Measuring and Mapping Traffic Noise Level of Islamabad City

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APPROVAL SHEET

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We hereby declare that we (Muhammad Ali, Subhan Sajid, Muhammad Hamza Baig and Rana Muhammad Ali Washakh (Team Leader)) are the sole authors of this thesis and the work has not been published anywhere else before.

This is the true copy of the thesis, including required any final revisions, as accepted by the examiners.

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iii. List of Abbreviations:

GIS	Geographical Information System
IDW	Inverse Distance Weightage
SLM	Sound Level Meter
dB	Decibels

Abstract

Noise map for Islamabad city has been generated in this study to identify the areas prone to excessive noise levels and to recommend mitigation measures to control this rapidly growing problem. The noise levels over the area were varying. Noise levels were higher in peak hours when there was a high traffic flow and lower in off-peak hours when the traffic flow was reduced. Correlation between noise levels and number of vehicles was also been derived to observe the effect of number of vehicles on noise levels. Noise maps generated for Islamabad city can play a vital role in sustainable urban planning, where a cost-benefit investigation of diverse options can be assessed before taking any decision.

Chapter 1

Introduction

1.1: What is Noise pollution?

Noise pollution is the distressing or extreme noise that may cause impairment of the activity or equilibrium of human or animal life. Machines, transportation system and aircraft are the worldwide sources of noise **(Loto et al., 2012).** Inadequate urban planning may give rise to noise pollution. In the residential areas, industrial and residential buildings built alongside can be a consequence in noise pollution **(Barton 2013).** Noise pollution takes place when there is too much amount of noise or a repulsive sound that causes momentary disturbance in the natural balance. This statement is usually applicable to sounds or noises that are aberrant in either their size or their production. Nowadays environment is such that it has become intricate to avoid noise. For example, the electrical appliances at home have a steady buzz or beeping sound **(Vines et al., 1984)**. Exposure to superfluous sounds has increased due to lack of urban planning. That is why noise pollution is crucial to restrain it in time.

1.2: Causes of Noise Pollution

1.2.1: Industrialization:

Majority of the industries use machinery which produce immense amount of noise. Despite the industries various machines like generators, compressors, exhaust fans, the grinding mills also contribute in emitting massive noise **(Maxfield, 1990)**. Workers in factories and industries are provided with ear plugs by the health and safety department to minimize the effect of noise.

1.2.2: Poor Urban Planning:

The developing countries which have meager urban planning could have played essential role in reduction of noise. Crammed residencies, large population sharing small space, fighting over basic facilities escort to noise pollution which may disturb the environment of public **(Moudon, 2009).**

1.2.3: Social Events:

In most of the social events noise is at its crest. For Instance if there is a religious ceremony, wedding ceremony or a party, people disobey rules set by the local administration and create annoyance in the surrounding area. Songs being played by some people in a very high volume till midnight affects the quality of life of people living in nearby areas. In Shopping center and markets, people are promoting their brand and shops through loud noise to fascinate the attention of people. **(Van Lange, 2002)**

1.2.4: Transportation:

Aero plane flying over houses, underground trains generate tremendous amount of noise and large number of vehicles on roads, people living nearby in such areas are disturbed with such exposure of noise. The continuous exposure to high noise leads hearing problems **(Bae et al., 2004).**

1.2.5: Construction Activities:

Noise is usually produced during construction of road, construction of dams, bridges, buildings, roads, stations, flyovers and mining which is being done approximately everywhere in the world. These construction require heavy equipment and these machines are too noisy **(Quince, 2011).**

1.2.6: Household Chores:

In Our daily life we use Devices like mobile phone, washing machine, Television, mixer grinder, pressure cooker, vacuum cleaners and dryer, cooler, air conditioners are although minute source of noise but they effect the surrounding of neighborhood in an adverse way **(Miedema, 1999).**

1.3: Effects of Noise Pollution

1.3.1: Hearing Problems:

Any redundant sound that our ears have not been built to sift can affect our body. Noise created from machinery, horns, airplanes and even vehicles can be too deafening for our audible range. Continuous experience to immense noise levels can result in the loss of hearing and is harmful to our ear drums. It also reduces our sensitivity to sounds that our ears usually pick up to normalize our body's rhythm **(Burns 1970).**

1.3.2: Health Issues:

Continuous noise pollution in workplace such as construction sites, offices, and even in our homes can cause psychological health impacts. Studies have revealed that constant stress, aggression, sleep disturbance, hypertension and fatigue and can be connected to extreme noise levels. This further can cause more harsh and persistent health issues later in life **(Plomp 1994)**.

