# RASTER DATA BASED AUTOMATED NOISE DATA INTEGRATION FOR NOISE MAPPING LIMITING DATA DEPENDENCY

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**KEYWORDS:** Noise, Vehicle extraction, Clustering, Classification, Path determination, Data Dependency, Instantaneous Noise

**ABSTRACT:**

Noise has become a recurrent problem worldwide. Road traffic noise studies in India are fewer and restricted only to the metropolitan areas. These studies focused on recording, monitoring, analysis, modelling, and mapping. The major concern is with the onsite collection of vehicular noise data from road sites. Road traffic noise maps have been generated by using traditional techniques that involve the collection of road traffic noise by experts. There are negligible studies in the area of automated noise generation for road traffic noise. In this paper, the study examines the problems that an individual is facing in collecting onsite noise data. Onsite Noise data collection with Sound Pressure level increases the delay. A noise map is a graphical representation of the spatial dissemination in a given area for a characterized period. Developing any geospatial application requires the collection of geospatial data and attribute information. Open-source geospatial data are largely available today in the form of Map APIs. Making a model to extract spatial and attribute information from it can offer an easy solution for urban applications, without needing a separate collection of geospatial or attribute information. Google raster maps for city roads and surrounding buildings in UP are tried to be used to extract roads, buildings, vehicles, trees, etc. Various geometrical setups of vehicles in several similar road segments are tried classified using ML algorithms. Vehicular clusters in road segments are classified into 3 categories, high, medium, and low. Further characterized in terms of the range of noise spectra associated with it incorporating field data. These noise scenes are then utilized to predict the various types of simulated noise maps predicted around the road segments on an instantaneous scale, with an estimation of accuracy.

## 1. INTRODUCTION

Noise pollution is one of the serious growing problems of environmental pollution that affects human health. Day by day, an incessant growth in the number of vehicles and the expanding road network increases road traffic noise. This increasing traffic noise gradually degrades the environmental quality. Road traffic noise has become a major concern for people living in the vicinity of major highway and road corridors(Of et al., 1996). It is causing more disturbances to people in comparison with any other sources. Managing road traffic noise is a big challenging task for urban planners and environmental managers. For the city planning assessment, urban planners often have to rely on road traffic noise prediction models. For managing noise, prediction of noise is needed for the nearby area of the road network. Noise prediction requires major information regarding terrain data (positional information about the building, road, etc.), noise data (of sources), and a prediction model to predict noise levels around different noise sources. Developing any geospatial application requires the collection of geospatial data and attribute information(Gulliver et al., 2015). Sometimes it is very time-consuming to physically visit the place and collect the traffic data to create a Noise map for that particular area. With the advancement in technology, we have come out with promising automated techniques by which time consumption is reduced. Nowadays there are many Open-source geospatial data are largely available in the form of Map APIs.

In this paper, the authors have developed a crowdsourcing platform where any user can participate with their interest. In which users can choose the area according to their interest in creating a noise map. Designing a well-planned model(Subramani and Sivaraj, 2012) for extracting spatial and attribute information. This model can offer the easiest solution for urban planning and applications. By which there is no need for a separate collection of geospatial or attribute information for the project site. This automated model takes google raster maps for city roads and surrounding buildings. For these google maps an algorithm is developed and is tried to be used to extract roads, buildings, vehicles, trees, etc. After extraction of building(s), vehicle(s), tree(s) out of the map, there is a need to classify the vehicles. Various geometrical setups of vehicles in several similar road segments from different cities of UP (India) are classified using Machine learning algorithms. Google map data for 100 different road networks from 4 different cities of UP (India) are taken. Extraction of vehicles is done for 100 google maps. A list of different vehicle geometrical setups is made. Once get the classified geometry setup of vehicles, clustering is needed. Clustering of vehicles mainly done to discuss the types of noise scenes. For the city road network, vehicular clusters are classified into 3 categories, big, small, and isolated clusters. These clusters are further characterized in terms of the range of noise spectra associated with it incorporating field data. Where vehicular cluster is defined in respect of several vehicles, type of vehicle, speed of the vehicle, etc. E.g., Big vehicles such as buses, trucks are considered in the big cluster as they produce a heavy range of noise. Group of small vehicles such as car, scooter, bikes is considered as small cluster and if any of the vehicles are running alone then it is categorized in isolate one. Field data for different vehicles at different speeds and different frequencies are recorded by a Sound Pressure Level meter(Bocher et al., 2019). Noise data for vehicles are recorded for any location mainly done from a crossing. From that, large vehicle such as truck has recorded with the noise of 83.5 dBA, small vehicles such as car have recorded with a value of 60.15 dBA(Zafar et al., 2020). From the recorded data of noise produced by vehicle different noise scenes are


