

DIFFERENT SCALES OF URBAN TRAFFIC NOISE PREDICTION

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ABSTRACT:

Noise pollution is an important problem. Places around the road or railway corridor can get serious noise hazards in the outdoor environment. The problem of noise is dynamic and varies from one location to another. It becomes more challenging due to the varying nature of noise sources (e.g., bus, truck, tempo, etc.) that differ in frequency spectra of audible noises. It is required to characterize the noise environment for an area, which requires noise measurement and use it for noise prediction. An attempt has been made to predict the noise levels in the form of noise maps. Noise prediction requires information on terrain data, noise data (of sources) and a model to predict noise levels around the noise sources. With the variation in terrain data, noise data, and use of prediction model the performance of prediction can vary. Thus, the study is conducted at three different locations i.e., (i) Ratapur Road crossing, Rae Bareilly (ii) Bahadurpur Road crossing, at Jais, and (iii) RGIPT Academic Block close to the railway track. The three studies indicated how the performance of prediction can vary with changes in the quality of terrain data, noise sampling, and schemes of noise modeling. Generally, with a better quality of terrain data (comprehensive and precise), better prediction can be possible. Similarly, more focused and event-specific noise recording, modeling can provide more detailed time-specific noise mapping, which is not possible otherwise with customary average noise recording technique. However, detailed and comprehensive modeling warrants complex and bigger data handling.

1. INTRODUCTION

Noise pollution is an important problem. Places around the road or railway corridor can get serious noise exposure in the outdoor environment. The problem of noise is dynamic in time and vary from one location to another (Kinsler, Frey, and Mayer. 1963). It becomes more challenging because of the varying nature of noise sources (e.g., bus, truck, tempo, etc.) differing the frequency spectra of audible noises. Further, the human perception of sound makes some of the noises acceptable to others not (Gleitman. 2012). This widely varying noise pollution problem is tried to be studied in present work. An attempt has been made to predict the noise levels in the form of noise maps. Noise prediction requires information on terrain data, noise data (of sources) and a prediction model to predict noise levels around the noise sources (Alina. 2016). With the variation in terrain data, noise data, and use of prediction model the performance of prediction can vary. Development in the urban transportation system becomes essential to increase the efficiency of transporting people and goods within cities. Noise pollution's health risks are not always understandable automatically. Although, it is apparent that during the recent century, many large cities have been facing this problem. It is always associated with intricate environmental concerns (Mason F. Ye. 2013).

The modeling for noise propagation in natural ecosystems needs commonly available datasets on land cover, topography, and weather conditions. Further, the calculation of noise patterns and its test against ambient thresholds requires information of frequencies of noise (i.e., 1/3 or 1/1 octave frequency bands) around multiple sound sources. Nevertheless, noise pollution is a serious issue and it brings out the attention of many planners due to its health effects. Noise can cause nerve irritation, raise heartbeat rate and blood pressure, and leave undesirable effects on body organs (Sim. 2015). Noise pollution at the high threshold for a long duration may lead to permanent damage to

Organs or psychoacoustic systems (Ryan. 2016). Even, the lower continuous equivalent A-weighted sound pressure levels, in a range between 50 dB and 80 dB, would result in annoyance, disturbance, inconvenience, and impairment. In other words, some part of noise effects is always associated with impacts on the nervous system and mental and behavioural status.

This research attempts to characterize the noise ambiance in different scenarios. It focuses on the need for noise and terrain data for noise mapping. The requirement of noise sampling is varied, along with the resolution of terrain data and the complexities of noise modeling algorithms. Different scenarios and types of noise, terrain, or modeling constraints are tested. For this purpose, pilot studies are planned to compare the equivalent sound levels (Leq) for different working days and different times in a day for the intervals of 10 min, 15 min, and 30 min, etc. The present study detects the impact of urban traffic on noise levels in cities.

