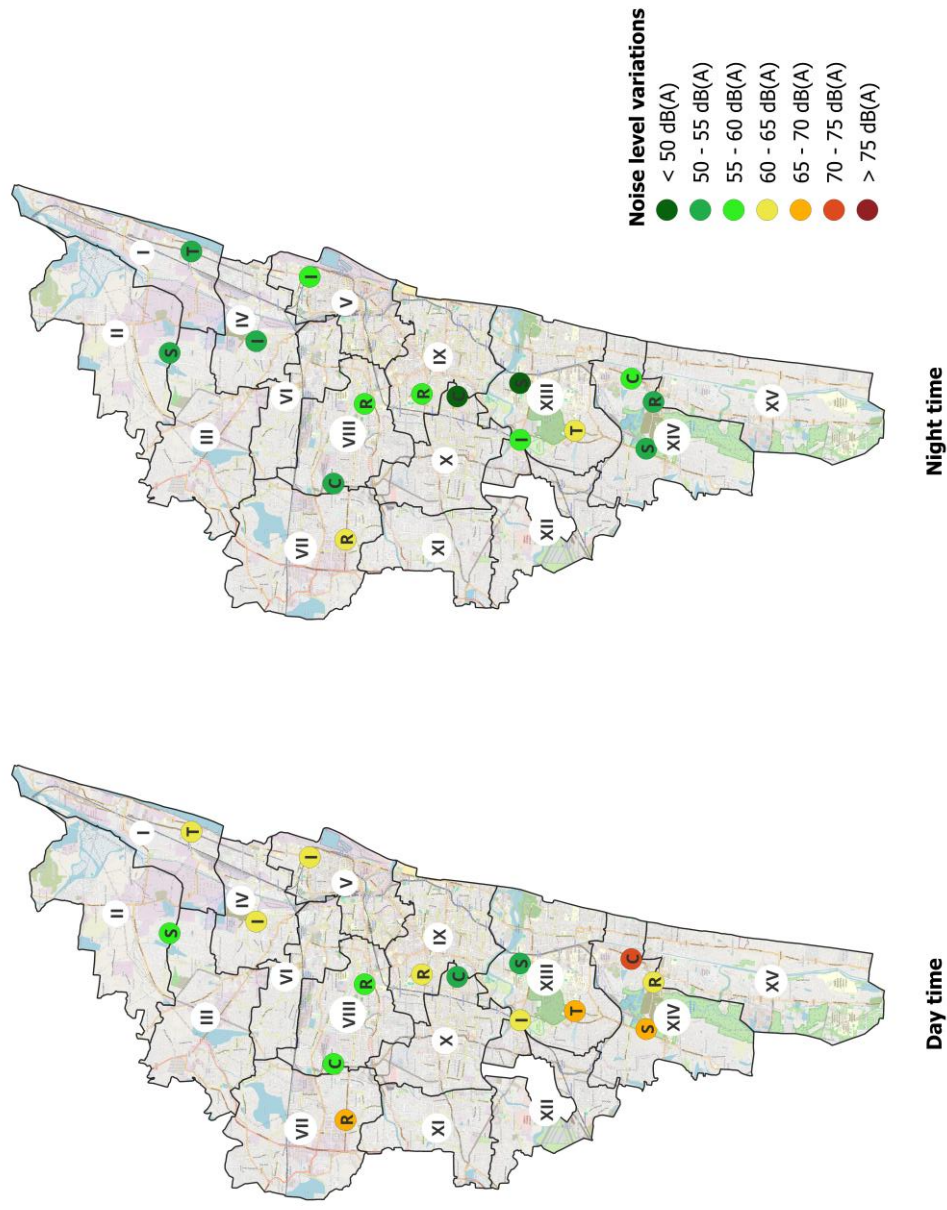


Figure E.2 Spatial noise maps for day and night time – April 2025

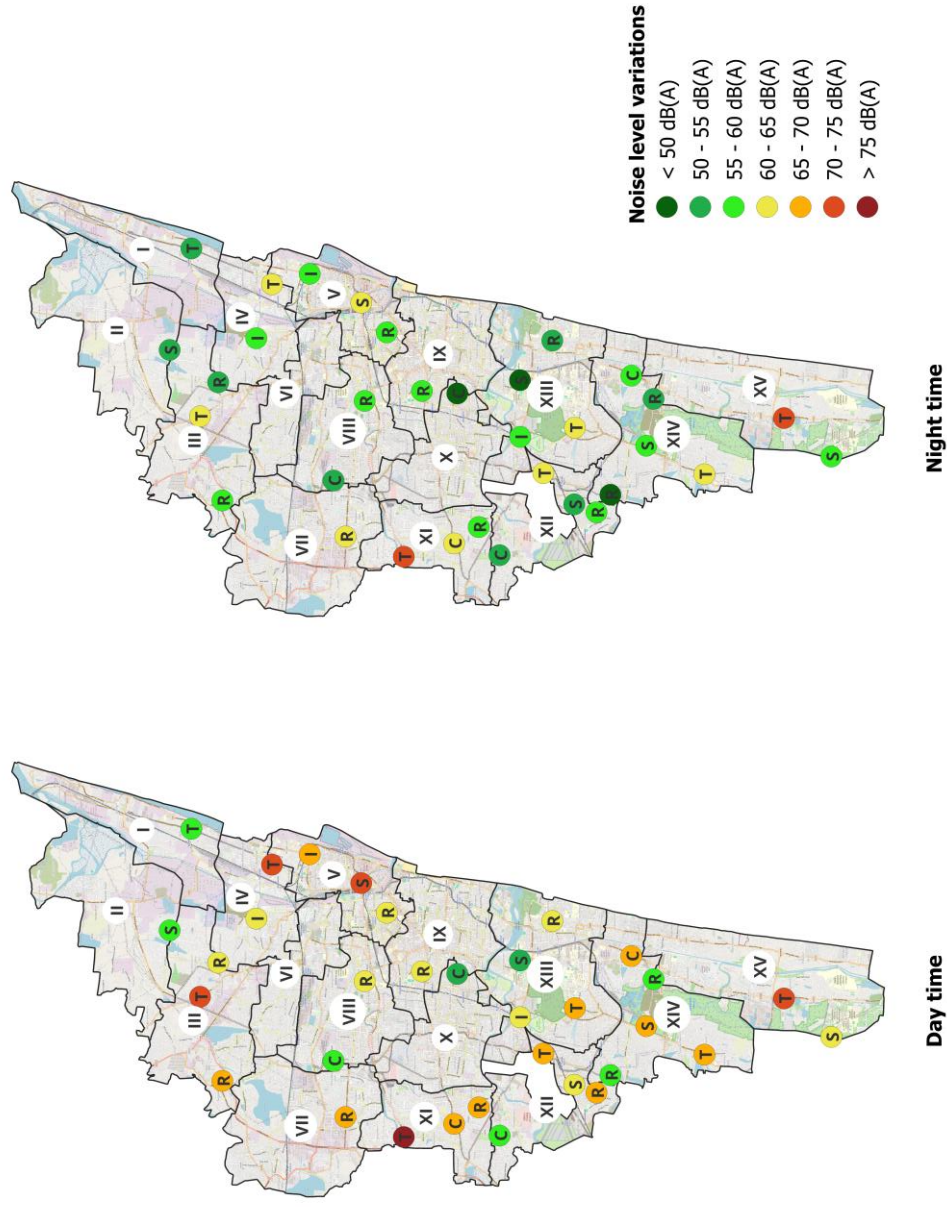


Figure E.3 Spatial noise maps for day and night time – May 2025

