

# Chapter 11

## Noise Pollution Modelling Using GIS Techniques in Srinagar City



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**Abstract** Due to swift urbanization and shifts in lifestyle, loud noise has permeated every aspect of our lives, becoming an inescapable element. Extensive research has demonstrated that both indoor and outdoor environmental noise pollution pose significant health risks, particularly impacting the well-being of fetuses, infants, children, adolescents, and adults. The detrimental effects of noise pollution encompass not only noise-induced hearing loss but also a wide range of nonauditory health issues. The diagnosis of these adverse effects, attributable to noise pollution, is steadily rising across all age groups. This chapter presents a comprehensive approach utilized for evaluating and delineating the levels of noise pollution in Srinagar city. The assessment and mapping processes were carried out utilizing geospatial techniques. At each selected location, noise measurements were conducted using a sound level meter for 5 days at the same location for morning, afternoon, evening, and nighttime. The resulting noise map was constructed based on the average calculated values using the interpolation technique, which showed that the noise levels in the morning ranged from 44.23 to 78.00 dB, with the outskirts having the lowest values and the city center, Pantha Chowk, and Hazratbal registering the highest levels. Afternoon noise increases from 53.00 to 80.15 dB, and most of the city falls into the medium to high range. In the evening, noise decreases (36.00–79.75 dB), while during the night, levels vary from 36.00 to 60.96 dB, with higher levels in Lal Chowk, Rajbagh, Pantha Chowk, and Khonmoh due to vehicle movements. The findings of this study serve as valuable references and guidelines for future urban planning endeavors and the formulation of noise regulations in areas similar to Srinagar city. These results offer crucial insights into establishing appropriate noise limits to be implemented for the betterment of urban environments.

**Keywords** Geospatial techniques · Inverse distance interpolation · Noise mapping · Noise pollution · Srinagar city

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## 11.1 Introduction

Noise, which is characterized as sound caused by undesired human activities, is widely recognized as an environmental stressor and a source of annoyance (Stansfeld & Matheson, 2003). The rapid urbanization of numerous regions has led to the emergence of noise pollution as a prominent environmental concern (Oyedepo, 2013). Noise pollution poses a genuine problem in all developed and developing countries and plays a significant role in deteriorating the overall health of the population, acting as a catalyst for various stress-related ailments (Vladimir & Madalina, 2019). It has been noted that prolonged exposure to high-intensity sound waves has adverse effects on human health (Gupta et al., 2018; Mehdi et al., 2018). The expansion of transportation networks, increasing number of motor vehicles, widespread mechanization, and inadequate protection of densely populated residential areas from noise due to unplanned rapid urbanization contribute to numerous challenges concerning public health (Esmeray & Eren, 2021). Numerous studies have demonstrated that both short-term and long-term exposure to noise not only diminishes human hearing capabilities but also raises the risk of conditions such as high blood pressure, cardiovascular disease, anxiety, and insomnia (Jariwala et al., 2017; Münzel et al., 2021).

Despite noise pollution being a silent and gradual threat to human well-being, there has been a notable lack of concerted efforts to mitigate this issue (Singh & Davar, 2004). Elevated levels of environmental noise have a detrimental impact on quality of life, necessitating the need to address this issue. However, before taking action, it is crucial to analyze the problem, which involves measuring the levels of noise pollution (Arokoyu et al., 2016). Environmental noise monitoring faces the challenge of achieving comprehensive measurements that encompass both temporal and spatial domains (Maijala et al., 2018). A single-point noise measurement is seldom indicative of an entire neighborhood, necessitating multiple sensor locations.

However, due to the expenses involved in equipment and human resources, the reliability, validity, and representativeness of environmental data often fall short of satisfactory standards. Therefore, the utilization of geographic information systems (GIS) holds significant value in methodological and scientific pursuits, as it enhances workflow efficiency and automates specific calculations, thereby streamlining the user's tasks (Fig. 11.1) (Bilaşco et al., 2017; Garg et al., 2021). The effectiveness of geographic information systems lies in their ability to enable the acquisition, management, analysis, modeling, and precise mapping of results (Sheng & Tang, 2011). One of the notable advantages is the capability to populate the georeferenced database with attributes, allowing for the inclusion of noise sources. Additionally, the utilization of spatial analysis is another significant benefit offered by geographic information systems (Garg & Maji, 2014; Haq et al., 2012).

The current research endeavors to utilize geospatial techniques to map and identify the areas most susceptible to noise pollution. The study aims to emphasize both high sound intensity zones and quiet areas within Srinagar city, where traffic and its associated environmental noise are steadily escalating. Moreover, through GIS

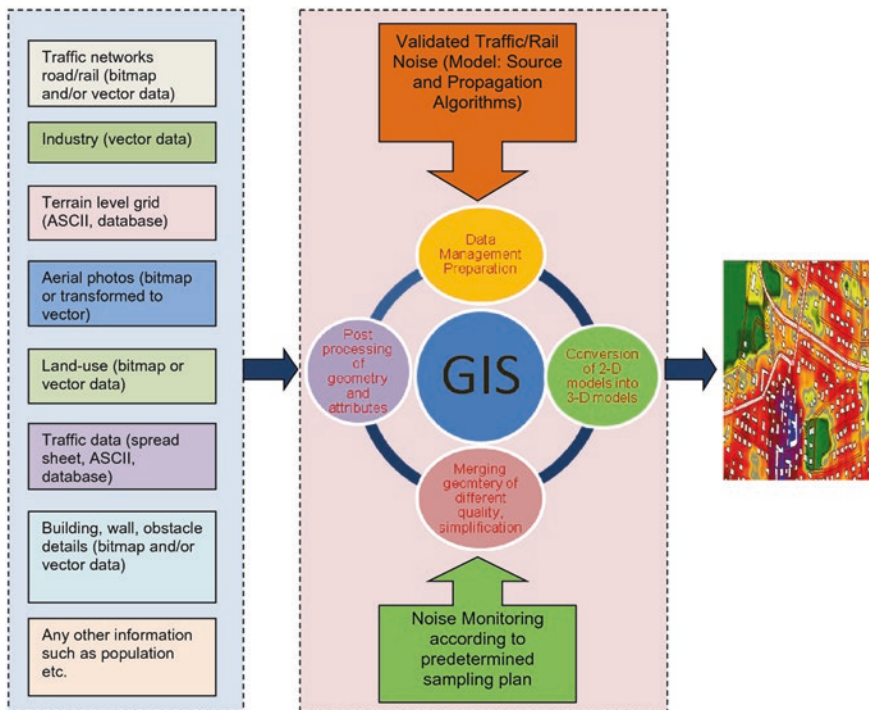


Fig. 11.1 Integrating GIS in noise mapping. (Source: Garg et al., 2021)

analysis, the study elucidates the variations in noise pollution across different representative time periods. In addition, the outcomes of the study can be utilized by local authorities in formulating policies to enhance public awareness regarding the risks associated with noise pollution and to contribute to the scientific literature by proposing potential measures to mitigate noise pollution.