https://doi.org/10.5194/isprs-archives-XLIII-B4-2021-159-2021  

developed for 100 sample data. Noise scenes for different cities of UP (India) are created, these noise scenes are then utilized to predict the noise map. In this paper, a Crowdsource application is implemented. In which a user, who is near the road segment can participate by analyzing the geometrical setup. They can predict the noise by entering the data such as how many vehicles, what type of cluster. Open participation from the user is done to make an accurate noise map for an area. One can watch the traffic scenario and analyze the noise for an instance. From the above-developed model, by analyzing noise scenes the various types of simulated noise maps are predicted. These noise maps are predicted around the road segments on an instantaneous scale, with an estimation of accuracy(R. Dubey et al., 2020). This model can enhance the way for automated modelling and reduce the data different noise scenes are developed for 100 sample data. Noise scenes for different cities of UP (India) are created, these noise scenes are then utilized to predict the noise map. In this paper, a Crowdsource application is implemented. In which a user, who is near the road segment can participate by analysing the geometrical setup. They can predict the noise by entering the data such as how much number of vehicles, what type of cluster. Open participation from user is done in order to make accurate noise map for an area. One can watch the traffic scenario and analyse the noise for an instance. From the above developed model, by analysing noise scenes the various types of simulated noise maps are predicted. These noise maps are predicted around the road segments in an instantaneous scale, with an estimation of accuracy. This model can enhance the way for automated modelling and reduce the data dependency.

## 2. METHODOLOGY

A method is planned for the determination of an automated noise map instead of using data collection which helps limit data dependency. The methodology defines in several steps as follow: -

Step 1- Initially, it starts with collecting a google map of road traffic crossing of 100 different locations of different cities. Analyzing road traffic of these 100 google map locations.

Step 2- After analyzing the traffic, maps are tried to be used to extract roads, buildings, vehicles, trees. From the list of lists of 100 google images, different geometrical setups of vehicles in several similar road segments from different cities of UP (India) are classified using Machine learning. Extraction of vehicles from the google map image will draw a scene for a study of the road traffic pattern.

Step 3- As from the map, vehicles are classified using three different clusters. These clusters are small, large, and isolated. Based on clustering, traffic is classified and details are recorded for 100 google map images. From this, a range of noise values for each cluster is assigned, depending on how much noise is produced by bike, car, autorickshaw, truck.

Step 4-This step will finally provide you the noise range data from that one can see and analyze the type of vehicle clusters and assign with the pre-set cluster value. At instant road traffic is analyzed and the classification of vehicles is carried out. Assigning values to the road after analyzing traffic/vehicle clusters for an area for which an instant noise map is required.
Step 5- A crowdsourced platform is created in which the user can analyze the traffic then provide the noise range after counting the clusters on the road at that instant.

Step 6-Assigning values to the cluster as mentioned in step 4 to the traffic analyzed in Step 5.

Step 7- For the Generation of Noise map of a particular area LiDAR data is used which comes as a point cloud that contains x, y,z without any direct information on terrain features like building, ground, vegetation, etc. So, the processing of data required the extraction of the terrain points, which obstruct and/or control the transmission of a Noise.

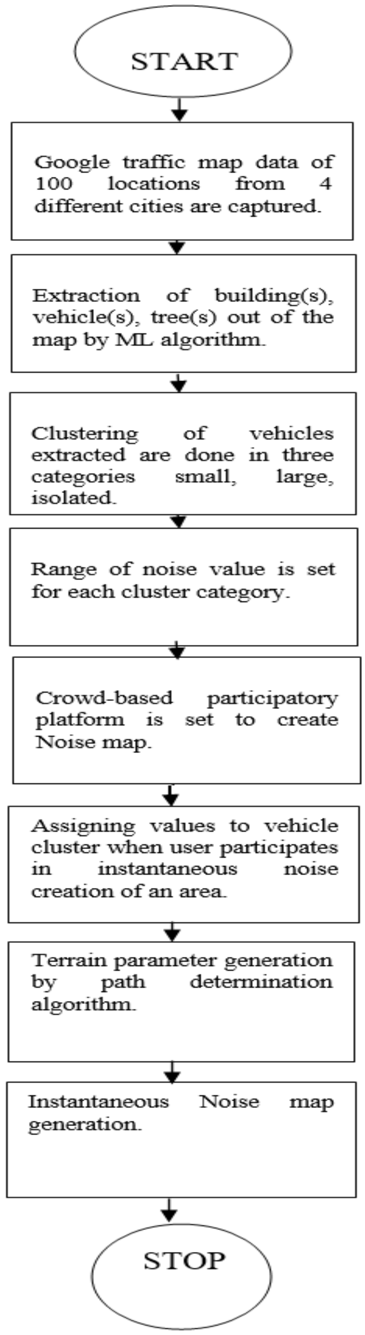


Figure 1. Methodology Flow chart.

Step 8- Path determination requires clear information about the boundary of the building or edges and other obstacles present between the source and receiver. Proper corners and edges of buildings or obstacles are determined which are coming in the possible paths between the source and receiver location. A plane cutting technique is used for the determination of paths(Biswas and Lohani, 2008). For the indirect path scenario of noise transmission, first, the path over the top of buildings is tried to be determined, then paths around the sides of the buildings are tried to be determined (Shruti Bharadwaj et al., 2020). The reflective paths are evaluated considering reflection from the ground as well as walls of barriers and assumed to follow Snell's law. Once the detailed noise transmission paths are determined the attenuations (loss of noise strengths) due to atmosphere, barrier, walls, etc. are tried to be determined.