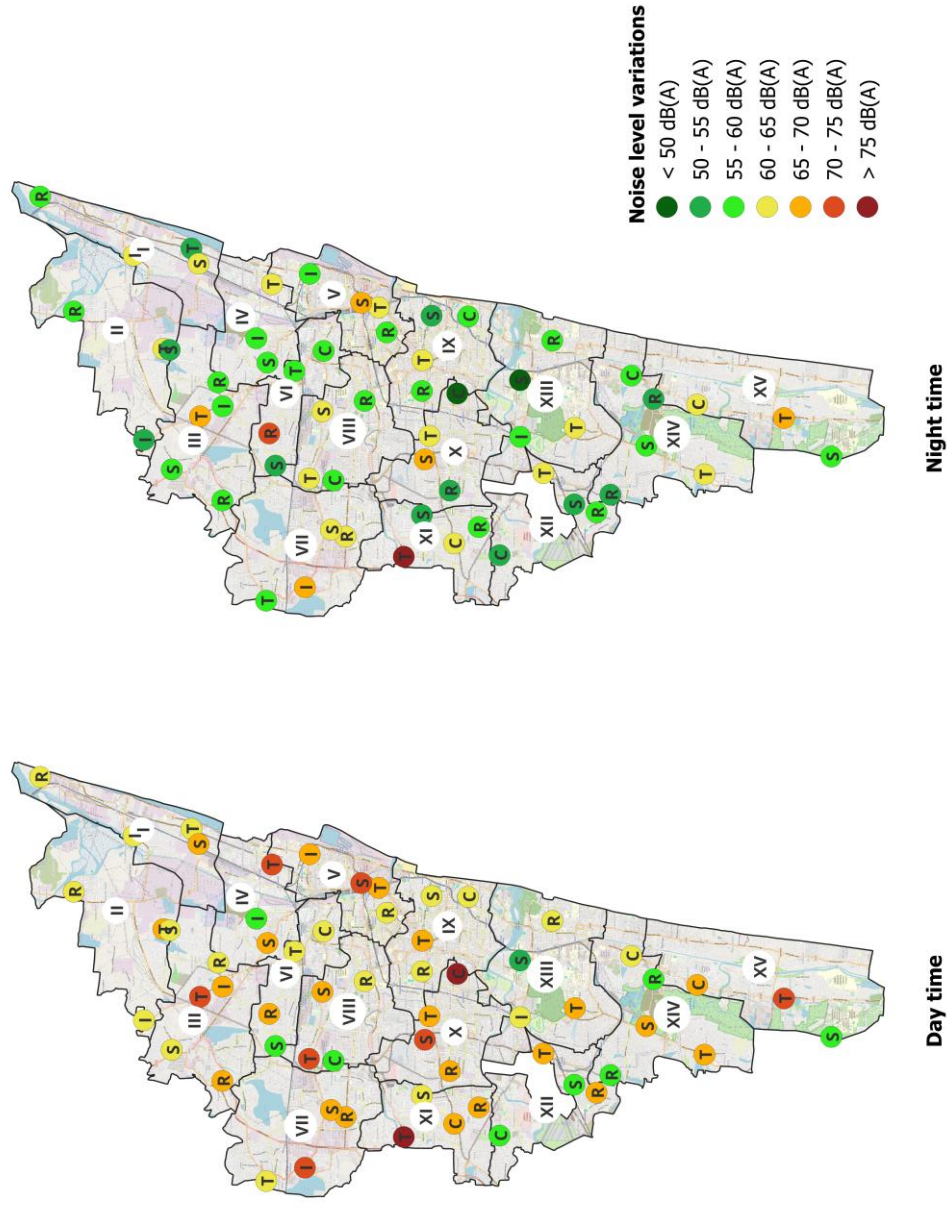


Figure E.4 Spatial noise maps for day and night time – June 2025

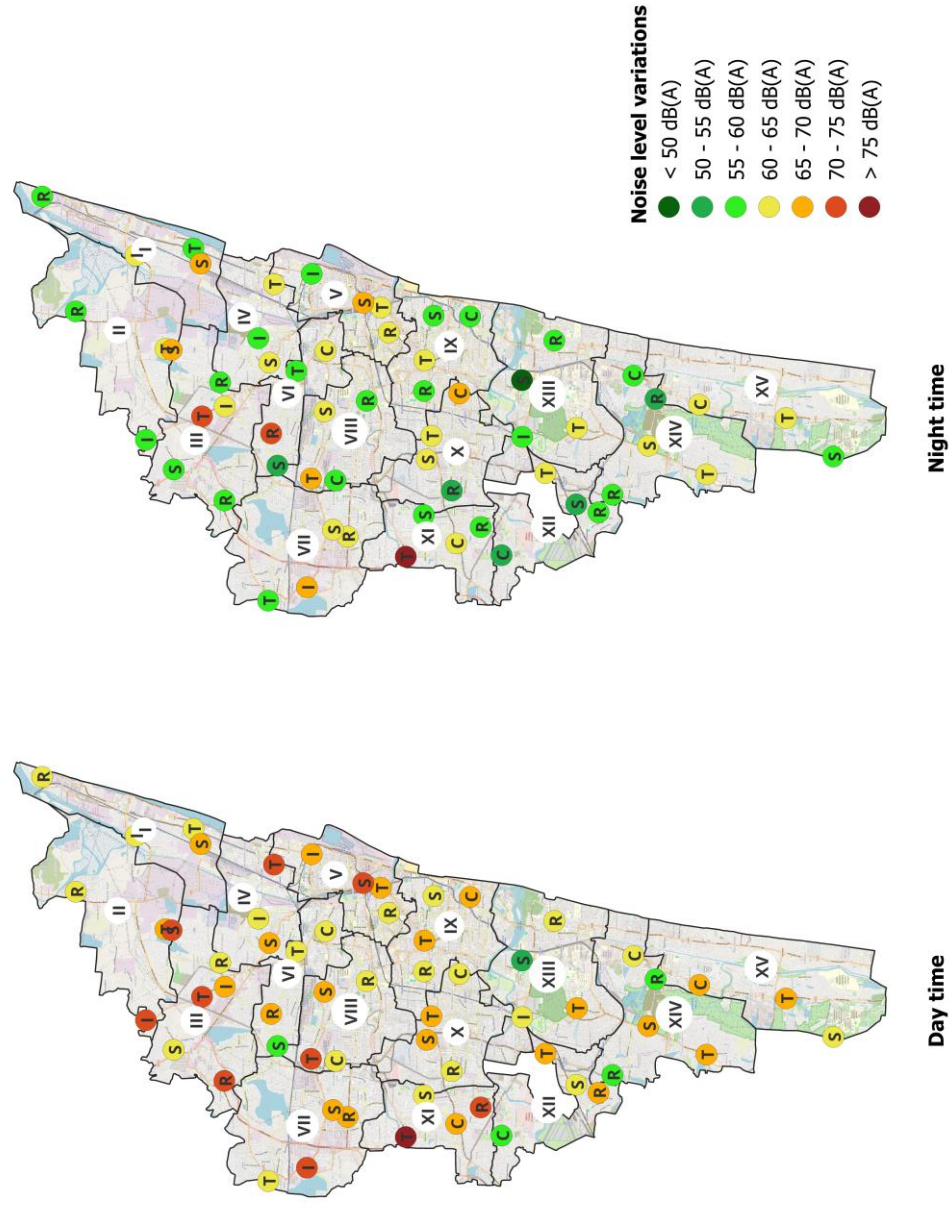


Figure E.5 Spatial noise maps for day and night time – July 2025