## 11.2 Study Area

Srinagar, the summer capital of the Union Territory of Jammu and Kashmir, is situated at an elevation of 5200 feet above sea level, within the latitudinal range of 34°00′–34°14′ N and the longitudinal range of 74°43′–74°52′ E (Fig. 11.2). Extending along the Jhelum River, the city spans approximately 29 km in length and has an average width of approximately 6 km on both sides. Excluding the cantonment area dedicated to defense purposes, the current total area of Srinagar city is 278.1 km<sup>2</sup>. As of 2023, the estimated population of Srinagar city is 1,627,000, while the Srinagar metro population is estimated at 1,742,000. With a population of over one million, Srinagar is undergoing rapid development. However, this growth has

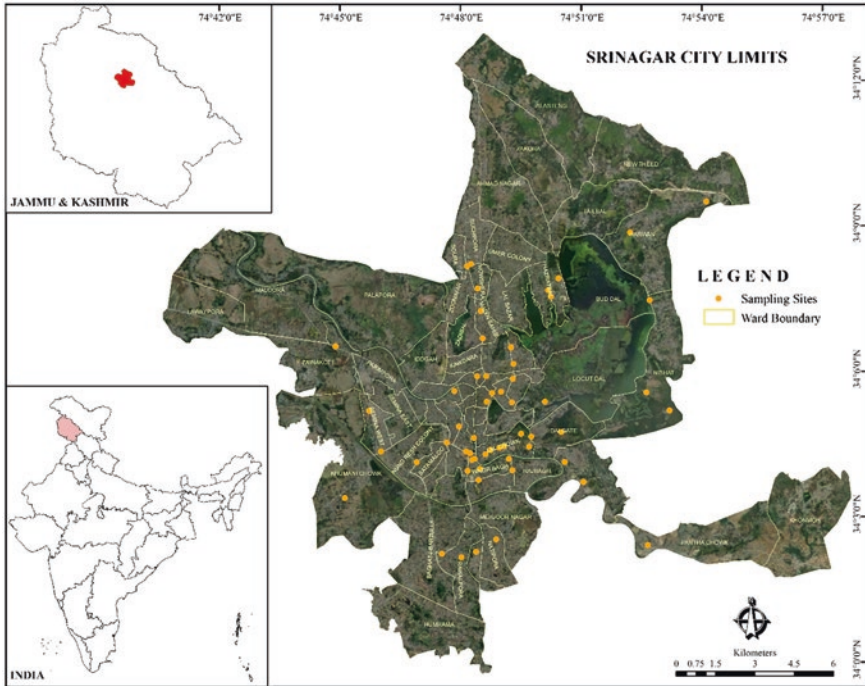


Fig. 11.2 Location map of Srinagar city with ward boundary

led to an escalation in noise pollution, adversely affecting the health and well-being of its residents.

### 11.3 Materials and Methods

Noise pollution modeling has been carried out for Srinagar city using the methodological framework presented in various studies (Esmeray & Eren, 2021; Farooq et al., 2017; Oguntunde et al., 2019). The noise level measurements were carried out during rush hours of the morning, afternoon, evening, and nighttime. Noise levels were assessed in four distinct categories of zones, namely, residential, commercial, industrial, and silence zones.

To achieve a comprehensive representation of all area types, a survey sampling strategy is implemented by dividing the city into multiple grid areas. This grid-based division facilitates a systematic assessment of noise levels across various regions of the city, ensuring the inclusion of all categories of areas in the evaluation process. An SLM 100 Type II sound meter was used to measure the noise levels, and a Trimble hand-held GPS device was used to obtain the exact coordinates of each location where noise level readings were recorded. The monitoring was carried out

consistently for a duration of 5 consecutive days during 2019–2020, maintaining the same locations throughout the entire monitoring period.

The collected data from the sampling sites underwent further processing to enable its utilization within a GIS environment for the creation of noise level maps across different zones within Srinagar city. This was accomplished by employing the inverse distance weighting (IDW) interpolation technique, which predicts unknown noise values for specific geographic points based on surrounding data points. The acquired data were superimposed onto the Srinagar ward boundary and road layer, resulting in the creation of noise pollution maps. Through a comparison of the calculated noise levels with the noise standards set by the Central Pollution Control Board (CPCB), it becomes feasible to assess the level of compliance with the established guidelines (Table 11.1).

## 11.4 Results and Discussion

### *Monitored Noise Levels*

**Industrial Area** The industrial zone comprises Sanatnagar, Baghi-Alimardan, and Shalteng. In the Sanatnagar industrial estate, the average noise levels were measured at 68 dB in the morning, 71.6 dB in the afternoon, and 68.8 dB in the evening (Table 11.2). The overall average noise level for the entire day was recorded as 69.67 dB, which was reduced to 39.5 dB during the night hours. In the Baghi-Alimardan industrial estate, noise levels ranged from 60 dB in the morning of December 28 to 76 dB in the afternoon of the same day. The average noise levels throughout the monitoring period were 69.25 dB in the morning, 73.2 dB in the afternoon, and 67 dB in the evening. The overall daily average noise level was

**Table 11.1** Ambient air quality standards with respect to noise

Area code	Category of area/zone	Day time limits in dB (A)	Night time limits in dB (A)
(A)	Industrial area	75	70
(B)	Commercial area	65	55
(C)	Residential area	55	45
(D)	Silence zone	50	40

**Table 11.2** Five-day average noise levels for selected industrial locations

Five-day average	Morning (dB)	Afternoon (dB)	Evening (dB)	Daily average (dB)	Night hours (dB)
Sanatnagar	68	71.6	68.8	69.67	39.5
Baghi-Alimardan	69.25	73.2	67	71.00	37.75
Shalteng	66	70	66.2	66.00	40.5

71.00 dB, which decreased to 37.75 dB during the night hours. Similarly, in the Shalteng industrial estate, noise levels varied from 62 dB in the morning to 77 dB in the afternoon during the monitoring period. The average noise levels were 66 dB in the morning, 70 dB in the afternoon, and 66.2 dB in the evening. The overall average noise level for the day was 66.00 dB, with a slight increase to 40.5 dB during the night hours.

In the Sanatnagar industrial estate, the highest noise level of 79 dB occurred during the afternoon of December 30, 2019, while the lowest recorded noise level of 65 dB was observed in the evening of December 28, 2019, indicating a relatively quieter period at that time (Fig. 11.3). Similarly, in the Baghi-Alimardan industrial estate, the highest noise level of 76 dB was observed in the afternoon of December 28, 2019, while the lowest recorded noise level of 60 dB occurred in the morning of the same day, implying a quieter start to the day in terms of noise levels. The Shalteng industrial estate experienced its highest noise level of 77 dB during the afternoon of December 30, 2019, suggesting a significant presence of noise sources or activities during that specific time. Conversely, the lowest recorded noise level of 62 dB was observed in the morning of December 28, 2019.