Step 9-Instantaneous map generation is done in the last step.

## 3. RESULTS AND DISCUSSION

The proposed methodology worked on different levels starting with Google traffic map data acquisition, feature extraction by ML algorithm, clustering of the vehicle and determine noise range of cluster, user-based participatory platform, path determination, and Instantaneous noise map generation. The Stepwise procedure is given below with performance: -.

### 3.1 Google traffic map data Acquisition

Google maps images of 100 Traffic road crossing are collected from 4 different cities like Agra, Kanpur, Lucknow, Raebareli (INDIA). These google images are taken so that a wide study can be carried out on the different patterns of traffic at Road crossing where we can see multiple types of traffic patterns. Out of 100 such images, some images are shown in Figure 2.

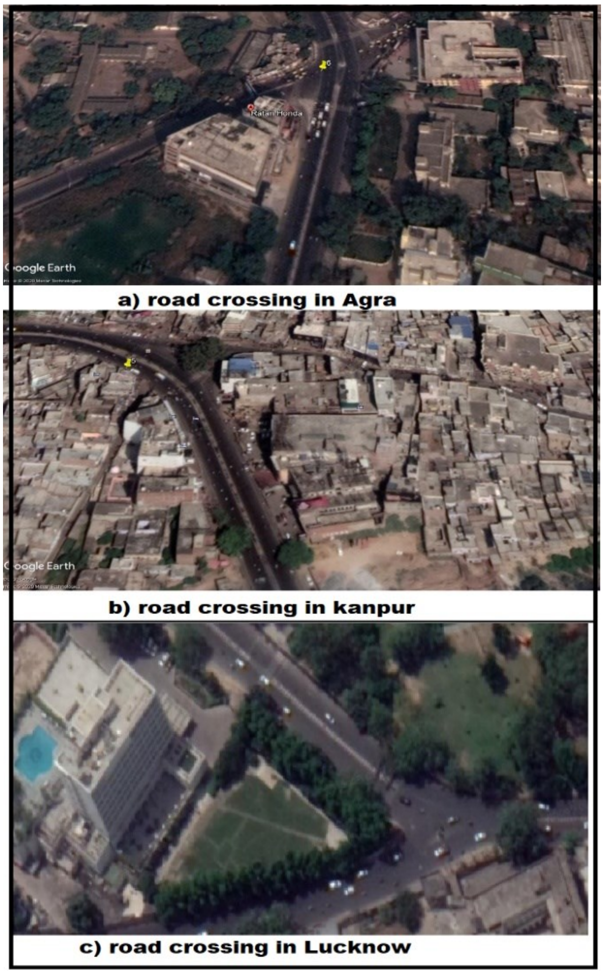


Figure 2. Google map road crossing image

### 3.2 Extraction of Features using ML algorithm

After collecting 100 different traffic pattern images at road crossing from Google maps. Now the challenging task is to classify different traffic patterns based on the speed and size of the vehicle. This will be carried out by first extract features such as building(s), tree(s), vehicles(s), vegetation(s)(Song and Civco, 2004). These features are extracted by developing a supervised classification algorithm (Chen et al., 2009) which used color and shape image retrieval along with the Support vector machine algorithm for different features like for car there is green classified color, for building red color, for trees green color, for water with blue color and road grey color. Here classification of one image (that is Figure 3) is shown in Figure 4. Likewise, for all 100 images classification is done in the same pattern.

Figure 3. Image to show feature extraction using ML algorithm

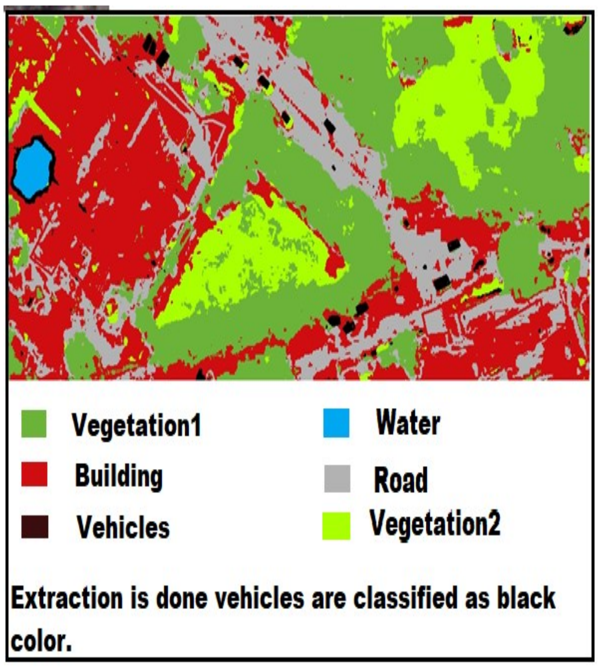


Figure 4. Classified image.

### 3.3 Clustering of the vehicle and determine noise range of cluster

Extraction in previous point gives the detailed classification of features that are building(s), tree(s), vehicle(s), road, vegetation(s).