1.3.3: Sleeping Disorders:

Strident noise can definitely hinder your sleeping precedent and may lead to exasperation and frustrating situations. Lack of good night sleep, may lead to problems related to exhaustion and your performance at home and office will be effected. So we should take sound sleep to give proper rest to body **(Xie, 2009).**

1.3.4: Cardiovascular Issues:

Noise Pollution causes certain ailments in humans. It destroys the peace of mind. The noise pollution is recognized as dominating factor in escalating the existing strains of modern living. Cardio-vascular disease, blood pressure levels, and stress related heart problems are growing. High noise levels cause high blood pressure and increases heart beat rate as it turmoil's the normal blood flow **(Van Kempen, 2002).**

1.3.5: Trouble in Communicating:

High noise level can put trouble and may cause trouble for people to communicate. This heads to misapprehension and it creates difficult in understanding the other person. Invariable incisive noise can give you ascetic headache and affect your emotional balance **(Blachman, 1982).**

1.3.6: Effect on Wildlife:

Wildlife has confronted more havoc due to noise pollution since animal are more relying and depending on sound. Animals have matured a better sense of hearing than us as their survival depends on it. The ailing effects of extreme noise begin at home. Pets behave more violently in houses where there is consistent sound. In nature, it may undergo from hearing loss, which makes them unpretentiously easy to prey and heads to declining of population. Animals become inept at hunting, disquieting the equilibrium of the flora and fauna. Genus that depend on comrade calls to reproduce are often incapable to hear these calls due to extreme man made noise. Consequently, they are unable to produce offspring and cause degeneration of populations. Some animals necessitate sound waves to echo-locate and acquire their way when migrating. Disconcerting their sound gesticulation means they get disoriented simply and don't migrate when they should. To manage with the escalating sound around them, animals are becoming boisterous, which may auxiliary put in to the pollution levels. This is why considering noise pollution can assist us subordinate the brunt it has on the environment. Currently, much elucidation does not subsist to diminish sound pollution. Individually everyone can ameliorate the noise in their homes by lowering the sound of the television, music system and the radio. Listening to melodies with headphones is also an excellent step forward. Amputation of loudspeakers is alternative way in which the pollution can be contradicted. Improved urban planning can facilitate in creating noise free societies. It is only when our perceptive about noise pollution is inclusive and then we can take action to eliminate it absolutely **(Chan 2011).**

Chapter 2
Literature Review

2.1: Measurement of Noise

The meter was held 1.3 to 1.5 m above the ground surface and 3.0 to 3.5 m away from reflecting surface, if any. Noise sampling was done for each sampling location. Measurements were taken continuously for the period of ten days, seven hours of monitoring per day and one hour after every hour of measurement. The scheduling done for sampling was like for morning sampling hours were 10.00-11.00 a.m., for afternoon it was taken as 12.00-1.00 p.m. and 2.00-3.00 p.m., for evening 4.00-5.00 p.m., 6.00-7.00 p.m. and 8.00-9.00 p.m. and for night it was selected as 10.00-11.00 p.m. The night readings acted as a control. The noise levels were recorded for each hour, after every two minutes and so, recorded 30 readings for every hour. The data collected from each location was processed for statistical analysis.

(Assessment of noise pollution indices in the city of Kolhapur, India)

The sound level meter was mounted on a stand at a height of 1.2m above the ground level and located at about a distance of 7.5 m from the center line of the roadway during interrupted traffic flow conditions. Various noise parameters, i.e., $L10$, $L50$, $L90$, Leq, Lnp, and TNI were recorded in DBA scale at intervals of 10 min. O'Cinneide stated that $L10$ indicates the upper end of the level range, while $L90$ includes the background noise level in the absence of nearby noise sources.

(Comprehensive approach for the development of traffic noise prediction model for Jaipur city)

The noise meter was held at a height of 1.5m above the ground. The noise level index that was measured is the $L10$(1 h). Measurements were recorded twice a day i.e. from 07:00a.m to 08:00a.m during the early morning peak hour and from 07:00p.m to 08:00p.m during the early evening peak hour. It should be noted that all the noise measurements were taken during weekdays in the summer span when the streets were dry.

(Evaluation of traffic noise pollution in Amman, Jordan)

The noise measurements were taken as recommended by the Brazilian Standard for noise assessment and also followed the recommendations of Parts 1 and 2 of the ISO 1996 standard. The equipment and software program used in the noise measurement analysis were sound analyzers (B&K 2238 and B&K 2250), and Predictor 8.11 software for acoustic map calculations. All the noise measurements were taken in good weather (without rain or strong wind). The measurements were taken at the daytime (07:01 to 19:00), between April and August 2012, with simultaneous traffic counts at different times on week days.