**Commercial Area** The commercial zone, which includes Rajbagh, Batamaloo, Bemina Crossing, Hawal Chowk, Jahangir Chowk, Exchange Road, Ghantaghar Lal Chowk, T.R. C, Batwara Chowk, and Lasjan exhibited noise levels higher than the ambient air quality standards with respect to noise, which was 65 dB during the daytime (Fig. 11.4). The average noise levels recorded during morning hours were found to be higher for all the sites: 70.25 dB (Rajbagh), 76.25 dB (Batamaloo), 75.5 dB (Bemina Crossing), 72.25 dB (Hawal Chowk), 77 dB (Jahangir Chowk), 75.75 dB (Ghantaghar Lal Chowk), 75.75 dB (T.R. C), and 67.75 dB (Batwara Chowk) (Table 11.3). Among all the sites, the noise level during morning hours was found to be within limits for Exchange Road (59.5 dB) and Lasjan (64 dB). During the afternoon hours, the average noise recorded for Rajbagh, Batamaloo, Bemina Crossing, Hawal Chowk, Jahangir Chowk, Exchange Road, Ghantaghar Lal Chowk, T.R. C, and Batwara Chowk were recorded on the higher side except for Lasjan at 74.4 dB, 80.2 dB, 79.6 dB, 74.8 dB, 78.8 dB, 76.2 dB, 73.4 dB, 75.8 dB, 72 dB, and 58.8 dB, respectively. The highest recorded noise levels were observed during afternoon hours and were 77 dB (Rajbagh), 85 dB (Batamaloo), 86 dB (Bemina Crossing), 76 dB (Hawal Chowk), 86 dB (Jahangir Chowk), 79 dB (Exchange Road), 81 dB (Ghantaghar Lal Chowk), 91 dB (T.R. C), 78 dB (Batwara Chowk), and 76 dB (Lasjan).

**Residential Area** For residential areas, the locations selected for the record of noise level are those that experience the highest footfall in Srinagar city, that is, Jawahar Nagar, Mehjoor Nagar, Chanapora, Hyderpora, Dalgate, Habbakadal, and Tankipora (Fig. 11.5). Among these areas, the highest average noise level was recorded for Chanapora and Dalgate at 64 dB and 62 dB, respectively, during morning hours. This is followed by Jawahar Nagar (59 dB) and Mehjoor Nagar (58 dB). During morning hours on average, the lowest noise was recorded for Habbakadal (43.5 dB)