2. MATERIALS AND METHOD

The study was performed to determine changes in the equivalent sound pressure level from Monday to Sunday in the morning, noon, and evening time slots and also using different time intervals. The time intervals were determined based on a recent recent observed survey (Megel, and Heermann, 1994) for 6.00-7.00am, 10.00-11.00am, and 4.30-5.30pm. Many monitoring stations were selected in the different crossings within various land uses, i.e., residential, recreational, educational, commercial, and residential-commercial. Three time-intervals of 10 min, 15 min, and 30 min were chosen during the morning, noon, and evening, for data sampling. GPS and Total Station were used for recording the coordinates of the measurement points. Equivalent-continuous A-weighted sound pressure levels were measured using a sound pressure level meter of (CESVA SPL). The calibrated device was mounted on the base at a

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distance of 5 meters from the edge of the roadway at a height of 120 cm from the ground. Afterward, measurements were taken at each station. The results were then analyzed using (CESVA capture studio) software. The positions for collection of noise data were planned considering propagation principles of noises. The objects obstructing noise and causing diffraction were thought of (Piechowicz. 2011). Attenuations due to diffraction, absorption, reflection, or transmissions were tried to be estimated to determine the likely noise levels at different positions.

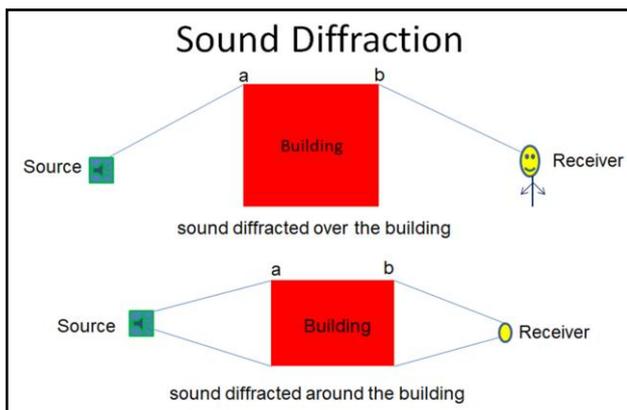


Figure 1. Sound diffraction

2.1 Computation

The technique to compute distance attenuation is given below

Distance Attenuation.

$$SPL_1 = SPL_2 - 20 * \log (R_1 / R_2)$$

Where:

- SPL_1 is the Sound Pressure Level at point 1,
- SPL_2 is the Sound Pressure Level at point 2,
- R_1 is the distance from the sound source to point 1, and
- R_2 is the distance from the sound source to point 2.

Comparable techniques were used during prediction to determine attenuations due to diffraction and absorption using ISO 9613.

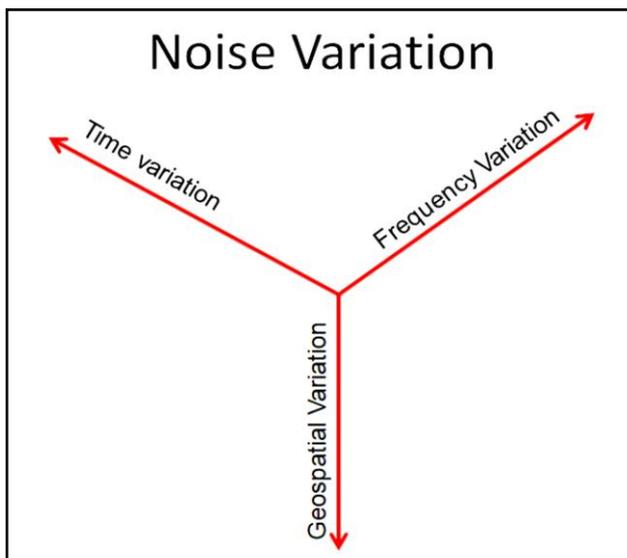


Figure 2. Noise variation

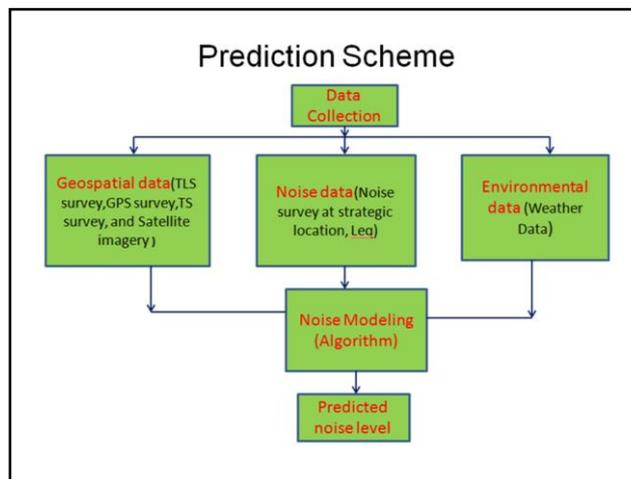


Figure 3. Methodology prediction scheme

2.2 Study area and mapping

The study is conducted at three different locations.