(Evaluation of noise pollution in urban traffic hubs-Noise maps and measurements)

Researchers of the study measured noise levels from 7:00 – 9:00 a.m (peak hours) and from 9:00 a.m to 6:00 p.m (off-peak hours. Although previous studies have produced noise maps at a height of 4 m above the terrain following the Directive 2002/49/EC , the present study has proposed conducting a noise mapping at a height of 1.5 m. Considering that the city has many one-story buildings, and that verification measurements are performed at this height (allowing for direct comparison between modeled and measured noise values),modeling at 1.5 m was the most appropriate alternative.

(Evaluation of noise pollution in urban traffic hubs—Noise maps and measurements)

- **Classification of zones**

1. Educational zone

Being the capital of the country, there are a lot of higher educational institutes located in Islamabad. Educational institutes require a safe limit of noise levels and are considered as silence zones. So the educational institutes are placed in sensitive sites category.

2. Commercial-cum-residential Zone

Mixed area consists of large number of shops and human dwellings. Being a developing country, we have a lot of such kind of areas in a city. Commercial as well as residential activities go together is such areas and thus the cumulative effect of noise levels is enhanced.

3. Industrial-cum-residential zone

Mixed area mainly consists of large number of small scale industrial units and human dwellings. Industrial activities including machinery operation and transporting stuff causes the noise levels to breach the safe limit.

4. Recreational zone

Peripheral parts of lake surrounded by roads; enormous traffic noise thereby impeding people's enjoyment. Being a recreational spot, it is considered to be a silence zone

5. Silence zone

Quiet area and acted as control in their studies

(Sampling locations for noise pollution monitoring in Kolhapur)

Equations for calculation of average noise level

Following equations were used to compute the noise pollution indices.

Leq = 20*log10*∑(10^(R1/20)+… 10^(Rn/20)/n

R1 = First reading

n = Total number of reading

2.2: Noise mapping calculations

The calculations to obtain acoustic maps require the demarcation of an area of calculation. After this step, the Predictor software generates a grid noise map whose distance between points on the grid is defined by the user. Grids of 15 × 15 m or 20 × 20 m generate acceptable approximations, with the advantage of greater processing speed, but may sacrifice some of the details of results in more densely populated areas. Thus, the grid size adopted here was 10 × 10 m. For maps of noise sensitive areas such as hospitals, the grid resolution was 2 × 2 m. The height of the grid was 4 m, as recommended by the Environmental Noise Directive.

(Evaluation of noise pollution in urban traffic hubs—Noise maps and measurements)

2.3: Methodology for GIS Map

A GIS database was developed using Arc GIS 9.3, and it contained topography, building- and transportation-related information, and population. The examples of GIS database for buildings with population and traffic, respectively. Speed limit for individual road was adopted as vehicle speed for noise mapping. A 3-dimensional urban spatial model which includes buildings, topography, roads and position information of noise sources and the traffic information including volume, speed and vehicle type, should be provided for noise map development. The height value of lattice points were obtained by conducting contour line extraction, altitude point layer extraction, contour point generation, grid generation and interpolation using digital maps. A topography model was developed using the

lattice points. The building models were generated using the information in digital and draft maps.

Acoustic maps are very useful tools for diagnosing and evaluating urban noise levels. Noise maps of a given area are calculated based on a number of geometrical, physical, traffic and acoustic parameters. Geo referenced cartographic data, such as topography (contour lines at 5-meter intervals), the street layout and ortho photo maps of the region were obtained from a database called Curitiba Digital—Edition 2006/CD, from the Curitiba Institute for Urban Research and Planning, and were imported into the Predictor software. The vehicle counting was done manually and simultaneously with the measurements of equivalent sound levels, Leq, and each measurement was taken for 10 min.

2.4: Software Package Approach, Geo statistical Approach & Noise Source Attenuation Approach

An undisclosed interpolation method was used in GIS to make a noise map in Turkey. The researchers used both point and line sources and created the maps shown in Figure below.