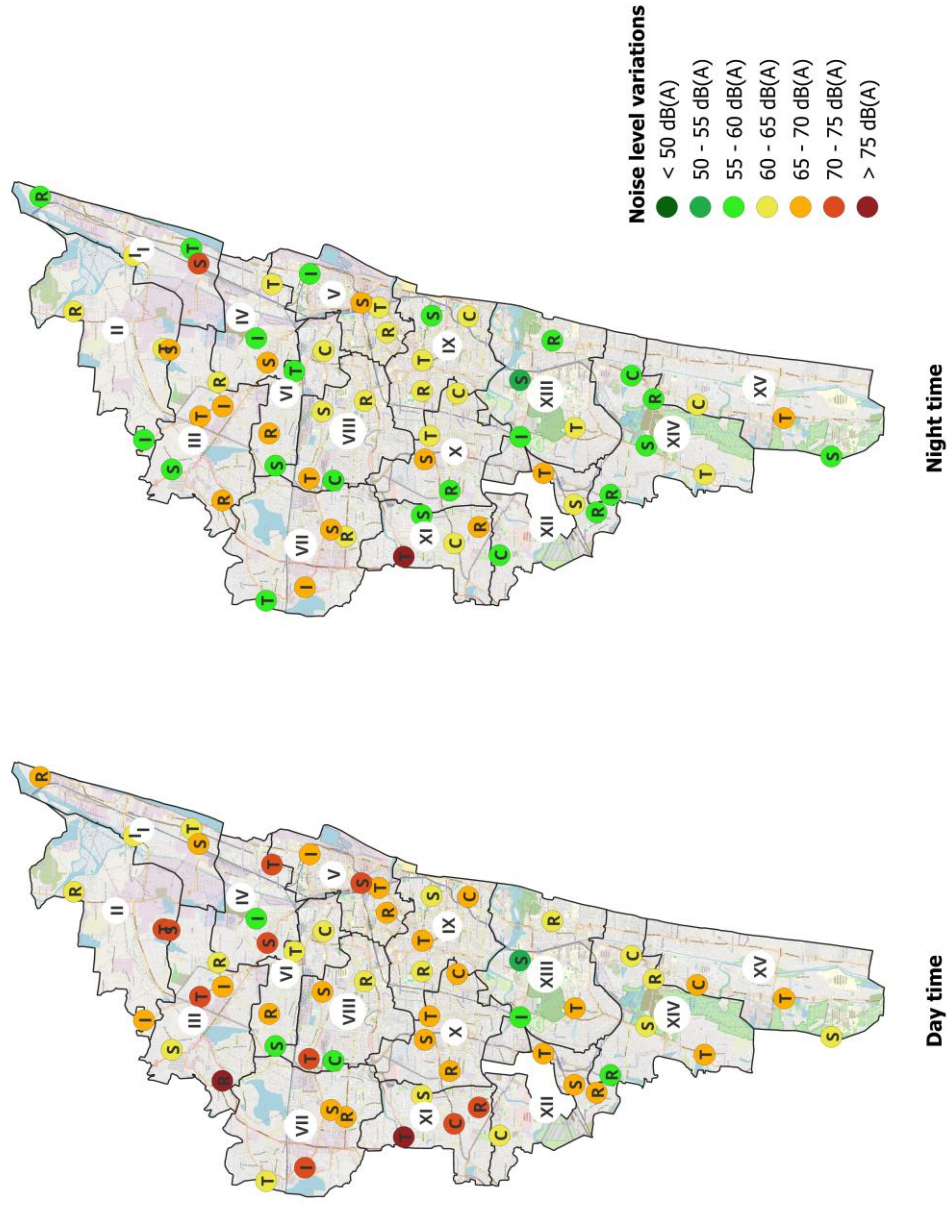


Figure E.6 Spatial noise maps for day and night time – August 2025

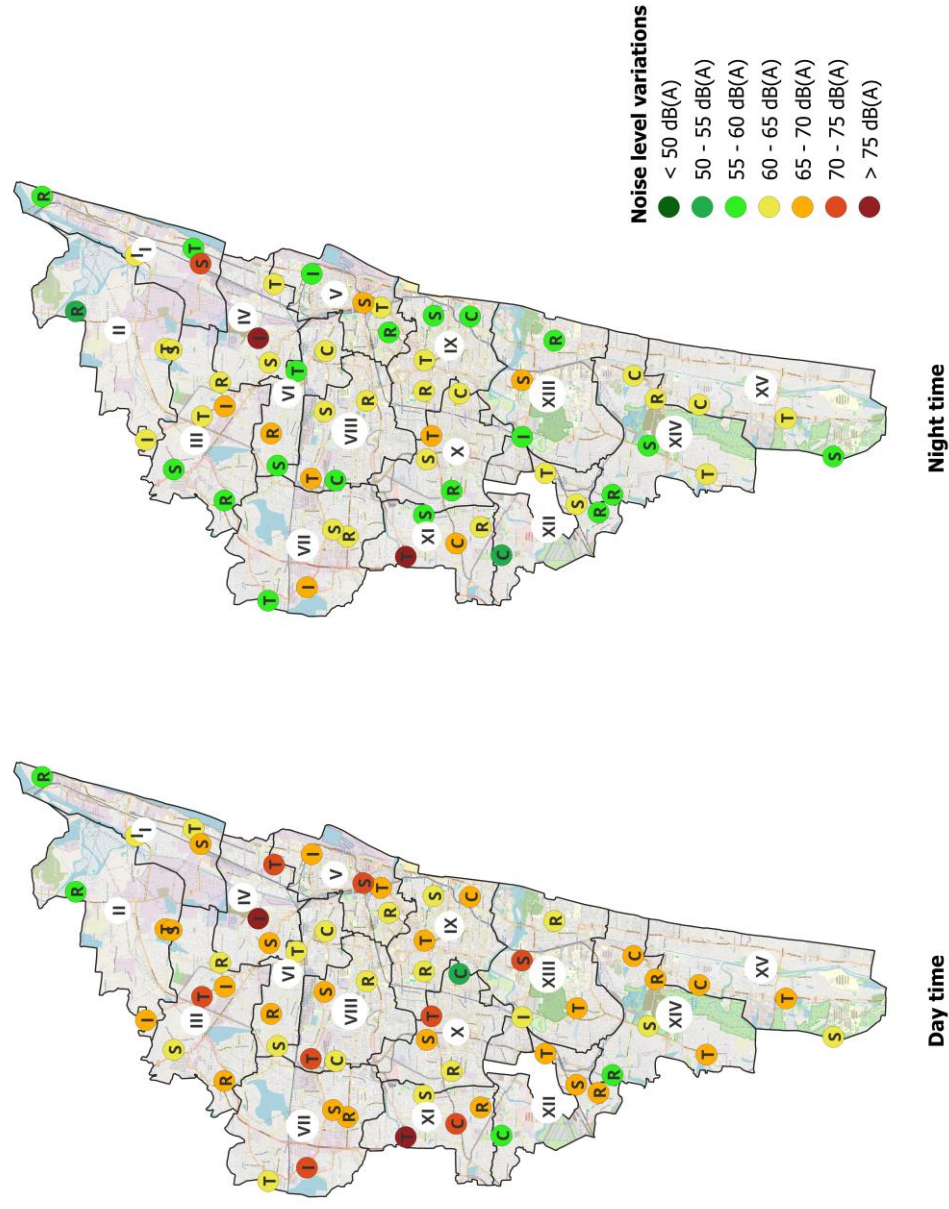
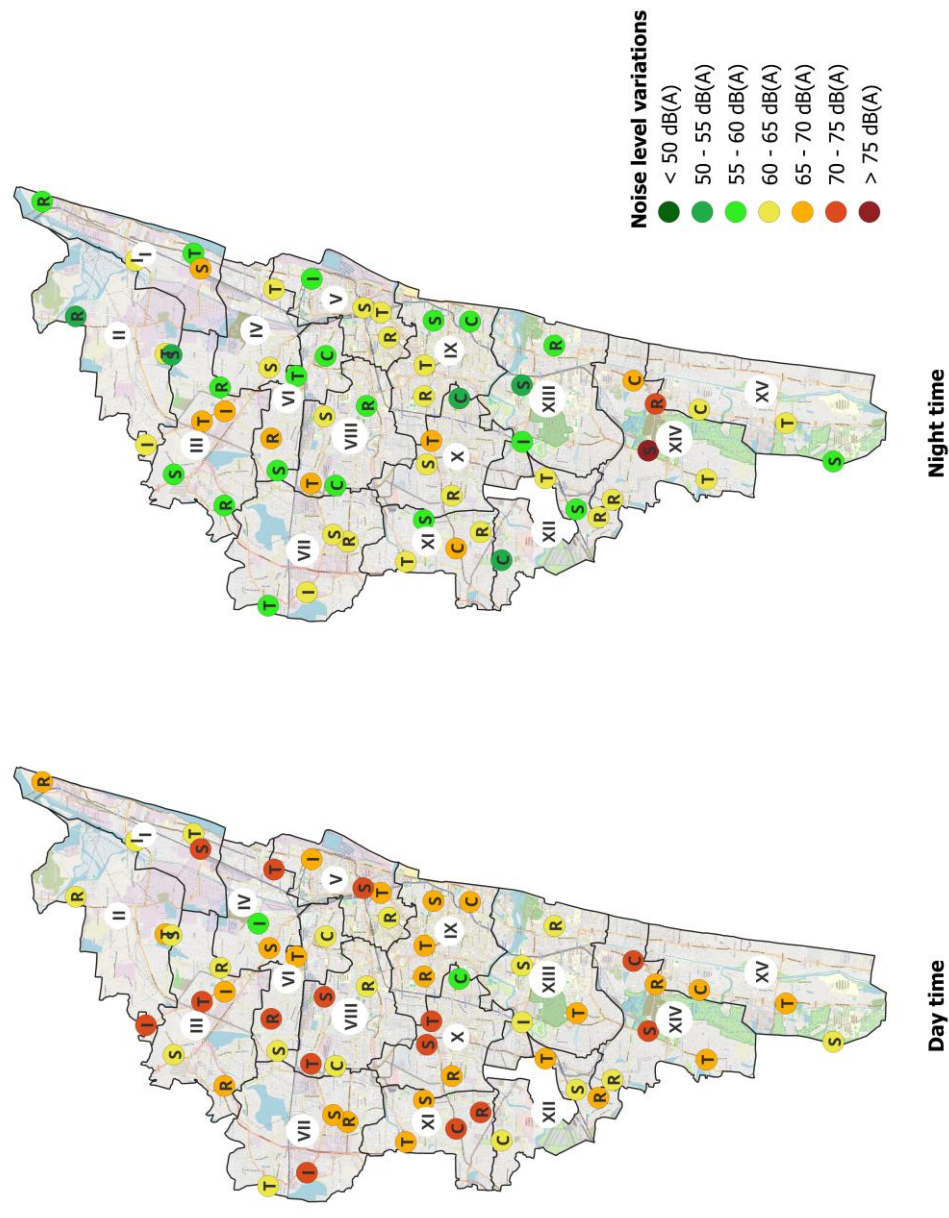