1. Ratapur Road crossing, Rae Bareli.
2. Bahadurpur Road crossing, at Jais.
3. RGIPT Academic Block close to the railway track.

2.2.1 Ratapur road crossing Raebareli: In Ratapur road crossing noise data were recorded in three different time slots i.e., from 10-11 am, 1-2 pm, and 5-6 pm for several days and over a month at high, low, and medium traffic densities. Noise data were captured close to the road and away from it. Some of the away points are later used to check the performance of prediction. A GIS map of Ratapur crossing was prepared after collecting a few ground points for road, building, and trees, along with using satellite images from Google Earth. The noise around the Ratapur crossing could be predicted through GIS interpolation (Maguire. 2016). The interpolation of the noise around the Ratapur crossing could be predicted through GIS interpolation (Maguire 2016). The interpolation did not take into account barriers and other objects thus accuracies varied vary significantly. In the crossing, as expected noises varied 11-13 dB over different test points. Generally, the predictions at and around the crossing were poor, as the impact of building, wall, and other local effects were not considered during prediction or mapping. The detailed map and predicted results are given in Figure 5 and Table 1.

2.2.2 Bahadurpur road crossing, at Jais: In Bahadurpur road crossing the noise data were also collected at different time slots i.e., at 9-10 am, 1-2 pm, and at 5-6 pm for high, low, and medium traffic densities over the month. Terrain data was taken using google images. Ground points were collected using a total station for geo-referencing. Here, the noise prediction involved consideration of attenuations due to distances from sources and building attenuations. GIS noise maps with predicted the noise levels were made for important periods. These were verified with different checkpoints on the ground using Sound Pressure Level meter. The modeling performances were consistent. Measured values varied 4-5dB from predicted ones. However, they were also not very detailed and accurate, as noise and terrain surveys were not undertaken very precisely. Predicted Noise Map for Bahadurpur crossing is given in Figure 6.

Averagely prediction noise map for Bahadurpur area is further categorized for different sampling intervals, i.e., 10 minutes and 20 seconds. Mapping at instantaneous and short time intervals has been undertaken to showcase the fluctuation in noise levels in an area (Figure 9-11).

2.2.2 RGIPT Academic Block close to Railway Track: A plan was thus made to capture the terrain data with better precision in 3D. A small cross-section of RGIPT's academic block was chosen for a detailed terrain survey using LiDAR technology (Terefenko. 2018). The very precise and detailed point cloud data were generated for AB2 building and its nearby areas (Figure 3). Instead of the average impact of noise sources, the impact of a different train passing events is tried to be mapped in an instantaneous scale. To carry out the detailed mapping in 3D, DEM is generated from LiDAR data of AB2 and its surrounding area. Noise levels on the sidewall of AB2 were predicted due to the noise from the passing train. Instantaneous noise levels were measured using the Sound Pressure Level Meter and then used for noise prediction. The area had a railway track, a boundary wall, and then the sidewall of the AB2 building. The terrain parameters were extracted from LiDAR data and then used to determine the path length, path difference, etc. to compute distance attenuation, barrier attenuation (due to wall), etc. All the attenuation values are integrated to compute the predicted noise levels at every point on the AB2 sidewall. Precise and detailed LiDAR data, terrain parameters, and accurate noise levels of train enabled the accurate computation of noise levels as shown in Figures 7 and 8. The presence of dense points over wall allowed prediction of noise levels at every nearby location, although, it involved handling more complexities.

3. RESULTS AND DISCUSSION

Different scales of mapping results over study areas are given below in Figure 4.



Figure 4. Google Image for RGIPT, AB1, and AB2 where Wall Act as a Barrier between Railways track and building AB2

SLN	X	Y	Measured	Predicted
1	81.24109	26.24493	85	95-101
2	81.24123	26.24474	90	95-101
3	81.24133	26.24458	88	95-101
4	81.24142	26.24447	90	95-101
5	81.24148	26.24444	95	95-101
6	81.24165	26.24433	95	95-101

Table 1: Large Deviations between Measured and Predicted noise levels at Ratapur Crossing

The results show that 10-15 dB deviation. The Prediction did not take into account the impact of building, wall, and any other local effect, thus not giving very high accuracy.