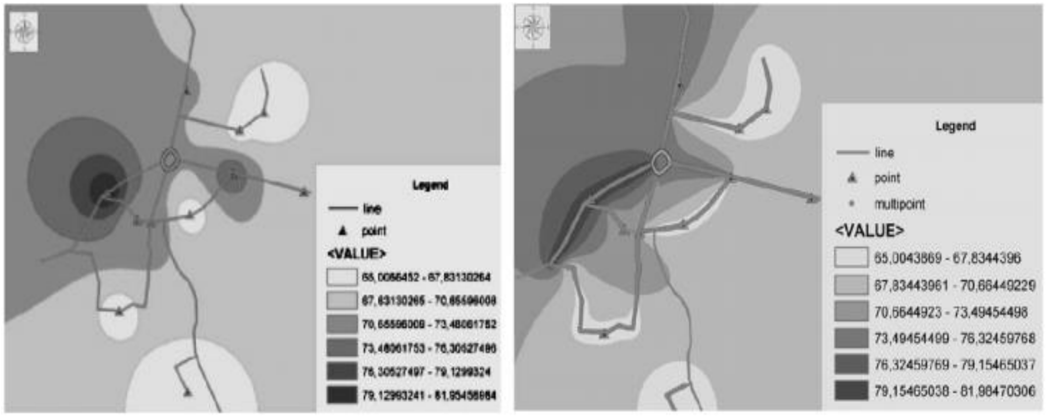

Fig 1: Point and Line Source Maps (Yilmaz 2006)

The maps above use highways as point and line sources for traffic noise in Turkey, interpolated with common GIS tools (Yilmaz 2006). These were designed for contiguous data such as air temperature or soil pH. Phenomena like that are spatially auto-correlated, meaning that nearby points are more similar to each other than more distant ones. Although this is also nominally true for noise, there is technically more going on than that. Sound propagation and combination behave differently than either temperature or soil pH. The maps below use economic activities as point sources and roads as line sources in Brazil. A new set of GIS based tools were developed by researchers in Brazil using the sound attenuation equations and concepts described earlier (Piedade 1999). An example of the maps created with this approach is shown in Figure below. Note that these maps are at a much larger scale (showing a smaller area) than those pictured above. This is because the sound attenuation rules state that sound decreases by six decibels every time the distance from the source doubles.

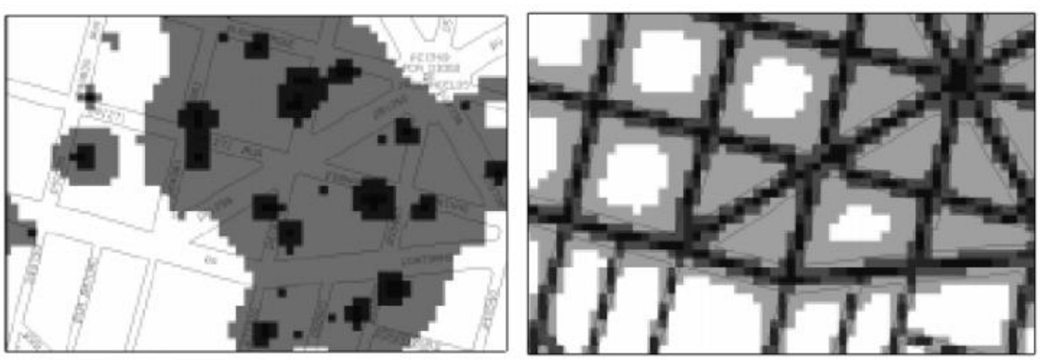

Fig 2: Point and Line Source Maps (Piedade 1999)

2.5: Tools in the Interpolation toolset:

IDW & Kriging tools are used in a combination as Inverse distance weighted (IDW) interpolation determines cell values using a linearly weighted combination of a set of sample points. The weight is a function of inverse distance. The surface being interpolated should be that of a locationally dependent variable.