Figure E.7 Spatial noise maps for day and night time – September 2025



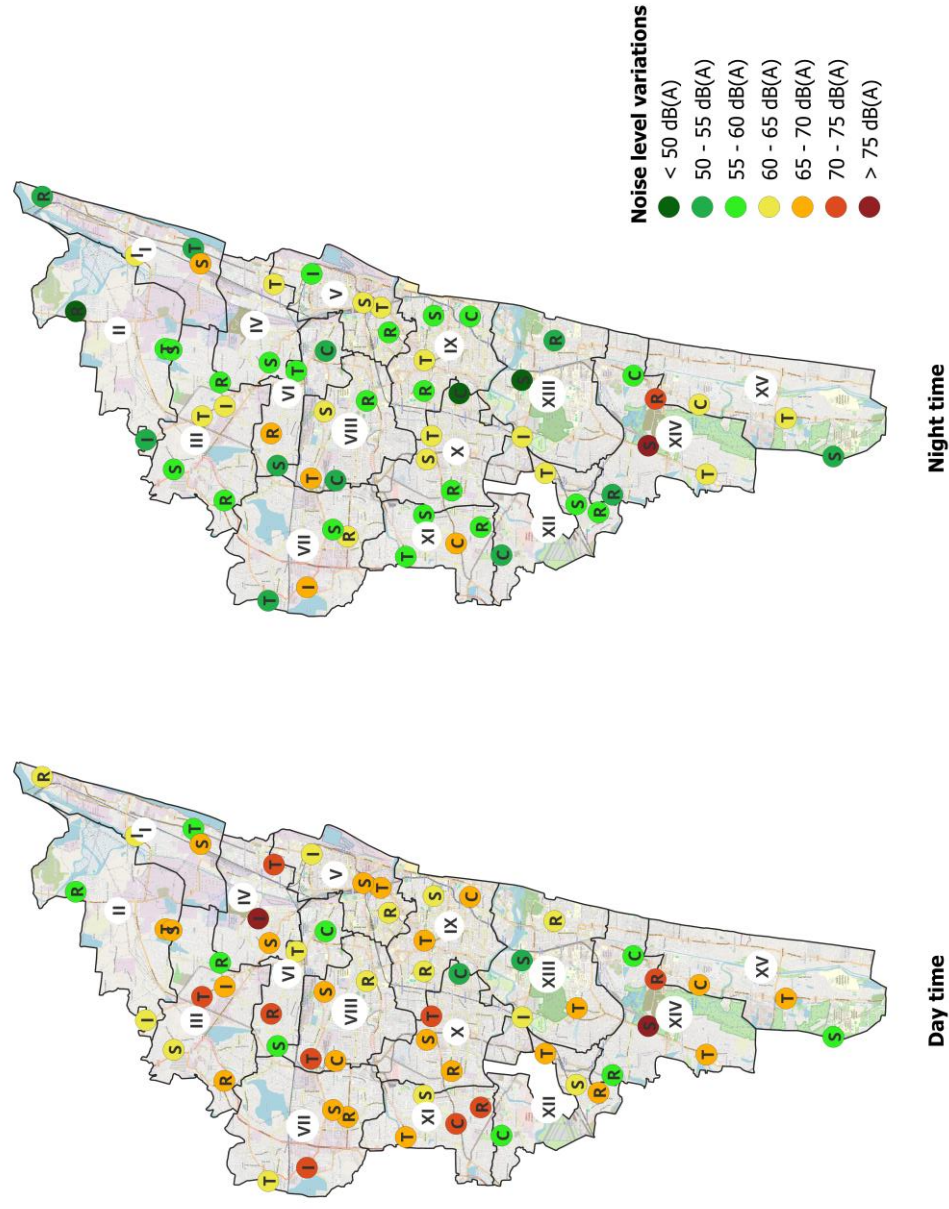


Figure E.9 Spatial noise maps for day and night time – November 2025

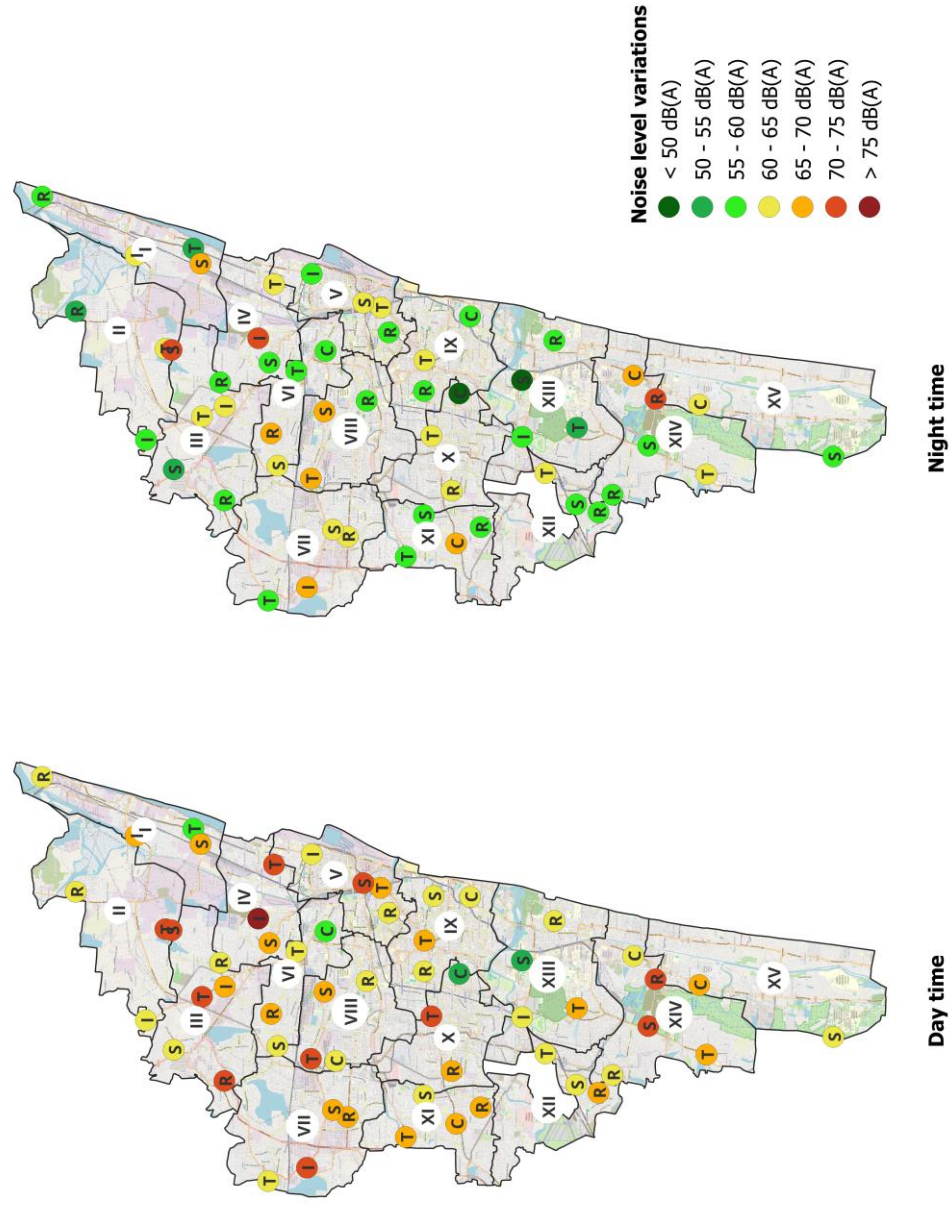


Figure E.10 Spatial noise maps for day and night time – December 2025