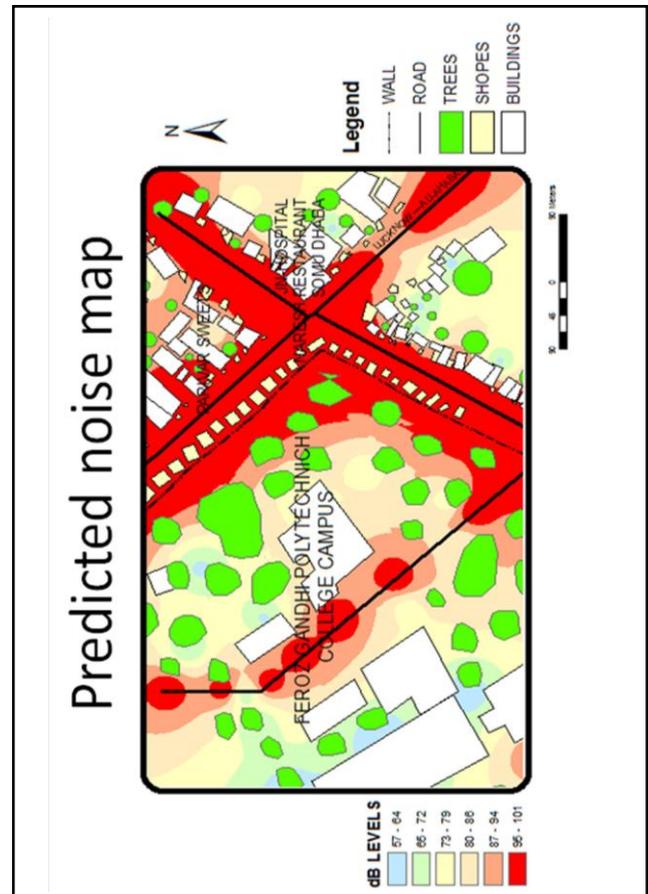


Figure 5. Rough Map of Noise at Ratapur Crossing, Determined with Noise Data and Interpolated with Arc GIS using Google Image

Location ID	X	Y	M1	M2	M3	LEQ	LM1	LM2	LM3
0	81.51986	26.26625	93.3	84	81.8	101.6	8.3	17.6	19.8
1	81.52	26.26623	93.3	84	81.8	106.3	13	22.3	24.5
2	81.52029	26.26619	81.6	84	96.4	107.2	25.6	23.2	10.8
3	81.5205	26.26615	75.6	96.5	96.4	102.9	27.3	6.4	6.5
4	81.52063	26.2663	84.9	96.5	98.4	99	14.1	2.5	0.6
5	81.52082	26.26646	80.6	99.4	95.7	91.7	11.1	-7.7	-4
6	81.52065	26.26613	81.3	82.4	88.9	102.8	21.5	20.4	13.9
7	81.52132	26.26603	79.5	90.4	98.4	96.9	17.4	6.5	-1.5
8	81.52154	26.26593	80.5	83	97.4	96.9	16.4	13.9	-0.5
9	81.52109	26.266	97.5	78.8	83.7	107	9.5	28.2	23.3
10	81.52082	26.26606	88.4	96.4	96.7	107	18.6	10.6	10.3

Table 2: The Short term and Instantaneous Average Noise Levels at Bahadurpur Crossing and their Variations

Where,

M1, M2, or M3 = 20 sec noise value at different time intervals;
LEQ = 10 min noise Leq value at every point.
LM1, LM2, LM3 = LEQ-(M1, M2, or M3), variation in the value of Leq for 10 minutes, and 20-seconds instantaneous scale.



Figure 6. Average Model Noise Map at Bahadurpur Road Crossing

Average Model Noise prediction where some parameters used such as Distance attenuation and Building attenuation and where we find the 5-10 dB difference between predicted and the observed value