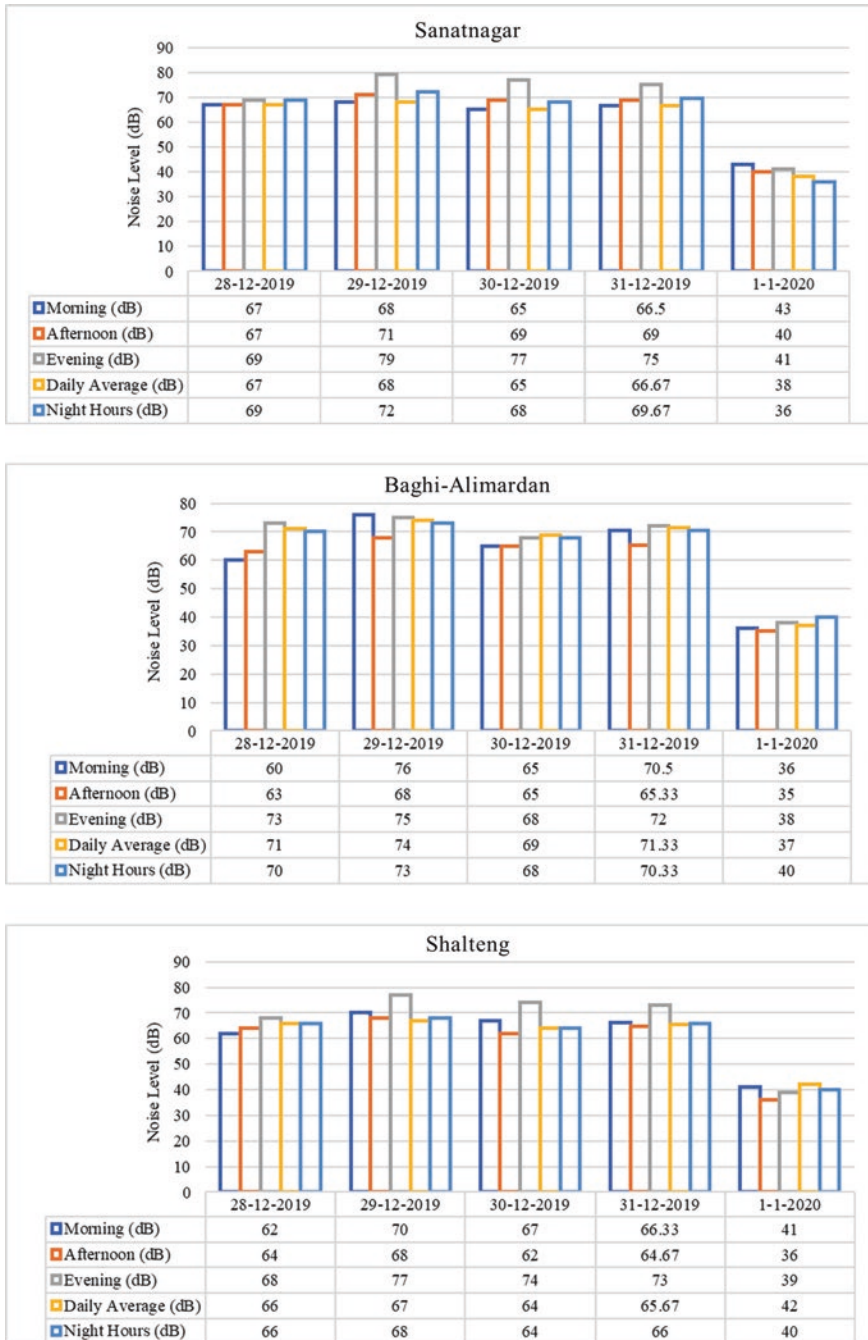


Fig. 11.3 Noise levels recorded for selected industrial locations

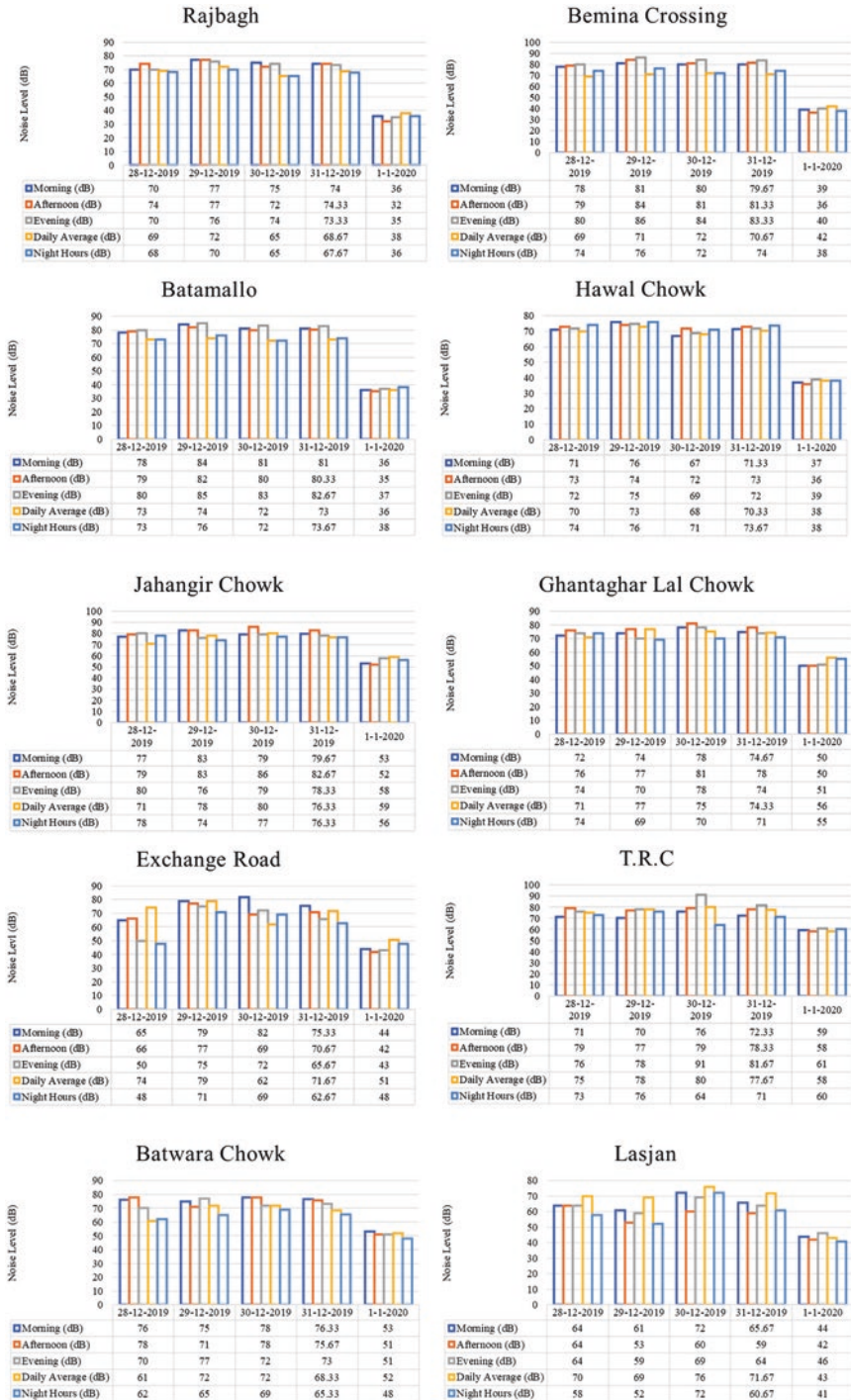


Fig. 11.4 Noise levels recorded for selected commercial locations



**Table 11.3** Five-day average noise levels for selected commercial locations

Five-day average	Morning (dB)	Afternoon (dB)	Evening (dB)	Daily average (dB)	Night hours (dB)
Rajbagh	70.25	74.4	70.2	70	36.25
Batamaloo	76.25	80.2	77.6	75	36.75
Bemina Crossing	75.5	79.6	77.8	74	39.75
Hawal Chowk	72.25	74.8	69.4	72	38
Jahangir Chowk	77	78.8	80.2	78	56.5
Exchange Road	59.5	76.2	70.8	74	46.5
Ghantaghar Lal Chowk	75.75	73.4	76.4	73	53
T.R.C	75.75	75.8	78	70	59.5
Batwara Chowk	67.75	72	73.8	63	51
Lasjan	64	58.8	69.8	65	43.5

and Tankipora (46 dB), which is within the limits of the standards for residential areas (Table 11.4). During nighttime, the noise levels for all seven locations were found to be under limits. On a daily average basis, it exceeds 62 dB for Chanapora and 60 dB for Jawahar Nagar, Mehjoor Nagar and Dalgate.

The growing body of research emphasizes the significant influence of interactions with nature on people's physical health and psychological well-being, both directly and by moderating various processes. To create health-promoting urban environments, residential areas should be carefully planned to provide easy access to nearby green spaces, offering relief from environmental stress and opportunities for rest and relaxation, while also striving for lower sound levels from road traffic. In their study, Gidlöf-Gunnarsson and Öhrström (2007) investigated the impact of the perceived availability of nearby green areas on well-being among groups living in different noise conditions. The results revealed that improved accessibility to green spaces positively affected the well-being and daily behavior of both groups, leading to reduced long-term noise annoyances and a lower prevalence of stress-related psychosocial symptoms, along with increased outdoor space utilization.

**Silence Zone** Silence zones are areas encompassing a distance of no less than 100 m around hospitals, educational institutions, and courts (Sahlthasneem & Deswal, 2023). Within these zones, the permissible noise level should not surpass 50 dB during the day and 40 dB at night. For silence zones, fourteen educational institutes were selected for recording the noise level, which includes lower and high courts as well (Table 11.5). In addition, the noise level was recorded at eight major hospitals in Srinagar City. It was observed that the noise level exceeded the permissible limit of 50 dB during the day for all educational institutes. The daily average was recorded for Gandhi Memorial College, Presentation Convent School, Higher Secondary School Amira Kadal, Amar Singh College, and Govt. Girls Higher Secondary School Khanyar were 54.96 dB, 71.53 dB, 71.87 dB, 73.668 dB, and 72.36 dB, respectively (Fig. 11.6). During the afternoon, the Higher Secondary