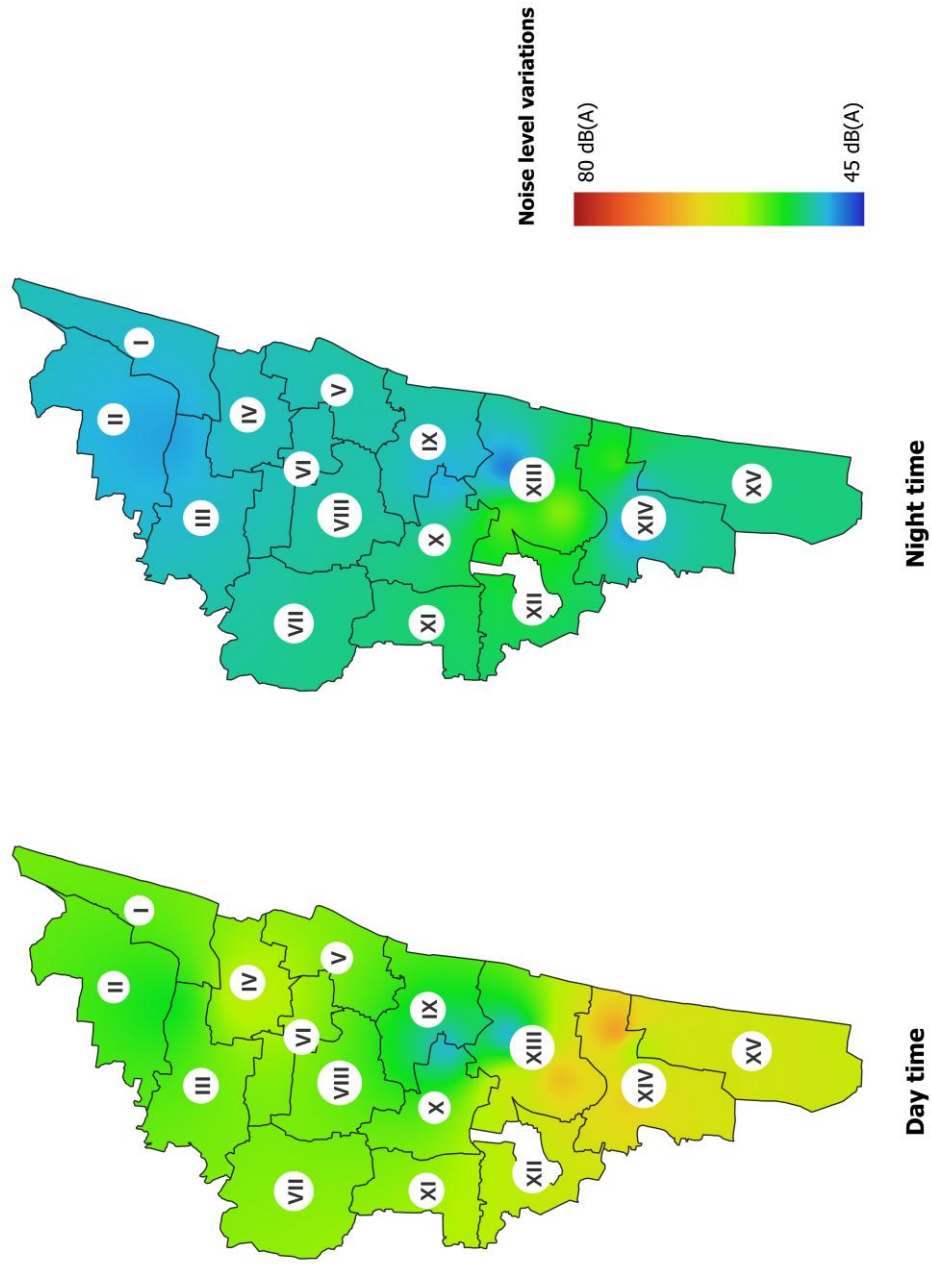


Figure E.11 Strategic noise maps for day and night time – March 2025

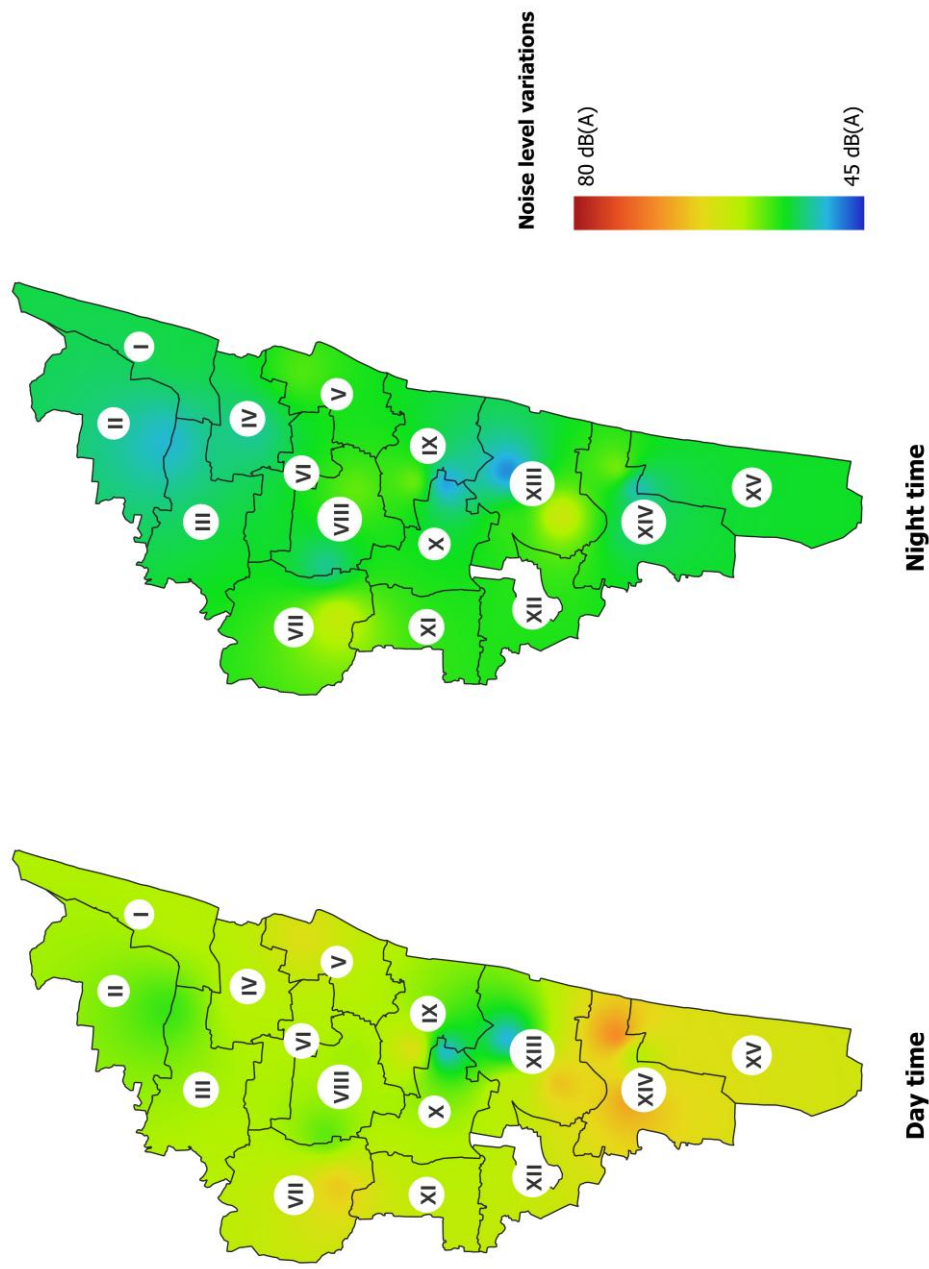


Figure E.12 Strategic noise maps for day and night time – April 2025

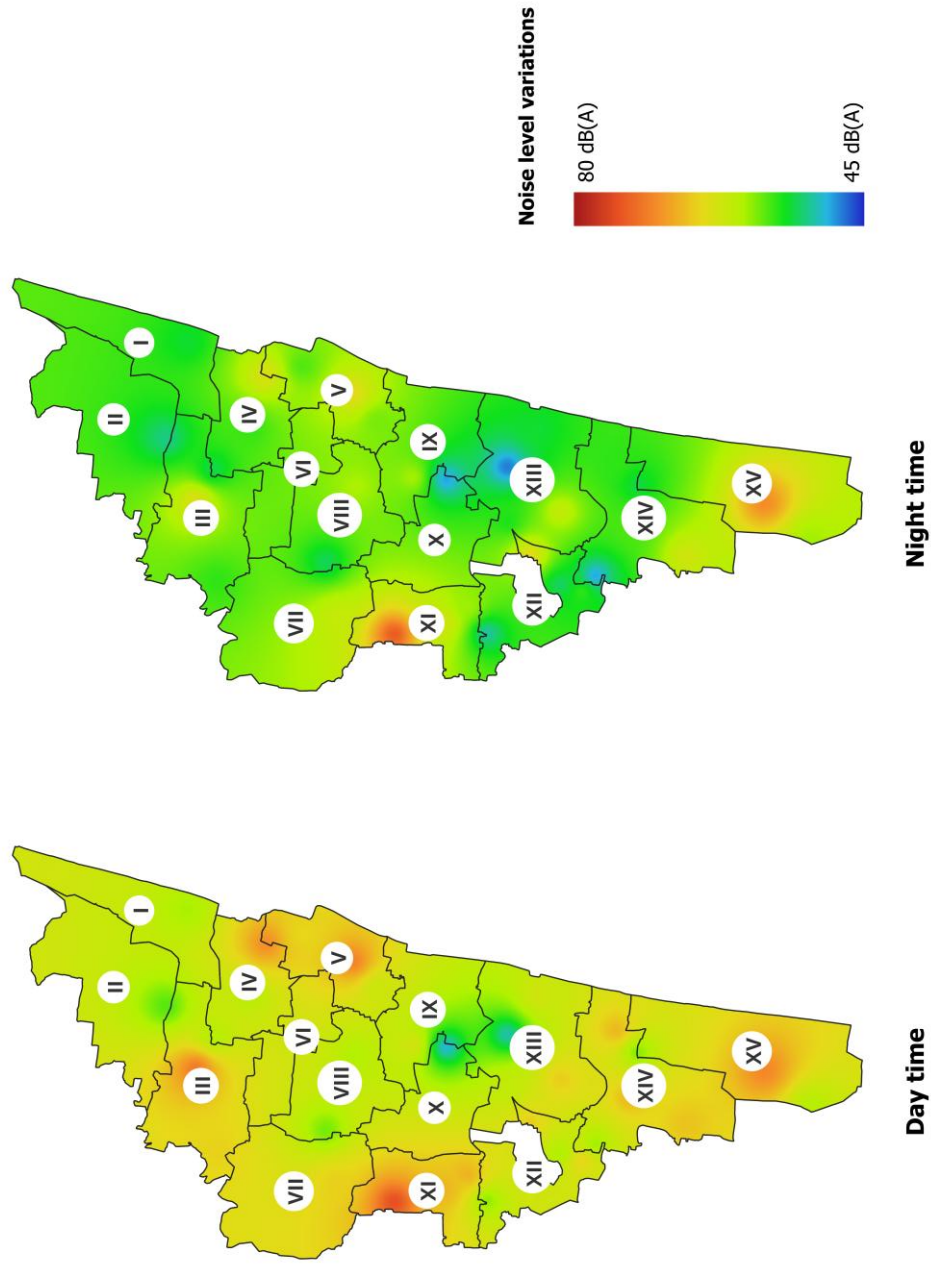