Instantaneous detailed noise mapping with accurate terrain and noise data

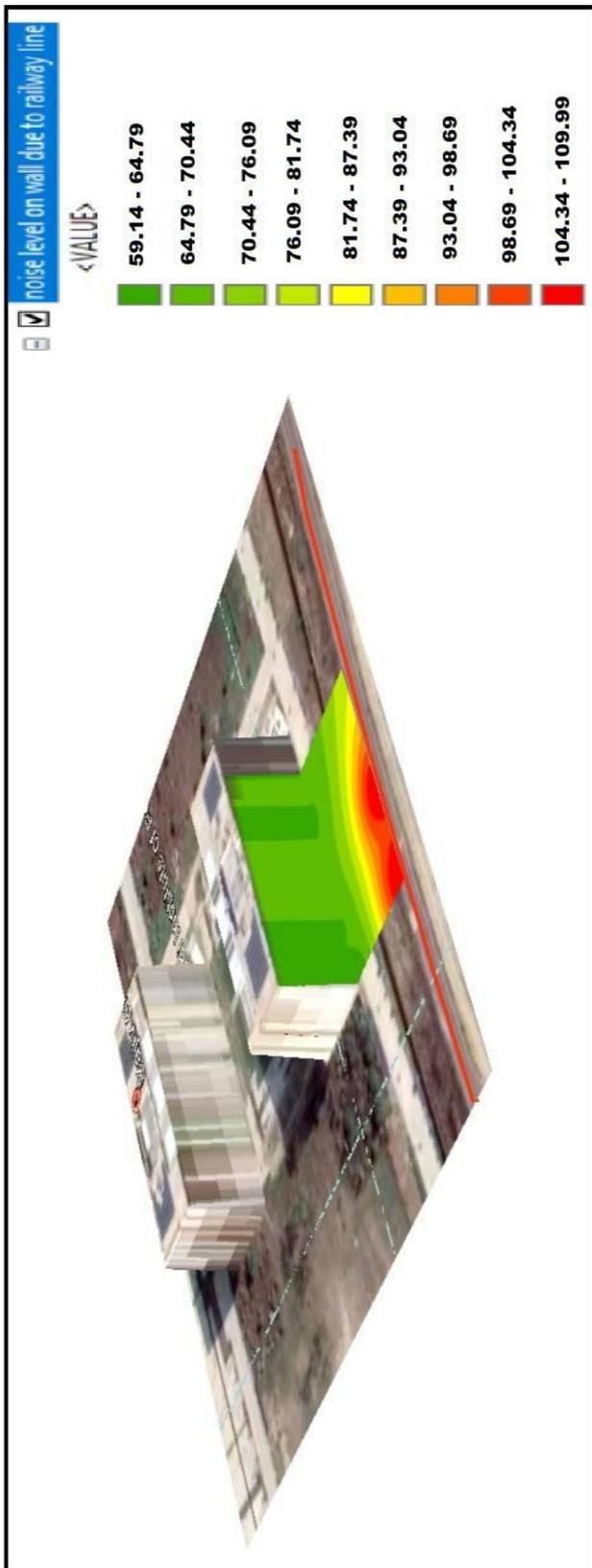


Figure 7. Railway Noise mapping on Sidewalls of AB2 Building. DEM is generated with LiDAR data

This is the 3D Map of the RGIPT Academic Building AB1 and AB2 with the noise value around and over the building and