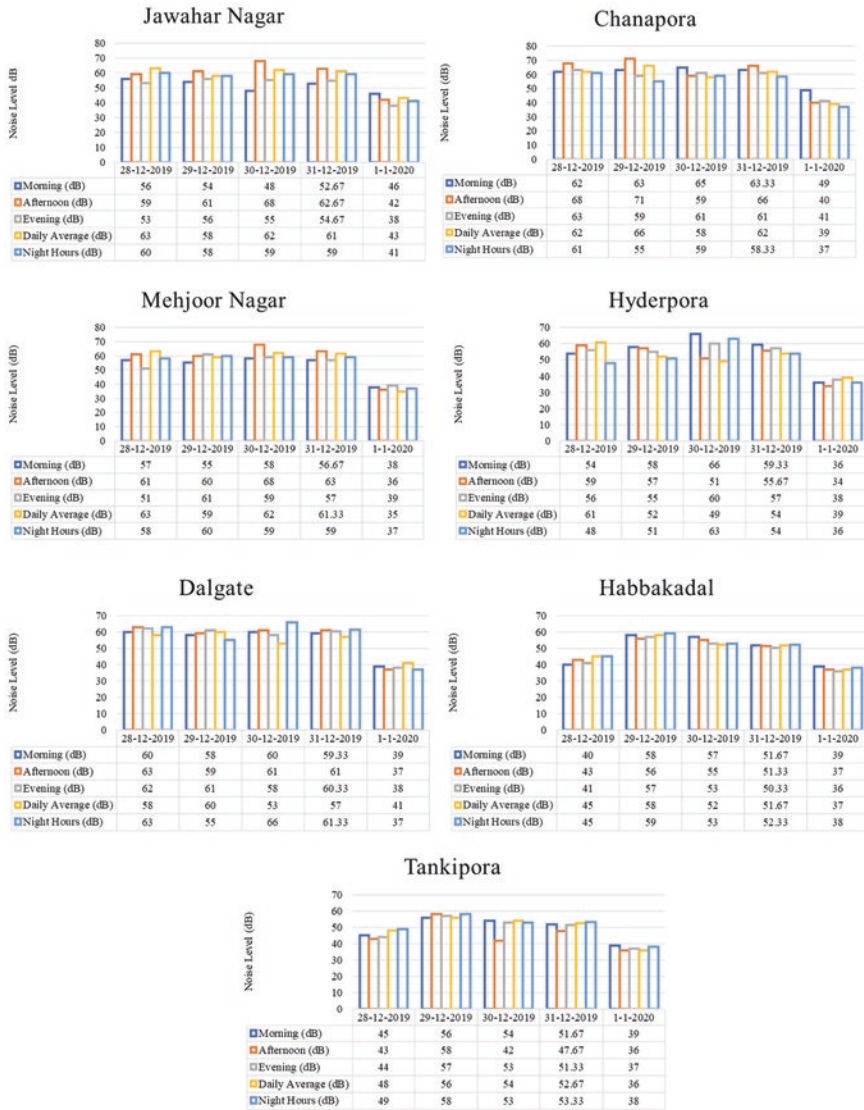


Fig. 11.5 Noise levels recorded for selected residential locations

School Amira Kadal and Amar Singh College recorded the highest noise level, reaching 84 dB. These locations stood out as having louder environments compared to others. The higher noise levels around educational institutes make children vulnerable in regard to the nonauditory health effects of noise. Due to their limited cognitive capacity to comprehend and cope with stressors, they are more susceptible to its impacts (Stansfeld & Matheson, 2003). Additionally, as children are still in the developmental stage, exposure to environmental stressors such as noise could

**Table 11.4** Five-day average noise levels for selected residential locations

Five-day average	Morning (dB)	Afternoon (dB)	Evening (dB)	Daily average (dB)	Night hours (dB)
Jawahar Nagar	59	57	58	60	42
Mehjoor Nagar	58	59	61	60	37.25
Chanapora	64	63	60	62	41.5
Hyderpora	56	54	58	57	37.25
Dalgate	62	59	60	60	38.75
Habbakadal	43.5	57.6	54	51	37.5
Tankipora	46	57	51.2	50	37.5

potentially lead to irreversible negative consequences for their physical and cognitive well-being (Stansfeld & Clark, 2015).

Conversely, Gandhi Memorial College displayed the lowest noise level of 50 dB in both the morning and evening, indicating relatively quieter surroundings during those time periods. In addition, the Higher Secondary School Amira Kadal surpassed the average noise levels during nighttime to 46.75 dB. Likewise, the noise levels at major hospitals in Srinagar City exceed the permissible limit during the whole day (Fig. 11.7). During the morning hours, the JLNMRainawari registered the highest recorded noise level, reaching 75.5 dB, followed by L. hospital (74.5 dB), SKIMS Soura, and JVC (72 dB). The situation is even more concerning during nighttime, as noise levels surpass the permissible limits of 40 dB for all hospitals, except for Gousia Hospital Khanyar and the Institute of Mental Health and Neuro Sciences.

Noise pollution in and around hospitals poses a serious health hazard, as recognized by Khaiwal et al. (2016). The World Health Organization (WHO) recommends maintaining continuous background noise levels in hospital rooms below 35 dB, with nighttime peaks inward not exceeding 40 dB (Berglund et al., 1999). High noise levels in hospitals can lead to issues concerning patient safety and recovery. Jue and Nathan-Roberts (2019) found that exposure to elevated noise levels significantly affects various aspects, including patients’ sleep quality, speech processing, and various physiological functions. Additionally, it may also contribute to stress and burnout among hospital workers. Grumet (1993) reported a significant correlation between increasing noise levels and extended length of hospital stay, emphasizing the importance of noise control in healthcare settings as a high priority.

### *Spatial Distribution of Noise Pollution in Srinagar City*

Figure 11.8 (a–d) displays noise pollution maps generated using the inverse distance weighting (IDW) technique in ArcGIS. These maps represent the average noise levels during morning, afternoon, evening, and nighttime. Focusing on the interpolated map for morning hours, it becomes evident that the noise levels range

**Table 11.5** Five-day average noise levels for selected silence zones (educational institutes and hospitals)

Five-day average	Morning (dB)	Afternoon (dB)	Evening (dB)	Daily average (dB)	Night hours (dB)
<i>Educational institutes</i>					
Gandhi Memorial College	54	59.6	50.8	54.96	37.5
Presentation convent school	70.25	74	69.8	71.53	37.25
Higher Secondary school Amira kadal	71.25	73.8	71	71.87	46.75
Amar Singh College	71.75	75	73.8	73.668	41.5
Govt. Girls Higher Secondary Khanyar	72	75.2	69.6	72.36	41
NIT Hazratbal	72.5	76	70.4	72.9	39.5
University of Kashmir Hazratbal (Rumi Gate)	72.5	75.8	69.6	72.69	39.75
University of Kashmir Hazratbal (Sir Syed Gate)	70.5	74.2	67.2	70.76	39.5
Govt Women's College Nawakadal	64.25	68	68.8	64	39
High court	73.75	76.6	74.4	75.3	37.5
Lower Court	72.75	75.8	72.2	73.69	38
Govt. Women's College M.A Road	56	70	66.4	65.36	52.75
S.P. College	60	73.6	74.6	71.36	52.5
Delhi Public School Pantha Chowk	77.5	76	75.6	76.33	49.5
<i>Hospitals</i>					
Gousia Hospital Khanyar	68.25	73.2	67.4	69.4	40.5
JLNM Rainawari	75.5	77.6	73.8	75.6	41.25
Institute of Mental Health and Neuro Sciences	59	60.2	55.8	58.27	38.25
L.D Hospital	74.5	75.6	72.8	74.27	42.5
SKIMS Soura	72	76.8	70.2	73.03	41.25
JVC	72	75.4	71.6	72.26	37.5
G.B. Panth Hospital	70.5	75.2	72.4	72.67	61
Chest Disease Hospital	67	73.2	70.8	71.07	51

from 44.23 to 78.00 dB. On the outskirts of the city, particularly toward the north-east and northwest, the average noise levels are observed to be the lowest. This may be attributed to the positive impact of green spaces on mitigating traffic noise pollution at the local scale; however, their effects on a broader urban level remain unexplored (Margaritis & Kang, 2017). Conversely, the highest noise values are concentrated in the main city center, with Pantha Chowk toward the east and Hazratbal located in the middle experiencing notably high noise pollution, exceeding the permissible limits. The remaining areas generally exhibit low to medium noise values.