Figure E.13 Strategic noise maps for day and night time – May 2025

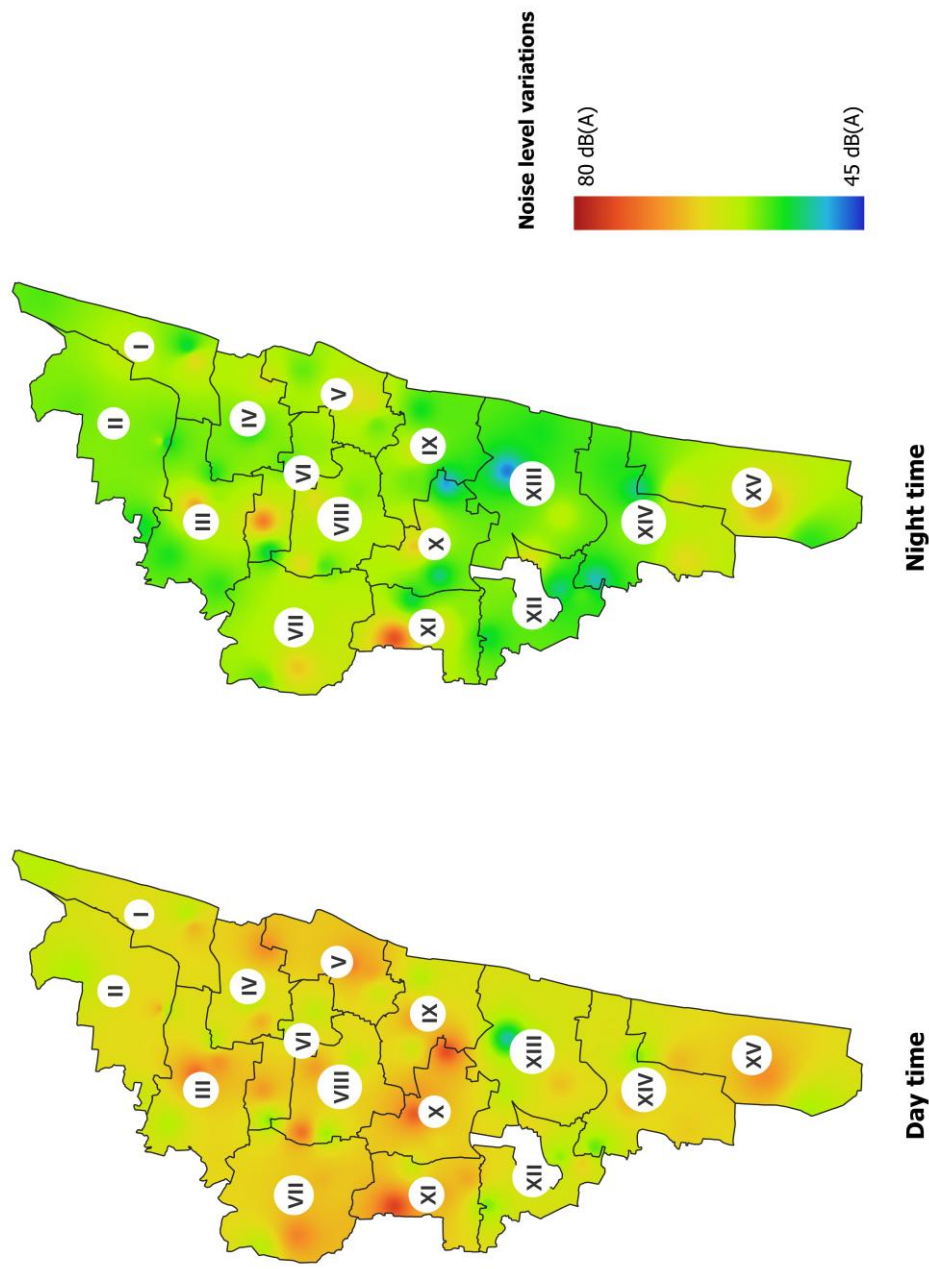


Figure E.14 Strategic noise maps for day and night time – June 2025

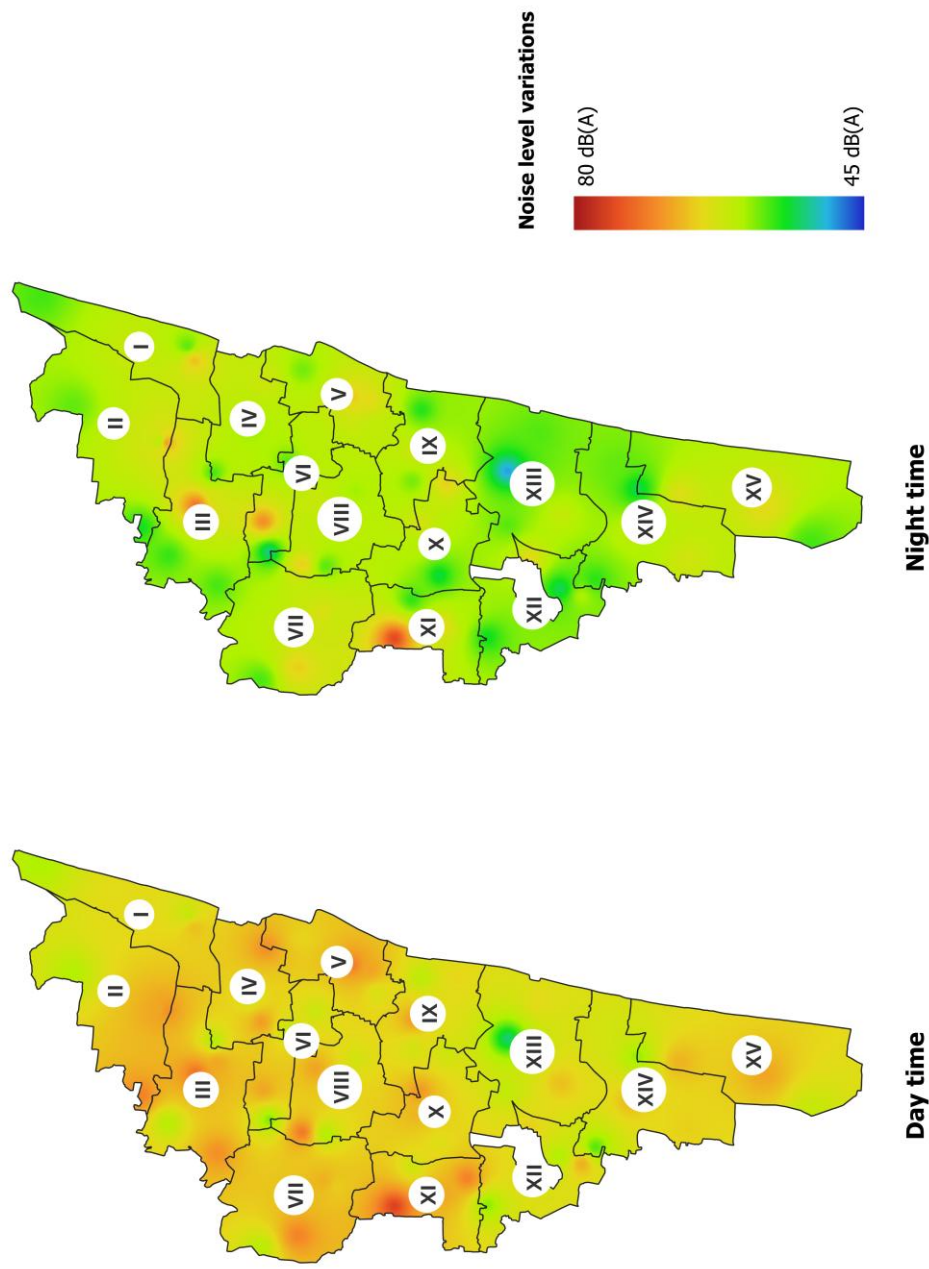


Figure E.15 Strategic noise maps for day and night time – July 2025

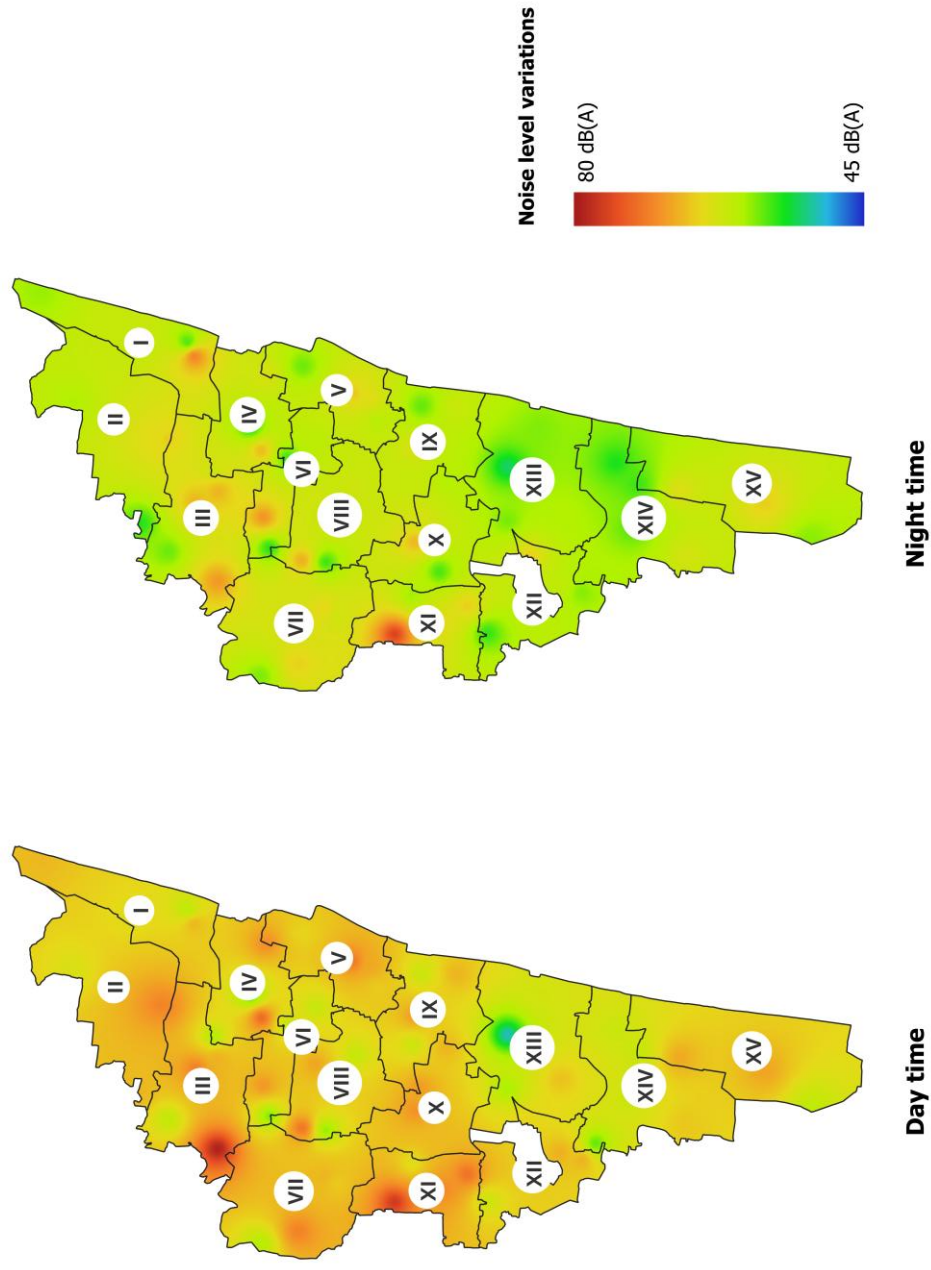