**3.3.1 Clustering of vehicle**: Extracted vehicles from the image are now classified based on the size and speed of the vehicle. The size of vehicles is a small vehicle and a large vehicle. Small included bike, auto-rickshaw, scooter, and car. The large vehicle includes a car, bus, etc. Noise values for different small and large vehicles are recorded by the Sound Pressure Level meter from a nearby crossing(Rakesh Dubey et al., 2020). Such as for scooter noise is recorded as (35 dB at high frequency, 41 at medium and 45.5 at low frequency), for the car (47.4 dB at high frequency, 58.3 at medium and 65 at low frequency), for the truck ((56.4 dB at high frequency, 75.1 at medium and 83.1 at low frequency). These vehicles on road are moving together like (two cars and 2 buses), (one car, one bike, and one truck). Several vehicle pairs are possible.

These possible pairs are now determined in three different clusters that are small cluster, large cluster, and isolated one is shown in Figure 5. The small cluster includes small vehicles such as cars, scooters, bikes, auto-rickshaws keeping the distance between vehicles in mind. For vehicles distance, more than 5m are considered in the different cluster and several vehicles in cluster depend on the dB sum of the noise of all vehicle if the dB sum of vehicles in a small cluster greater than the dB value of a big vehicle then that cluster will be considered in a large cluster. An isolated cluster is a cluster that contains 1 single vehicle it may be a car, scooter, truck, and bus.

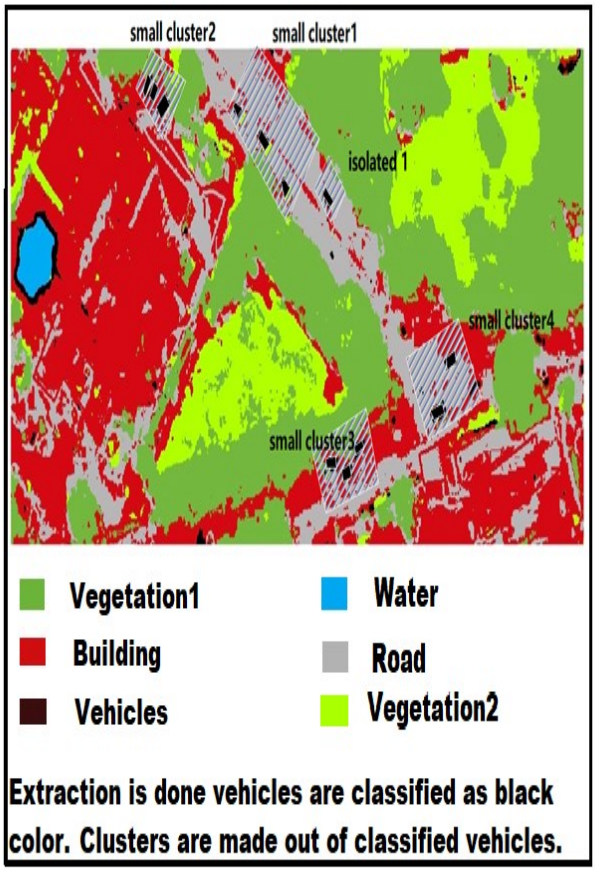


Figure 5. Cluster formation from classified vehicles.

**3.3.2 Determine Noise range of vehicle cluster**: For determining the range of Noise for vehicle cluster. On-road site there is a combination of clusters they are like (2 small, 1 large, 1 isolated), (3 small, 2 large), etc. The total number of clusters (number of the small, large, isolated cluster) of 100 google map road crossing images are categorized in the table. E.g., One of the road crossing locations contains 3 small, 1 large, 2 isolated clusters. By seeing the effect of the cluster at a different frequency can set a range for small, large, isolate cluster. The effect of source noise on receivers' points can be determined by path calculation of noise transmission from source to receiver. For understanding the effect of cluster noises on area receivers first have to understand path determination.

| No. | Place | | Class cluster | | |
|---|---|---|---|---|---|
| | | | Small class | Large class | Isolated class |
| 1 | Bgwan Takies Crossing | 100x15 | 2 | 1 | 0 |
| 2 | Raja Ki Mandi Crossing Agra | 100x15 | 3 | 1 | 1 |
| 3 | Pachkuiya Crossing Agra | 100x15 | 3 | 0 | 2 |
| 4 | Idgah Railway Crossing Chauraha | 100x15 | 4 | 1 | 1 |
| 5 | Subhas Nagar Market Chauraha | 100x15 | 4 | 1 | 4 |
| 6 | Ratan Honda Chauraha | 100x20 | 0 | 2 | 3 |
| 7 | Arjun Nagar Chauraha | 100x15 | 4 | 0 | 2 |
| 8 | Kothi Meena Bazar | 100x15 | 1 | 0 | 5 |
| 9 | Sadar Bazar Agra | 100x15 | 1 | 0 | 3 |
| 10 | Madhu Nagar Agra | 100x15 | 1 | 2 | 0 |

Table 1: Clustered data report for different locations

### 3.4 Path determination

For understanding the noise strength at different locations from the source location, there is a need to understand the transmission manner of noise from one location to another. When propagating from one location to another, noise follows direct transmission or indirect transmission (through diffraction, reflection). The different paths are as follow: -

**3.4.1 Direct path**: Direct path is the path that is estimated initially when there is no obstruction between the source (road) and Receiver location.