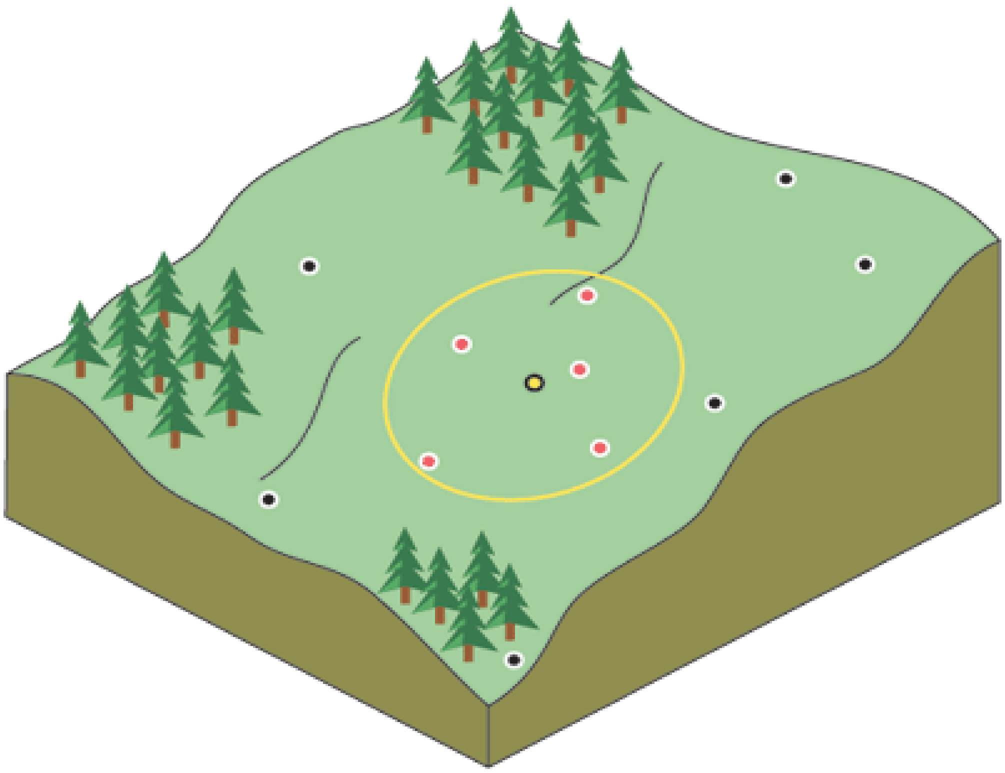

Fig 3: IDW neighborhood for selected point

This method assumes that the variable being mapped decreases in influence with distance from its sampled location. For example, when interpolating a surface of consumer purchasing power for a retail site analysis, the purchasing power of a more distant location will have less influence because people are more likely to shop closer to home.

2.5.1: Controlling the influence with the Power parameter

IDW relies mainly on the inverse of the distance raised to a mathematical power. The Power parameter lets you control the significance of known points on the interpolated values based on their distance from the output point. It is a positive, real number, and its default value is 2.

By defining a higher power value, more emphasis can be put on the nearest points. Thus, nearby data will have the most influence, and the surface will have more detail (be less smooth). As the power increases, the interpolated values begin to approach the value of the nearest sample point. Specifying a lower value for power will give more influence to surrounding points that are farther away, resulting in a smoother surface.

Since the IDW formula is not linked to any real physical process, there is no way to determine that a particular power value is too large. As a general guideline, a power of 30 would be considered extremely large and thus of questionable use. Also keep in mind that if the distances or the power value are large, the results may be incorrect.

An optimal value for the power can be considered to be where the minimum mean absolute error is at its lowest. ArcGIS Geo statistical Analyst provides a way to investigate this.

- **Limiting the points used for interpolation**

The characteristics of the interpolated surface can also be controlled by limiting the input points used in the calculation of each output cell value. Limiting the number of input points considered can improve processing speeds. Also consider that input points far away from the cell location where the prediction is being made may have poor or no spatial correlation, so there may be reason to eliminate them from the calculation.

You can specify the number of points to use directly, or specify a fixed radius within which points will be included in the interpolation.

- Variable search radius

With a variable search radius, the number of points used in calculating the value of the interpolated cell is specified, which makes the radius distance vary for each interpolated cell, depending on how far it has to search around each interpolated cell to reach the specified number of input points. Thus, some neighborhoods will be small and others will be large, depending on the density of the measured points near the interpolated cell. You can also specify a maximum distance (in map units) that the search radius cannot exceed. If the radius for a particular neighborhood reaches the maximum distance before obtaining the specified number of points, the prediction for that location will be performed on the number of measured points within the maximum distance. Generally, you will use smaller neighborhoods or a minimum number of points when the phenomenon has a great amount of variation.

- Fixed search radius

A fixed search radius requires a neighborhood distance and a minimum number of points. The distance dictates the radius of the circle of the neighborhood (in map units). The distance of the radius is constant, so for each interpolated cell, the radius of the circle used to find input points is the same. The minimum number of points indicates the minimum number of measured points to use within the neighborhood. All the measured points that fall within the radius will be used in the calculation of each interpolated cell. When there are fewer measured points in the neighborhood than the specified minimum, the search radius will increase until it can encompass the minimum number of points. The specified fixed search radius will be used for each interpolated cell (cell center) in the study area; thus, if your measured points are not spread out equally (which they rarely are), there are likely to be different numbers of measured points used in the different neighborhoods for the various predictions.

- Using barriers

A barrier is a polyline dataset used as a breakline that limits the search for input sample points. A polyline can represent a cliff, ridge, or some other interruption in a landscape. Only those input sample points on the same side of the barrier as the current processing cell will be considered.