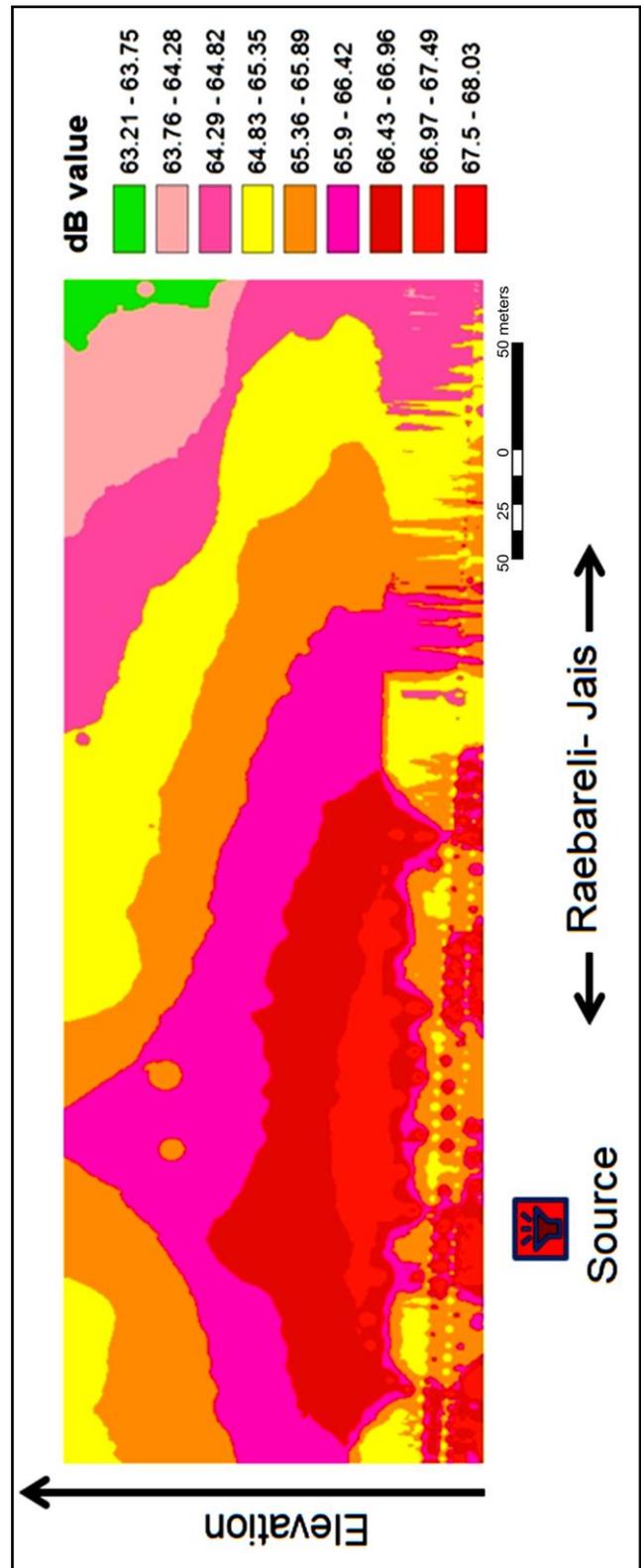


Figure 8. The Detailed and Accurate Prediction of Noise on the Facade of Academic Building -AB2 Building. The variation of Noise Levels on the Vertical wall of AB2 is demonstrated

how it spared this map is generated using high-resolution LiDAR data.

This is the Accurate Model Prediction where high-resolution geospatial data (LiDAR) data is taken for DEM Generation and all attenuation were considered such as barrier attenuation and

distance attenuation etc. Here authors found an accurate prediction. The measured values differed from modelled values by only 1- 2 dB on an average. Here, the deviation in dB was less compared to other maps due to the accurate consideration of the barrier between source and receiver, which decreased the deviation in prediction.

Variability in noise levels in Bahadurpur Road crossing at an instantaneous and short time interval. Noise data of 10 minutes and 20 seconds are mapped and compared separately.