**3.4.2 A path over the top of the building**: Signal path over the top of the building is determined in the following steps: -

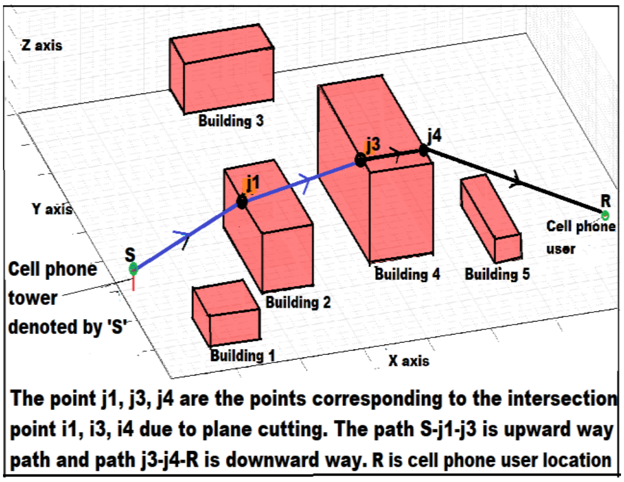


Figure 6. A signal path over the top of buildings(S. Bharadwaj et al., 2020)

**3.4.3 A path around the sides of the building**: Signal path around the sides of building and obstruction is determined in the following steps: -

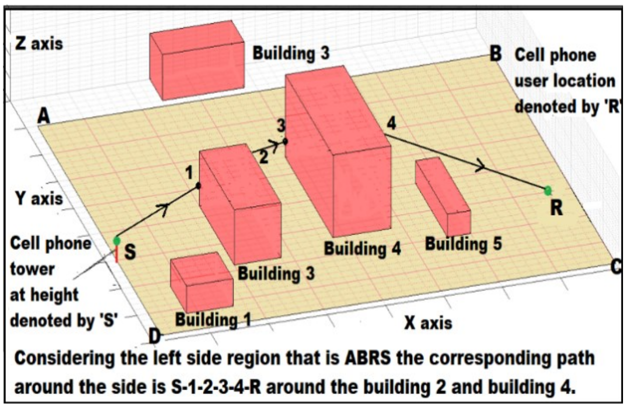


Figure 7. A signal path around the left side of the building(S. Bharadwaj et al., 2020)

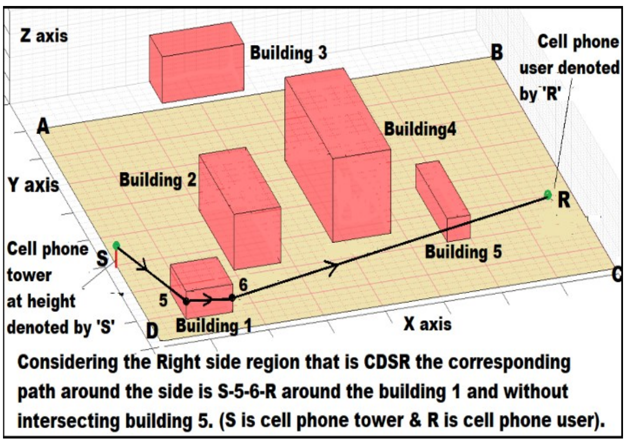


Figure 8. A signal path around the right side of the building(S. Bharadwaj et al., 2020)

**3.4.4 Path due to reflection**: Signal during propagation reflects from ground and wall of buildings forms the reflection path of the signal. These paths are determined by the following steps: -

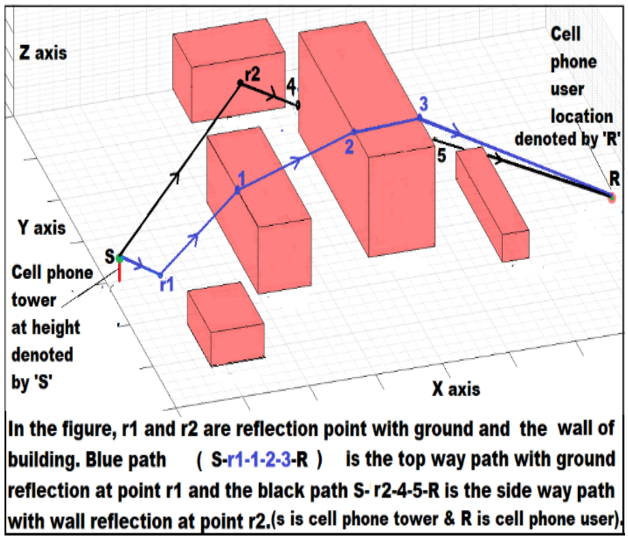


Figure 9. Signal path due to reflection(S. Bharadwaj et al., 2020)

### 3.5 User-based Participatory platform

After understanding the concept of path determination, the effect of clusters noises on surrounding receivers in that area. The noise strength at receiver location from the cluster is calculated and analysed in a different way such as:

**3.5.1 Small cluster:** Noise strength at the receiver from a small cluster at three different frequency (low, medium, and high) for an area of Agra city is shown in Figure 11, Figure 12, Figure 13: -

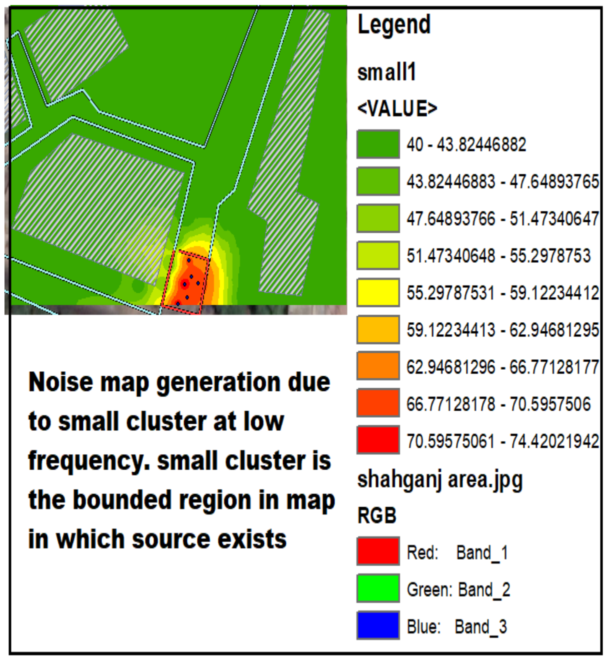


Figure 10. Noise map for the small cluster at low freq. 31.5 Hz.


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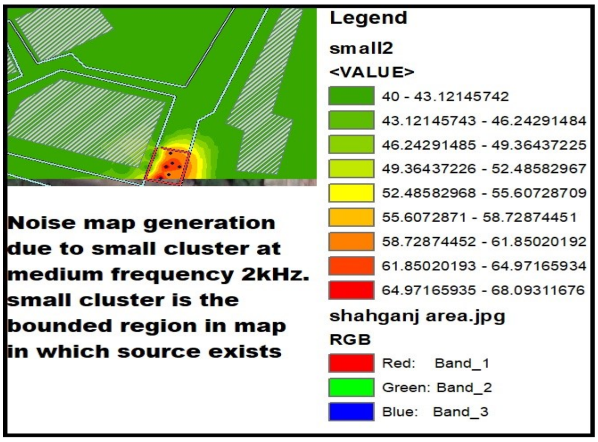



Figure 11. Noise map for the small cluster at medium freq. 2kHz.

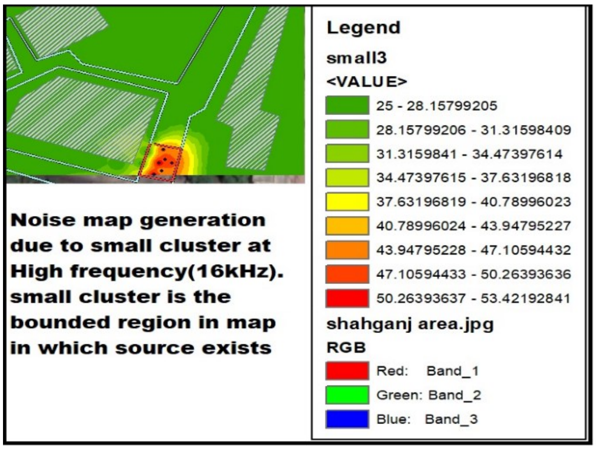



Figure 12. Noise map for the small cluster at large freq. 16 kHz.

**3.5.2 Large cluster**: Noise strength at the receiver from the large cluster at (low frequency) is shown in figure 14.

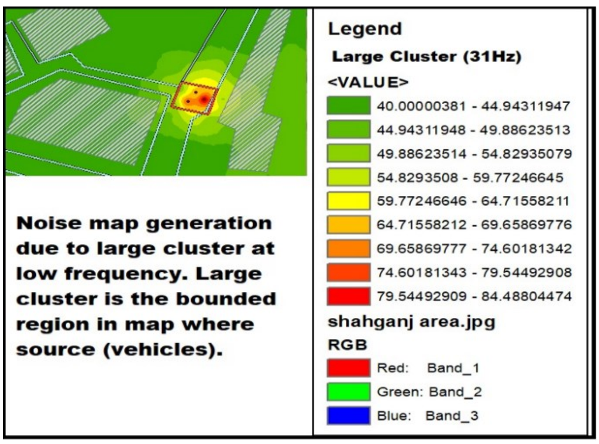



Figure 13. Noise map for the large cluster at large freq. 16 kHz.

**3.5.3 Combination cluster:** A combination cluster means a combination of the cluster it may be small, large, isolated. Two combinations are the first one is shown in figure 15 it is a combination of small and large clusters and the second one is the combination of all three (small, large, isolated) shown in figure 16.