2.2.2: What is kriging?

The IDW (inverse distance weighted) and Spline interpolation tools are referred to as deterministic interpolation methods because they are directly based on the surrounding measured values or on specified mathematical formulas that determine the smoothness of the resulting surface. A second family of interpolation methods consists of geo statistical methods, such as kriging, which are based on statistical models that include autocorrelation—that is, the statistical relationships among the measured points. Because of this, geo statistical techniques not only have the capability of producing a prediction surface but also provide some measure of the certainty or accuracy of the predictions.

Kriging assumes that the distance or direction between sample points reflects a spatial correlation that can be used to explain variation in the surface. The Kriging tool fits a mathematical function to a specified number of points, or all points within a specified radius, to determine the output value for each location. Kriging is a multistep process; it includes exploratory statistical analysis of the data, variogram modeling, creating the surface, and (optionally) exploring a variance surface. Kriging is most appropriate when you know there is a spatially correlated distance or directional bias in the data. It is often used in soil science and geology.

2.5.3: How Kriging works?

Kriging is an advanced geo statistical procedure that generates an estimated surface from a scattered set of points with z-values. Unlike other interpolation methods supported by ArcGIS Spatial Analyst, to use the Kriging tool effectively involves an interactive investigation of the spatial behavior of the phenomenon represented by the z-values before you select the best estimation method for generating the output surface.

2.5.4: The Kriging formula

Kriging is similar to IDW in that it weights the surrounding measured values to derive a prediction for an unmeasured location. The general formula for both interpolators is formed as a weighted sum of the data:

$$\hat{Z}(s_0) = \sum_{i=1}^{N} \lambda_i Z(s_i)$$

- where:

$Z(s_i)$ = the measured value at the *i*th location

λ_i = an unknown weight for the measured value at the *i*th location

s_0 = the prediction location

N = the number of measured values

In IDW, the weight, λ_i, depends solely on the distance to the prediction location. However, with the kriging method, the weights are based not only on the distance between the measured points and the prediction location but also on the overall spatial arrangement of the measured points. To use the spatial arrangement in the weights, the spatial autocorrelation must be quantified. Thus, in ordinary kriging, the weight, λ_i, depends on a fitted model to the measured points, the distance to the prediction location, and the spatial relationships among the measured values around the prediction location. The following sections discuss how the general kriging formula is used to create a map of the prediction surface and a map of the accuracy of the predictions.

2.5.5: Creating a prediction surface map with kriging

To make a prediction with the kriging interpolation method, two tasks are necessary:

- Uncover the dependency rules.
- Make the predictions.

To realize these two tasks, kriging goes through a two-step process:

1. It creates the variograms and covariance functions to estimate the statistical dependence (called spatial autocorrelation) values that depend on the model of autocorrelation (fitting a model).
2. It predicts the unknown values (making a prediction).

It is because of these two distinct tasks that it has been said that kriging uses the data twice: the first time to estimate the spatial autocorrelation of the data and the second to make the predictions.

2.6: Variography

Fitting a model, or spatial modeling, is also known as structural analysis, or variography. In spatial modeling of the structure of the measured points, you begin with a graph of the empirical semivariogram, computed with the following equation for all pairs of locations separated by distance h:

Semivariogram($distance_h$) = 0.5 * average{($value_i$ – $value_j$}^{2}]

The formula involves calculating the difference squared between the values of the paired locations.

The image below shows the pairing of one point (the red point) with all other measured locations. This process continues for each measured point.