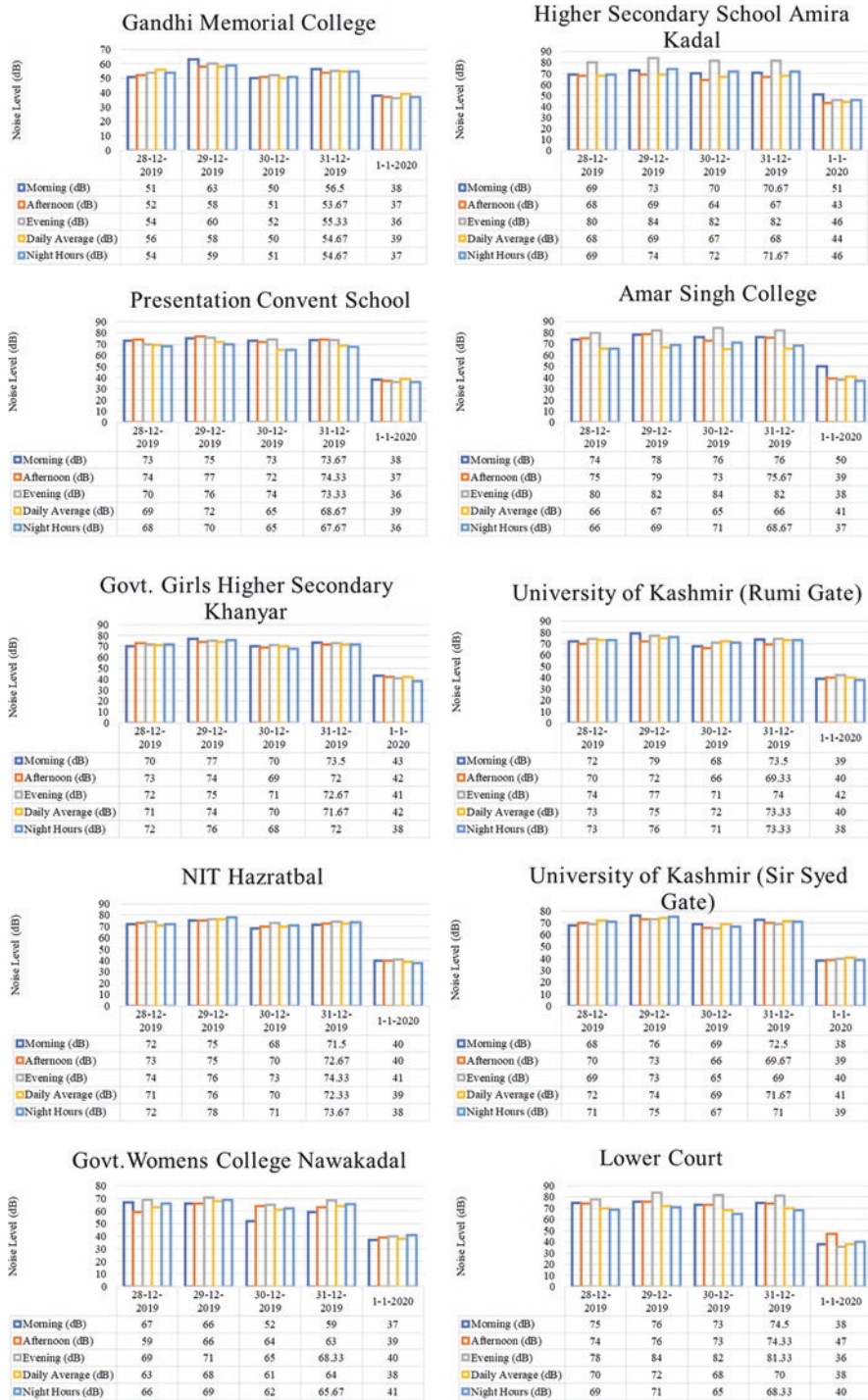


Fig. 11.6 Noise levels recorded for selected silence zones (educational institutes)

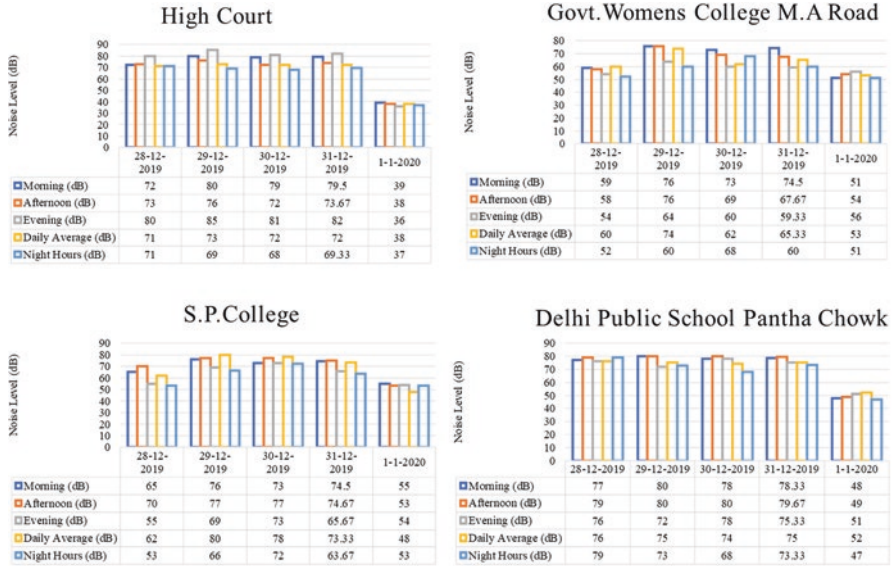


Fig. 11.6 (continued)

During the afternoon, there was a noticeable increase in the average noise level compared to the morning hours, ranging from 53.00 to 80.15 dB. The lowest value of 53.00 dB was limited to specific locations such as Nishat, Dalgate, Nowshera, and Baghat-I-Barzulla. However, the majority of the city experienced medium to high noise levels during this time. Similar to the morning hours, the highest noise pollution during the afternoon was observed in Lal Chowk and its adjacent areas, which serve as the primary commercial zones and major hubs of the city. The commercial areas are exceeding the noise levels as per the standards. On the other hand, areas situated in the north and north-western outskirts of the city had noise levels mostly falling within the medium range.

During the evening, the average noise level map indicates a reduction in noise compared to the afternoon hours, ranging from 36.00 to 79.75 dB. Despite this decrease, the noise levels in commercial areas remain on the higher side, even as day activities wind down. Similar to the morning and afternoon, the main city center continues to exhibit the highest noise values during the evening. Interestingly, Pantha Chowk, which had the highest noise level in the morning, experienced a decrease during the afternoon but showed a surge again in the evening hours. This could be attributed to the traffic flow transitioning from the main city to other districts. Overall, while there is a slight reduction in noise during the evening, it is still important to consider and adhere to the established noise limits, especially in commercial zones, to mitigate potential disturbances during this time.