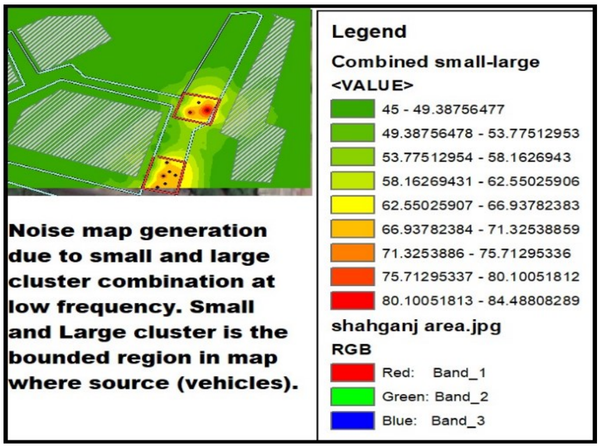



Figure 14. Noise map for the combination of the small and large cluster at low freq. 31.5Hz.

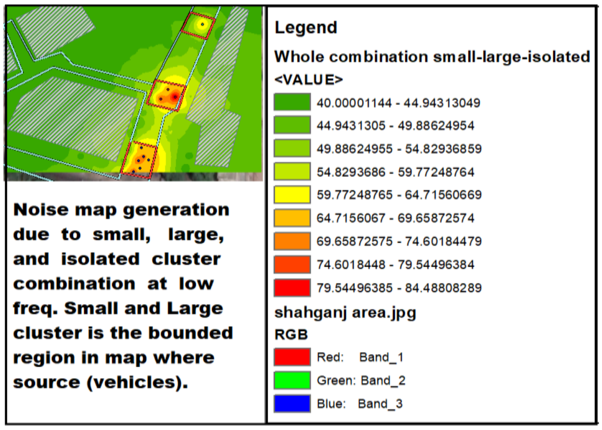



Figure 15. Noise map for a combination of the small, large, and isolated clusters at low freq. 31.5Hz.

### 3.6 Instantaneous noise map

For an instantaneous measurement of Noise strength, there is no need to carrying SPL for recording value of dB values. Users can generate a map by just analyzing the road traffic describing that scenario in the type of cluster present and apply path determination. For the location of Lucknow (INDIA), we have developed an instantaneous noise map after collecting data from SPL at road crossing shown in Figure 18. Now from automated data integration, two cases are taken here that are shown in Table 1 and Table 2.

| Case 1 | | | |
|---|---|---|---|
| time | dB value frequency(31.5 Hz) | dB value frequency(2 KHz) | dB value frequency(16K Hz) |
| 10 min | 84.5 | 76.4 | 56.1 |
| 45 min | 70.8 | 65 | 59.1 |
| 5 min | 65 | 58 | 47.1 |

Table 2. Case 1 data for L calculation

For case 1 equivalent noise levels for different frequencies and noise maps are shown in Figure 17.

1.L(equivalent) defines as

$$L_{eq} = 10log \sum_{i=1}^{i=n} 10^{\frac{L_i}{10}} X\, t_1$$

(n= total number of sound samples, $L_i$ is noise level of any ith sample, t is the time duration expressed as a fraction of total sample time).

2. Low-frequency low

$$L_{eq}(1) = 10\log[10^{\frac{94.5}{10}} X \frac{10}{60} + 10^{\frac{70.8}{10}} X \frac{45}{60} + 10^{\frac{65}{10}} X \frac{5}{60}]$$

= 10log [46.973 x 10^6 + 9.016 x 10^6 + 2.635 x 10^6]

=77.68 dB

3.Medium frequency

$$L_{eq}(2) = 10log[10^{\frac{76.4}{10}} X \frac{10}{60} + 10^{\frac{65}{10}} X \frac{45}{60} + 10^{\frac{58}{10}} X \frac{5}{60}]$$

=69.8675dB

4.Medium frequency $L_{eq}(3)$

$$L_{eq}(3) = 10log[10^{\frac{56.1}{10}} X \frac{10}{60} + 10^{\frac{59.1}{10}} X \frac{45}{60} + 10^{\frac{47.1}{10}} X \frac{5}{60}]$$

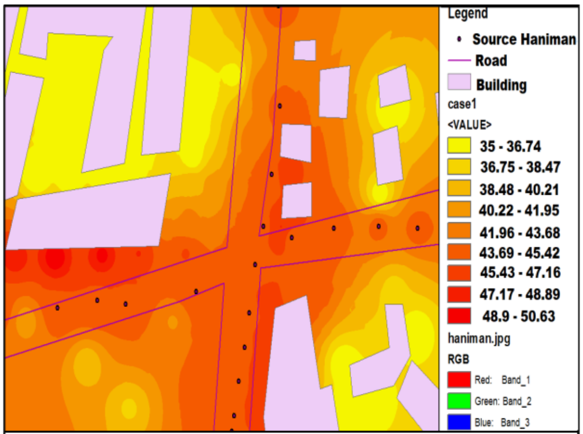
=58.3365dB

(Case1) Total L
=10*LOG10((10^($L_{eq}$(1)/10)+10^($L_{eq}$(2)/10)+10^($L_{eq}$(3)/10))
= 78.388 Db

| Case 2 | | | |
|---|---|---|---|
| time | dB value frequency(31.5Hz) | dB value frequency(2KHz) | dB value frequency(16KHz) |
| 20 min | 74.5 | 67.1 | 53.5 |
| 25 min | 81.2 | 73.4 | 59.2 |
| 15 min | 62.3 | 55.1 | 45 |

Table 3: Case 2 data for L calculation

In figure. 16 shows the case 1 scenario noise map where the user analyzes the traffic type which depends on the time interval when the vehicle is on the road.