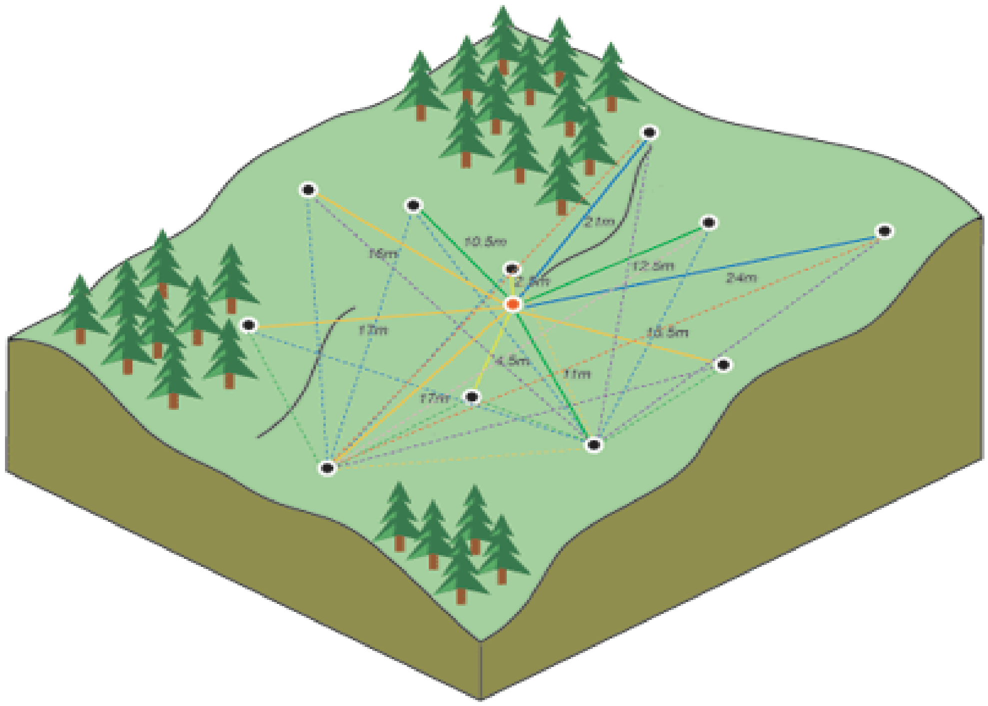

Fig 4: Calculating the difference squared between the paired locations

Chapter 3
Methodology

3.1: Flow chart for methodology:

The Flow chart of the activities for project is shown in figure below:

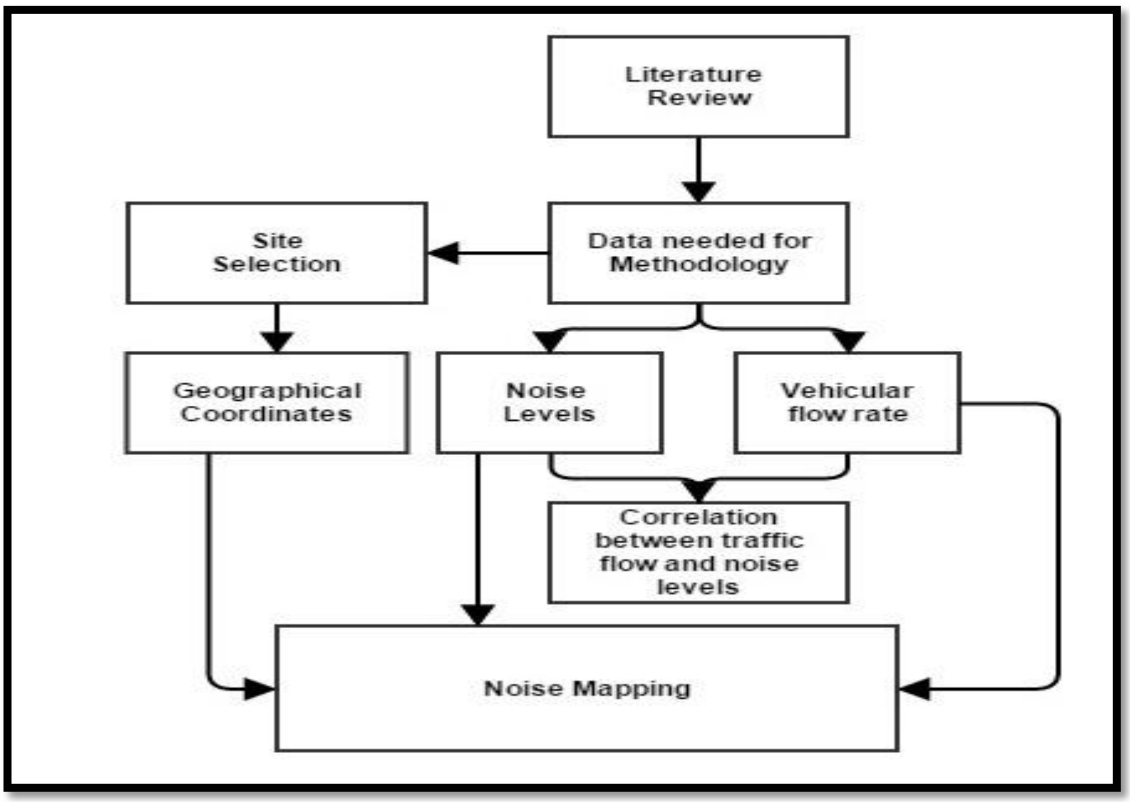

Fig 5: Flow chart for project activities

3.2: Site Selection:

After reviewing adequate literature, sites for noise level monitoring were selected that provided the representative noise levels of a particular area. Research area has been classified into four zones that are

- Residential Areas
- Commercial Areas

- Sensitive Areas
- Highways

Familiar sites were selected in Islamabad which could give us representative data for noise levels. A total of 55 sites were pin pointed on a printed map of Islamabad city. Although, a few of the sites were excluded due to the ongoing Metro Bus project during the study time frame. So sites lying in the vicinity of Peshawar Mor were ignored in order to minimize the abnormality in the noise levels and ultimately the map.