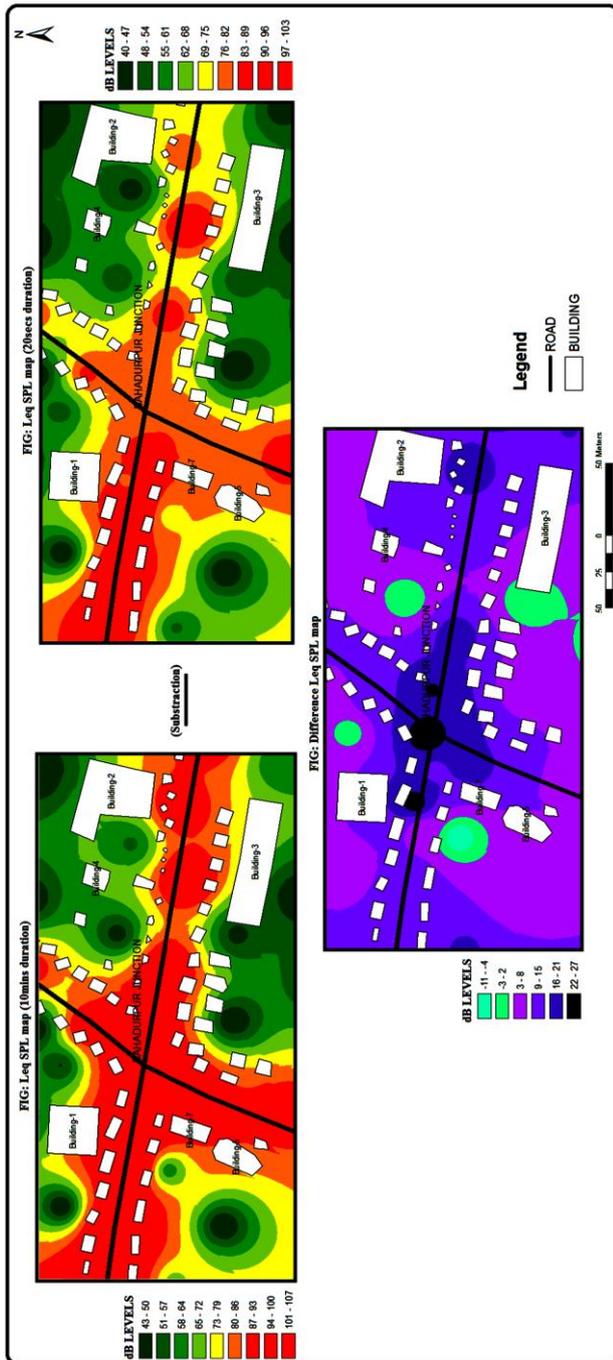


Figure 9. Average Noise Maps in Bahadurpur Crossing for Instantaneous and Short Time Duration and their Difference at 9-10 AM

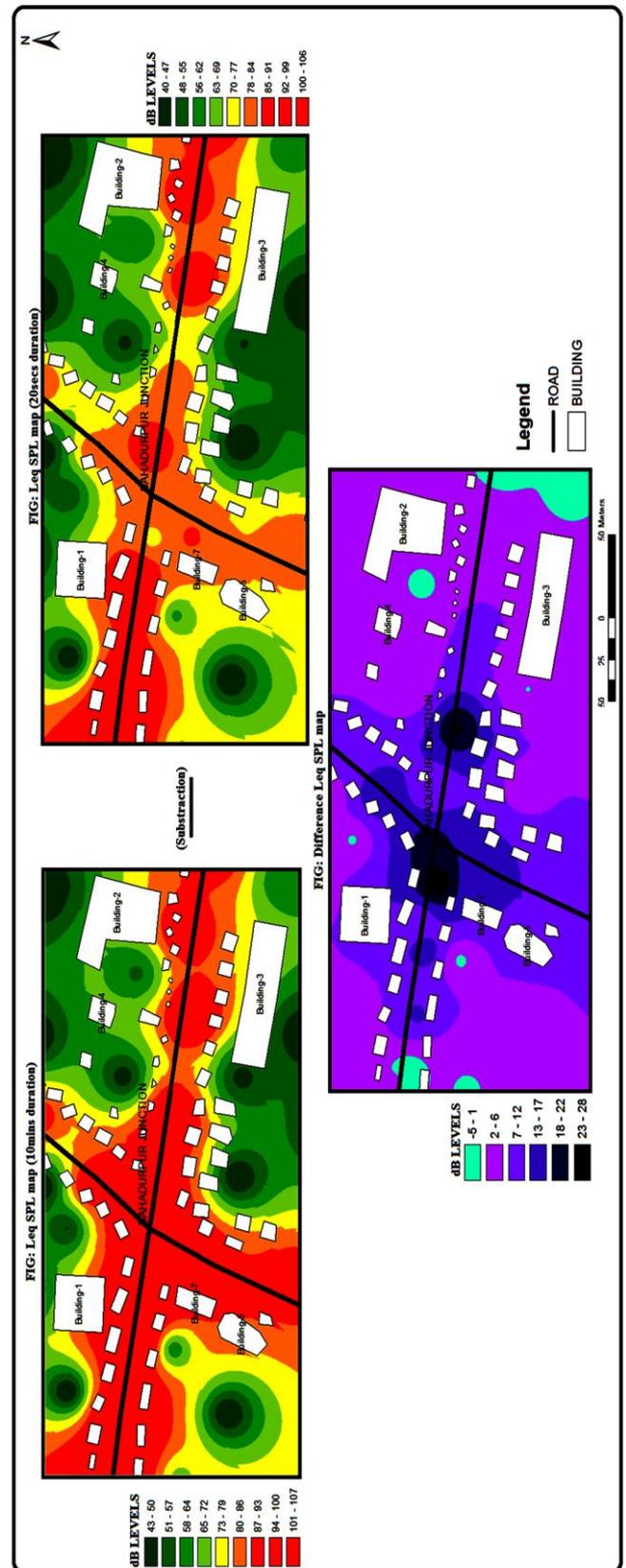


Figure 10. Average Noise Maps in Bahadurpur Crossing for Instantaneous and Short Time Duration and their Difference at 1-2 PM