Figure E.16 Strategic noise maps for day and night time – August 2025

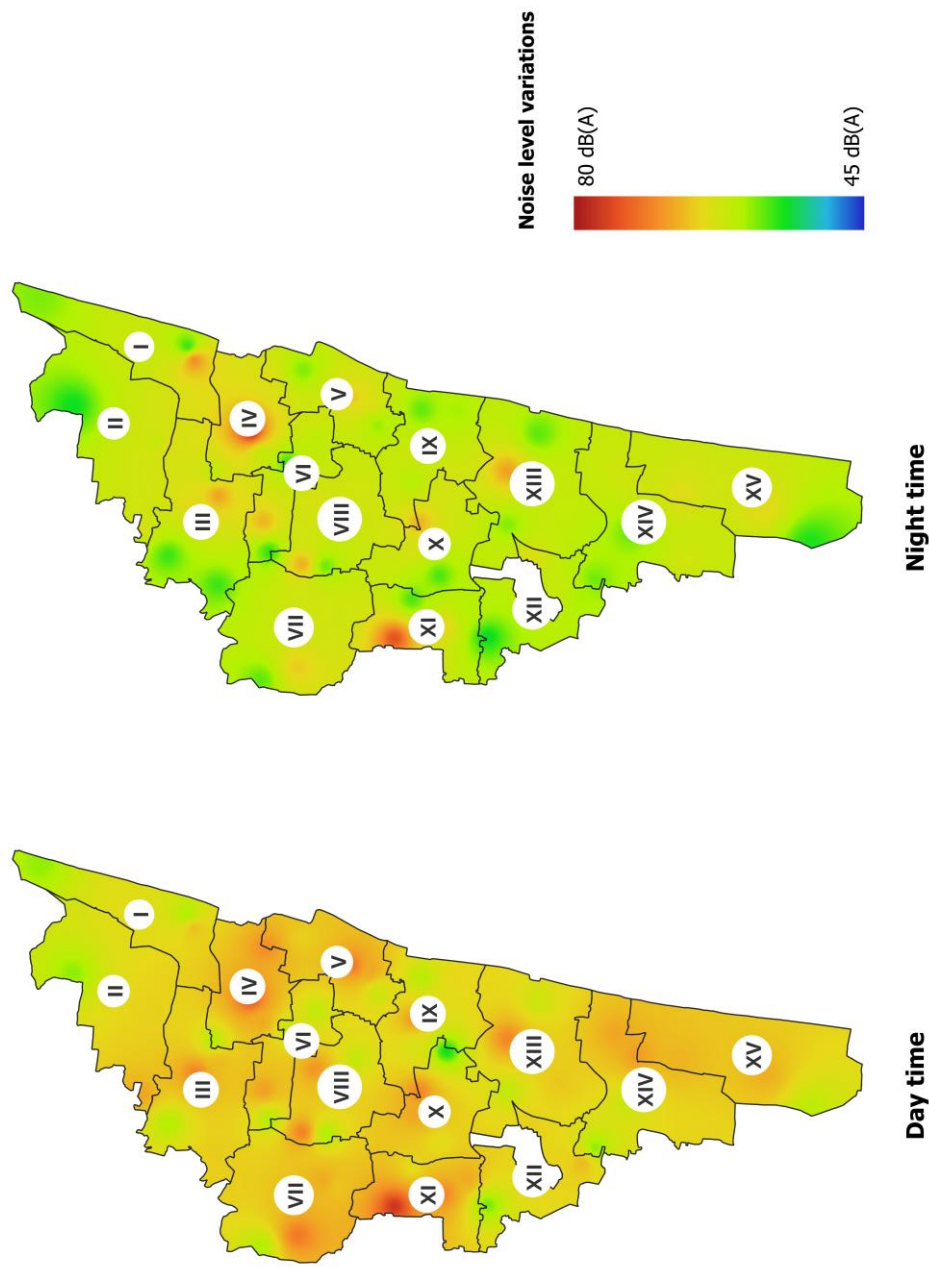


Figure E.17 Strategic noise maps for day and night time – September 2025

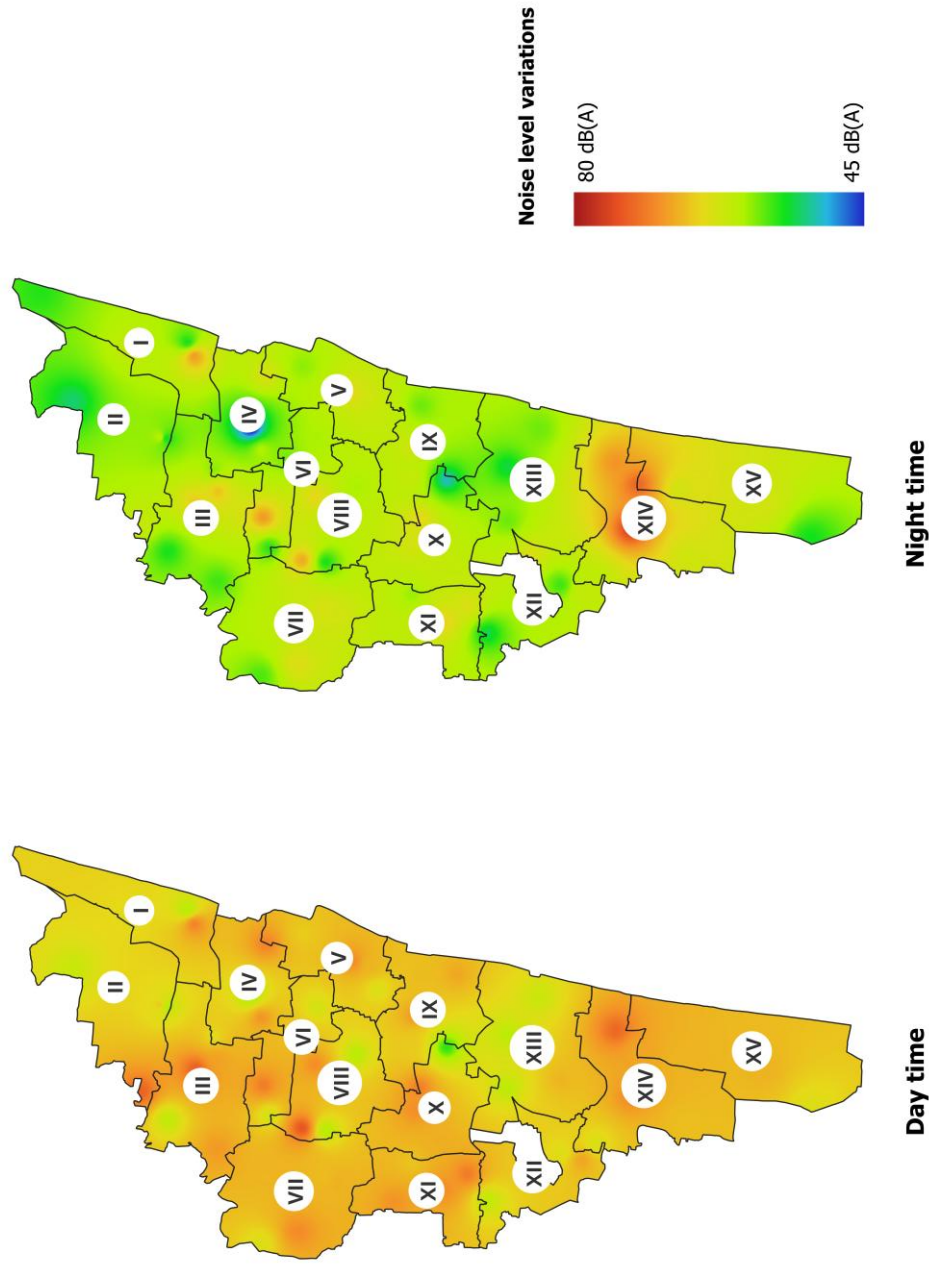


Figure E.18 Strategic noise maps for day and night time – October 2025