Throughout the night, the average noise level displayed variations ranging from 36.00 to 60.96 dB. The majority of the city areas maintained noise levels within permissible limits, registering lower values. However, specific areas such as Lal

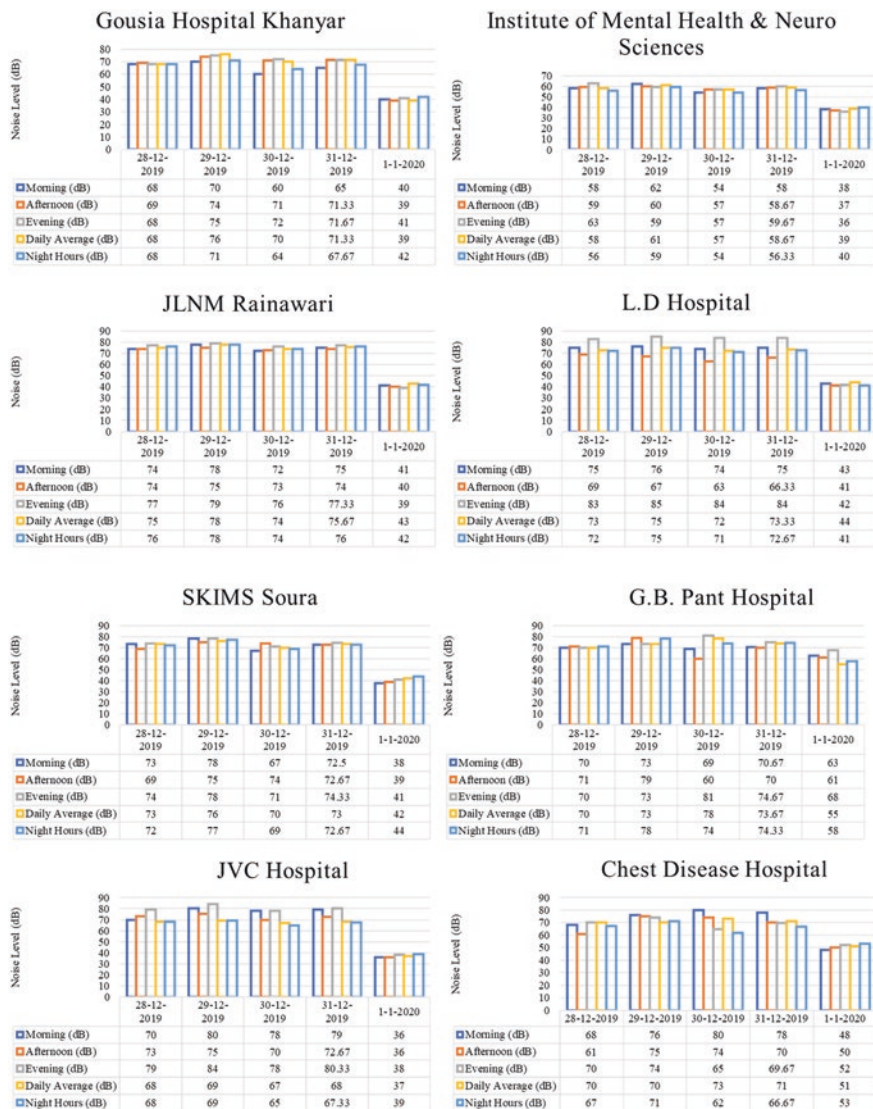


Fig. 11.7 Noise levels recorded for selected silence zones (hospitals)

Chowk, Rajbagh, and their connecting regions, along with Pantha Chowk and Khonmoh, recorded higher noise levels, reaching 60.96 dB during the night. This increase in noise can be attributed to the movement of vehicles, particularly heavy ones, using routes that pass through Pantha Chowk and Khonmoh, leading to the Jammu highway. In their study, Banerjee et al. (2009) also observed a similar pattern of significantly elevated noise levels during nighttime, which was attributed to the movement of heavy trucks. Despite these localized higher noise levels, the

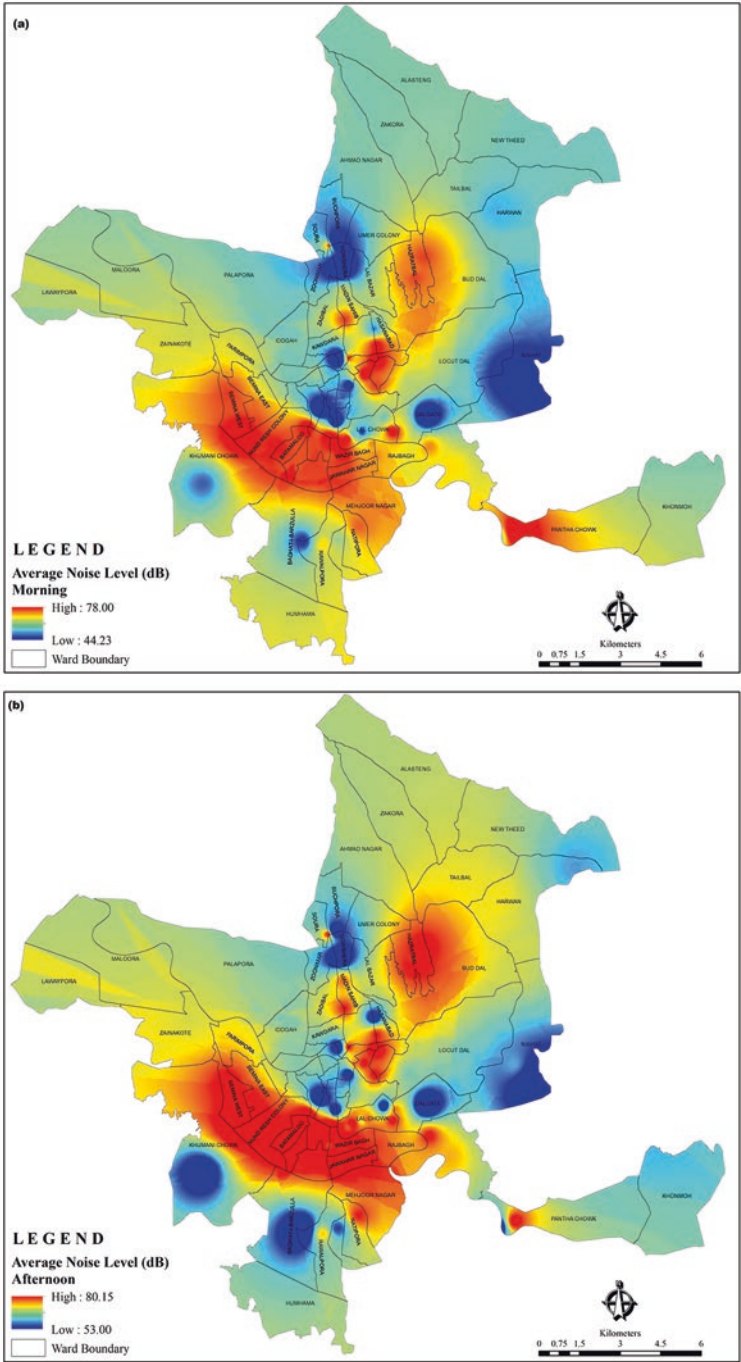


Fig. 11.8 Spatial distribution of noise level in Srinagar city developed using IDW