Noise map for the case 1(when user analyse a traffic type which is depend on time interval in which vehicle is on road at what speed) where the L value is 78.388 dB uniform at whole road. Location is at Lucknow (INDIA).

Figure 16. Noise strength for case 1 scenario

Similarly, for Case 2 Noise map is shown in Figure 18.

1. Low frequency

$$L_{eq}(1) = 10\log[10^{\frac{74.5}{10}} X \frac{20}{60} + 10^{\frac{81.2}{10}} X \frac{25}{60} + 10^{\frac{62.3}{10}} X \frac{15}{60}]$$

=80.158 dB

2. Medium frequency

$$L_{eq}(2) = 10\log[10^{\frac{67.1}{10}} X \frac{20}{60} + 10^{\frac{73.4}{10}} X \frac{25}{60} + 10^{\frac{55.1}{10}} X \frac{15}{60}]$$

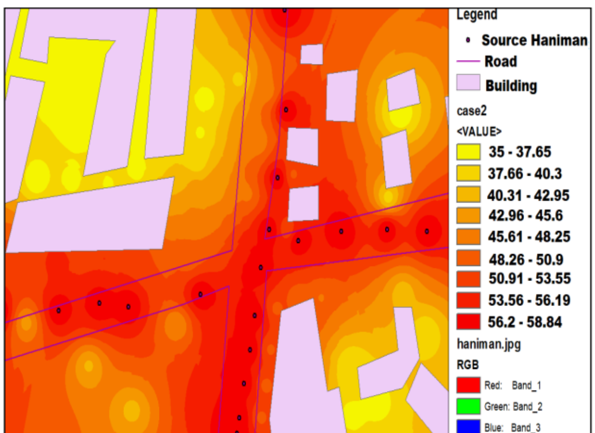
= 72.377dB

3. High frequency

$$L_{eq}(3) = 10\log[10^{\frac{53.5}{10}} X \frac{20}{60} + 10^{\frac{59.2}{10}} X \frac{25}{60} + 10^{\frac{45}{10}} X \frac{15}{60}]$$

=58.220176dB

Total L(case2) =
=10*LOG10((10^($L_{eq}$(1)/10)+10^($L_{eq}$(2)/10)+10^($L_{eq}$(3)/10))
= 81.844 dB




Noise map for the case 2(when user analyse a traffic type which is depend on time interval in which vehicle is on road at what speed) where the L value is 81.844 dB uniform at whole road. Location is at Lucknow (INDIA).

Figure 17. Noise strength for case 2 scenario

Noise map created by using SPL for data collection of points all over the road at an instant is shown in Figure 19. and compared with the two scenarios of live road traffic. The instantaneous map lies in the range of the noise map created by the automated version.

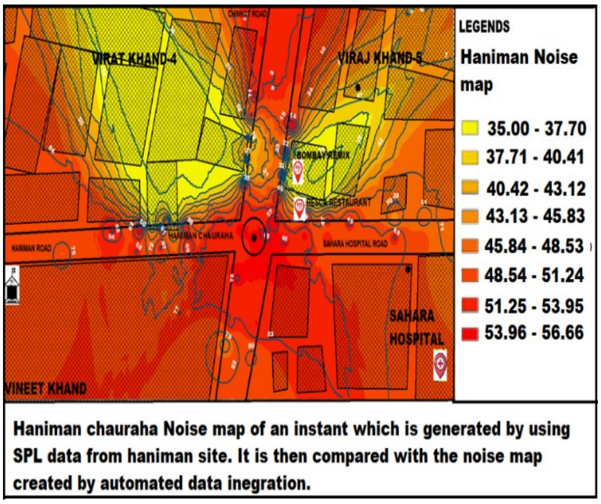



Figure 18. Noise strength of Haniman Chauraha Lucknow (INDIA) (R. Dubey et al., 2020)

## 4. CONCLUSION

The authors have reviewed the work of various researchers working in Road traffic noise areas. The challenge of noise generation for large areas of cities is tried to be handled based on automated noise map generation. Authors have tried to compare the traditional noise generation technique which includes onsite noise data collection with the automated version. The approach involved two calculation: one by the traditional method which is shown in Figure 18 and another one is for two instants, the noise map for these two instants are generated by analyzing the traffic data by the user. And the results in this work clearly show that both the traditional map and automated noise map are similar in range. This study will give strong support to automated noise generation that will surely reduce data dependency.

## 5. FUTURE WORK

The users will be able to ascertain the likely impacts by using automated noise generation by analyzing the road traffic. Thus, it can be applied to any location. Users can get detailed information about noise ambiance at the desired place. For further study, the author would like to add a web platform where users can participate and add their noise experiences one after other. This will provide us an accurate map of a particular area.

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