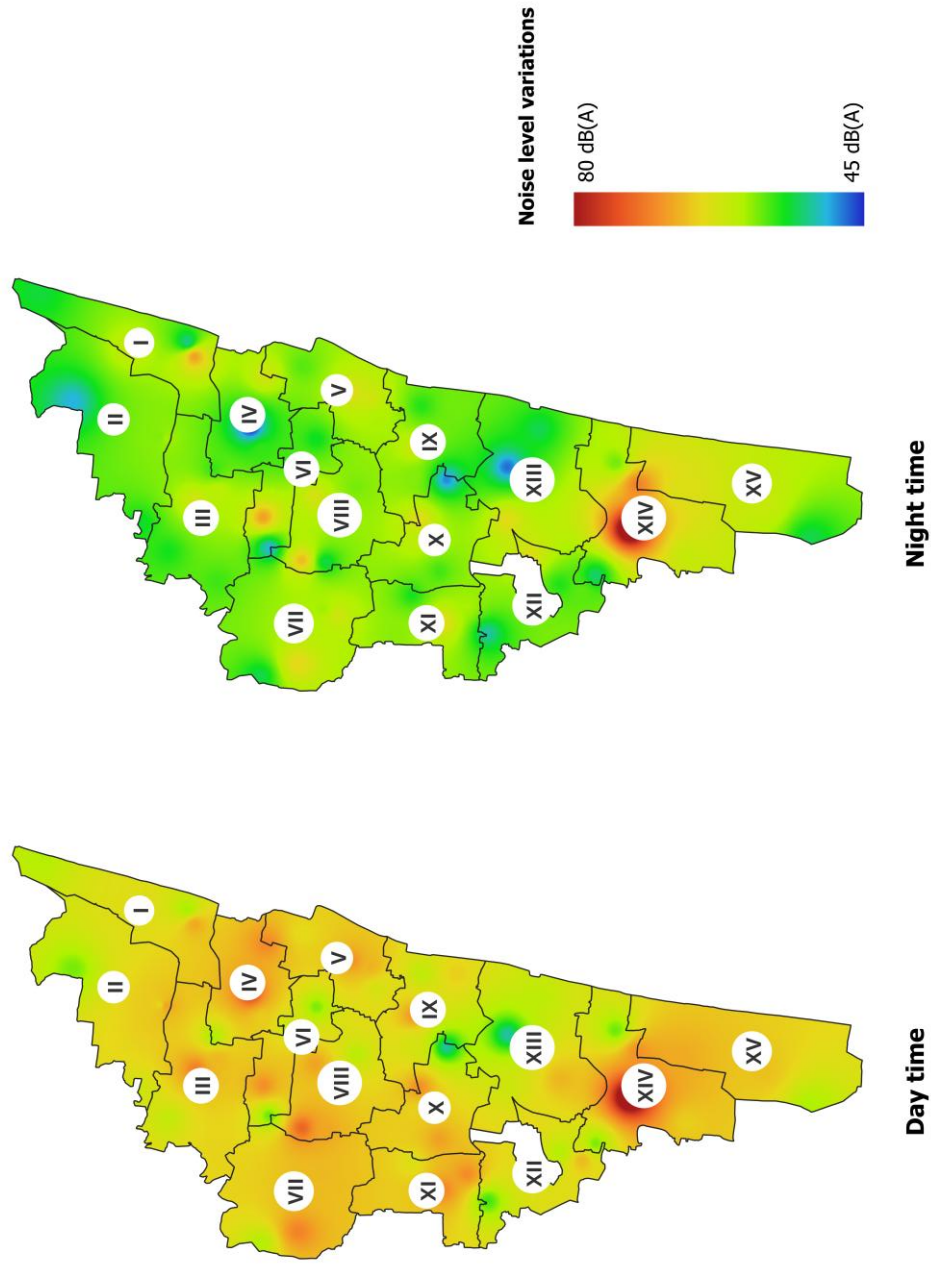


Figure E.19 Strategic noise maps for day and night time – November 2025

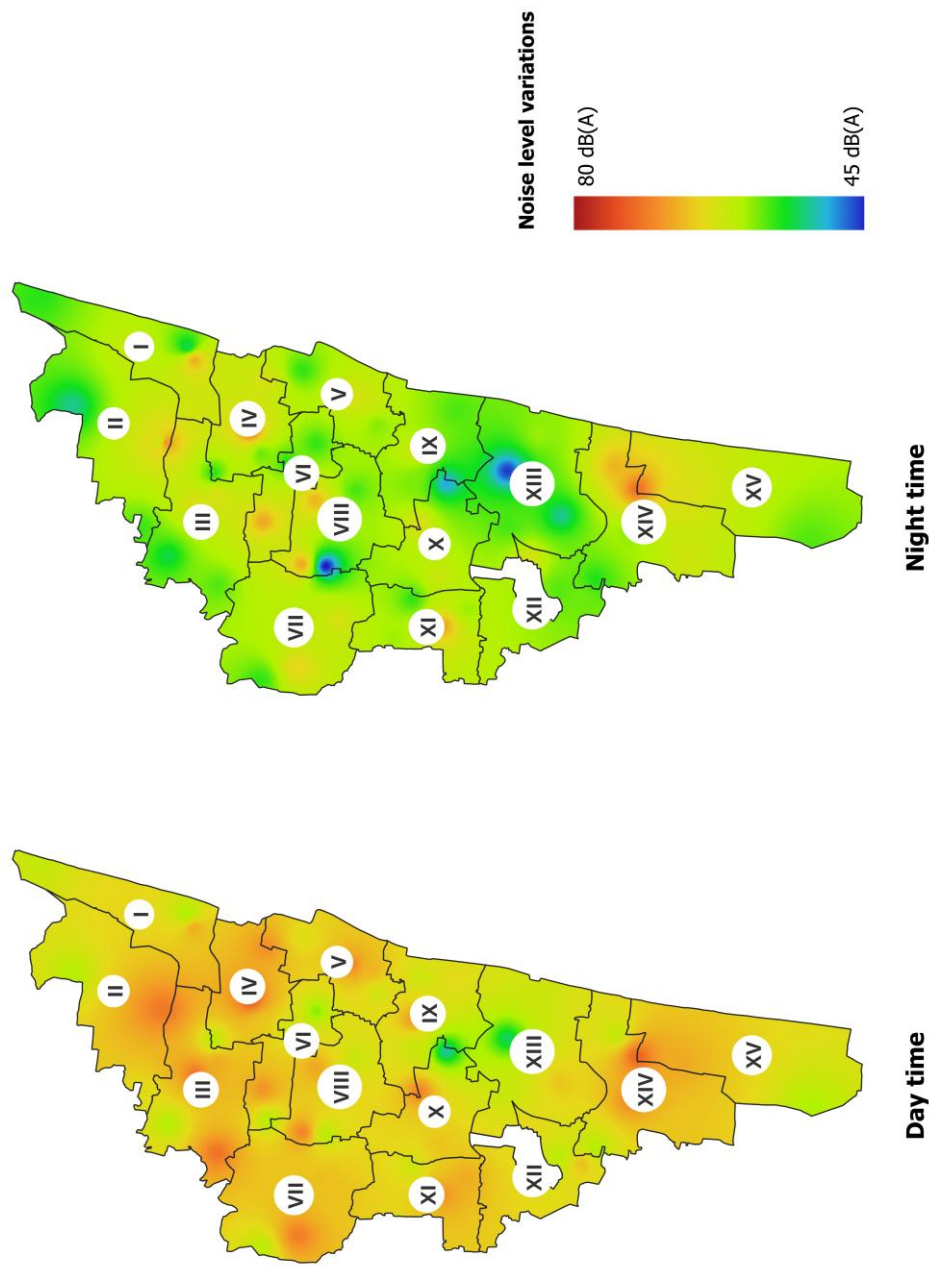


Figure E.20 Strategic noise maps for day and night time – December 2025

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