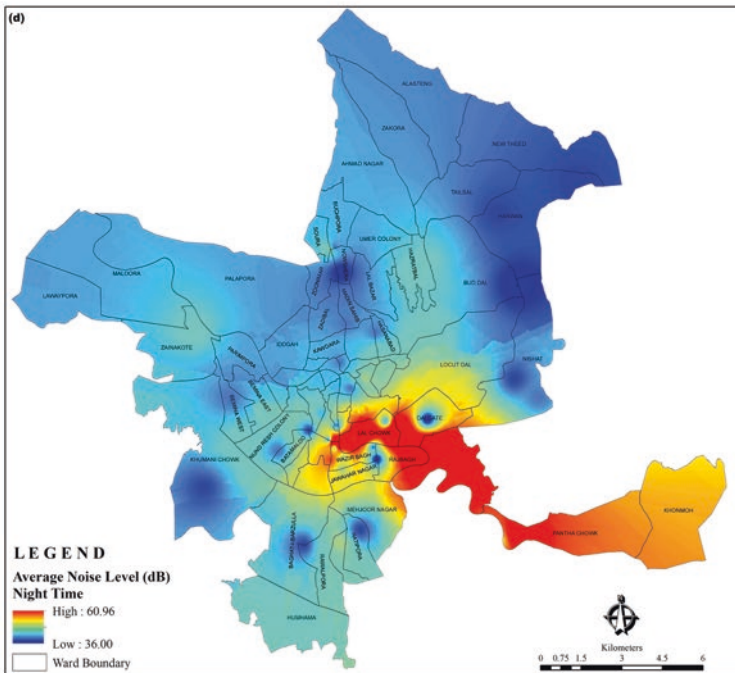
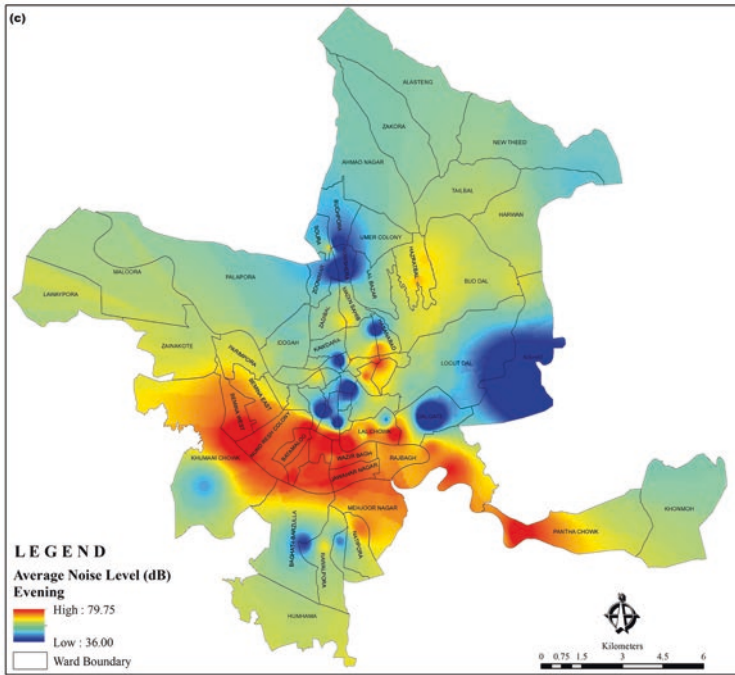


Fig. 11.8 (continued)

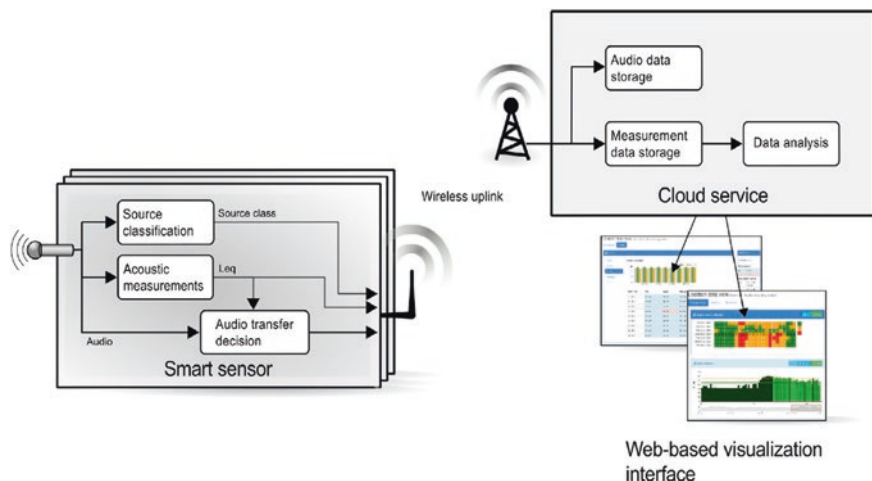
overall noise situation in the city during the night remained generally within acceptable limits, contributing to a quieter and more peaceful environment during nighttime hours.

## 11.5 Conclusion

In conclusion, the noise pollution maps derived using the IDW technique in ArcGIS provide valuable insights into the spatial distribution of average noise levels across the city during different time periods. The noise level findings indicate that the acoustic environment in our study area is generally classified as medium to high. This suggests that prolonged exposure to these noise levels could potentially impact human health and overall quality of life. Noise levels vary throughout the day in the city, with mornings ranging from 44.23 to 78.00 dB and higher levels in the city center. Afternoons see an increase from 53.00 to 80.15 dB, while evenings show a reduction from 36.00 to 79.75 dB, and nights vary from 36.00 to 60.96 dB, with higher levels in specific areas due to vehicle movements. This study's findings highlight the presence of moderate to high noise zones, with significant variations based on both location and time of day. The primary factors contributing to these variations are related to traffic characteristics, such as traffic volume, vehicle horns, vehicle-mounted speakers, and the presence of unmuffled vehicles at road junctions, major roads, and commercial centers. Monitoring selected residential and commercial areas consistently revealed noise levels exceeding acceptable thresholds. Overall, the noise pollution analysis indicates that the city's outskirts generally enjoy quieter environments, while noise levels tend to be higher in the city center and major commercial zones. To maintain a healthier and more sustainable soundscape, it is crucial for urban planners and policymakers to address noise hotspots and implement suitable mitigation measures, especially in areas with consistently high noise levels. Such efforts can contribute to a more pleasant living environment for the city's residents and promote overall well-being and quality of life.

## 11.6 Recommendations

The installation of smart sensors in cities for noise monitoring is highly recommended. These advanced sensors can provide real-time data on noise levels across different areas, helping authorities identify noise hotspots and patterns (Fig. 11.9). With this information, effective noise mitigation strategies can be developed to improve the overall acoustic environment, enhance public health, and ensure a better quality of life for residents. Smart sensors offer a cost-effective and efficient way to monitor and manage noise pollution in urban areas, making them an essential tool for modern urban planning and environmental management.



**Fig. 11.9** Schematics showing the working flow of smart sensors for noise monitoring along with a web-based visualization interface. (Source: Majjala et al., 2018)

Furthermore, integrating a web-based interface for data visualization would significantly enhance the accessibility and usability of the noise monitoring system. By offering a user-friendly web platform, the general public, researchers, and policy-makers can easily access and interpret noise data, fostering greater awareness and engagement in noise pollution management efforts. This interactive visualization plays a crucial role in empowering communities to actively participate in creating a quieter and more sustainable urban environment.

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