4. CONCLUSION

Based on a study on a different scale, it is found that noise is dynamic, it varied at different locations, and it also varied at different times and different places. The accuracy of prediction varied based on different geospatial data. Hence, based on this study authors observed that accurate noise data can be predicted after defining the space, time, and data variation accurately. This study is very important to find accurate noise values at different locations and at different time intervals, and through the use of different types of geospatial data. In this study, the authors found the role of data to predict the noise accurately. The impact of instantaneous noise and short-time noise on prediction was also found to be significant. In this study, the author found that if low-resolution data taken variation of noise predicted and observed is very high i.e. 10-15 dB varies and if data is taken medium resolution then found that 5-10 dB Variation an if data is taken high resolution Like LiDAR data then found that variation is very low between the predicted value and observed value it is only 1-2 dB differences then author concludes that for better prediction model high-resolution data is required. Here the author also studies on the high duration noise data and low duration noise data and found that there is too much difference for prediction noise due to data duration differences low duration data give high noise value due to single specific event at that time high noise value captured and if used long-duration data that give the whole value of hole noise value throughout the day over the month and that gives the accurate noise prediction value so the author concludes that duration of data is also very important for the prediction of noise value.

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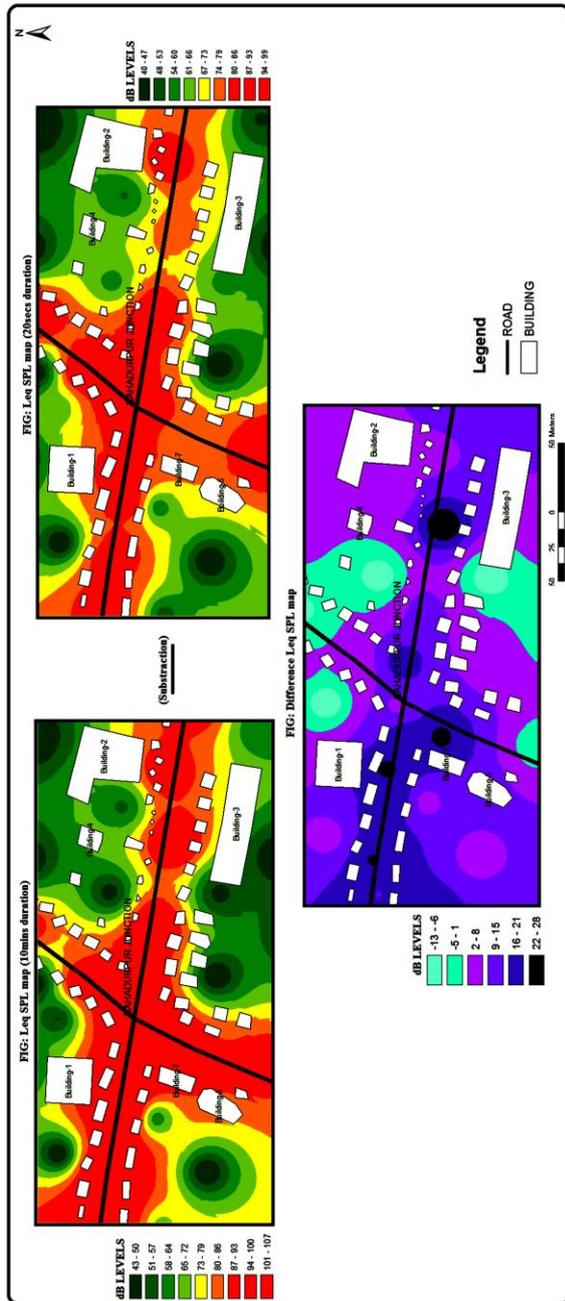


Figure 11. Average Noise Maps in Bahadurpur Crossing for Instantaneous and Short Time Duration and their Difference 5-6 PM

It was an average noise prediction modeling where two types of noise data were taken one for 10 minutes, i.e., short time interval and another for the 20-seconds for an instantaneous interval of noise sampling. Average noise maps were generated using the above noise data and were compared to reflect how the noise levels in a crossing vary even within a short time. A reflection on instantaneous variation in noise levels in time scale was demonstrated in this scheme

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