3.3: Equipment:

As a noise map of Islamabad city has to be developed and a correlation between noise levels against vehicular flow rates was to be determined, **f**ollowing equipment's/tools were used:

- Sound level meter
- GPS device
- Video recorder
- Arc GIS Software

3.3.1: Noise meters used:

Noise levels were recorded by using Sound level meter.

Fig 6: Sound Level Meter (SLM)

3.3.2: Geographical Co-ordinates:

Geographical coordinates were recorded of each site by using GPS device. After selecting the co-ordinates option in GPS, it provides

- Easting value
- Northing value

Fig 7: A typical GPS

3.3.3: Vehicular flow rate:

Video recorder records number of vehicles passing through each site during noise level measurements that was required to find a co-relation between noise levels versus traffic flow rate. After video recordings on each site for each measurement interval, the number of vehicles was counted against each site during peak as well as a off-peak hours. Then the data was transformed (number of vehicles and noise levels against the vehicular flow) in a particular format on excel sheets to find a co-relation between the two factors.

Fig 8: Vehicular flow rate

3.3.4: Arc GIS:

This section provides an introduction and overview to ArcMap, which is the central application used in ArcGIS. ArcMap is where you display and explore GIS datasets for your study area, where you assign symbols, and where you create map layouts for printing or publication. ArcMap is also the application you use to create and edit datasets.

ArcMap represents geographic information as a collection of layers and other elements in a map. Common map elements include the data frame containing map layers for a given extent plus a scale bar, north arrow, title, descriptive text, a symbol legend, and so on.

- Typical tasks performed in ArcMap

ArcMap is the primary application used in ArcGIS and is used to perform a wide range of common GIS tasks as well as specialized, user-specific tasks. Here is a list of some common workflows we performed:

- Work with maps—we open and use ArcMap documents to explore information, navigate around your map documents, turn layers on and off, query features to access the rich attribute data that is behind the map, and to visualize geographic information.

- Print maps—we create maps, from the simplest to very sophisticated print-quality cartography, using ArcMap.
- Compile and edit GIS datasets—ArcMap provides one of the primary ways that users automate geo-database datasets. ArcMap supports scalable full function editing. You select layers in the map document to edit and the new and updated features are saved in the layer's dataset.
- Use geo-processing to automate work and perform analysis—GIS is both visual and analytical. ArcMap has the ability to execute any geo-processing model or script as well as to view and work with the results through map visualization. Geo-processing can be used for analysis as well as to automate many mundane tasks such as map book generation, repairing broken data links in a collection of map documents, and to perform GIS data processing.
- Organize and manage your geo-databases and ArcGIS documents—ArcMap includes the Catalog window that enables you to organize all of your GIS datasets and geo databases, your map documents and other ArcGIS files, your geo-processing tools, and many other GIS information sets. You can also set up and manage geo-database schemas in the Catalog window.
- Publish map documents as map services using ArcGIS Server—ArcGIS content is brought to life on the web by publishing geographic information as a series of map services. ArcMap provides a simple user experience for publishing your map documents as map services.
- Share maps, layers, geo-processing models, and geo-databases with other users—ArcMap includes tools that make it easy to package and share GIS datasets with other users. This includes the ability to share your GIS maps and data using ArcGIS online.
- Document your geographic information—A key goal in GIS communities is to describe your geographic information sets to help you document your projects and for more effective search and data sharing. Using the Catalog window, you can document all of your GIS contents. For organizations who use standards-based metadata, you can also document your datasets using the ArcGIS metadata editor.

- Customize the user experience—ArcMap includes tools for customization, including the ability to write software add-ins to add new functionality, to simplify and streamline the user interface, and to use geo-processing for task automation.

3.4: Calibration of noise meter:

Before measuring the noise levels, noise meter was calibrated. Standard method was adopted i.e calibrated noise meter at 94 db and 114 db. The calibrator was attached to the head of sound level meter. The calibrator produces vibrations for noise levels of 94 and 114 db. As a result of those vibrations, the digital dial showed the same intensity of vibrations. In this way the sound level meter was calibrated.

3.5: Background Noise:

Another important factor was also addressed before measuring noise levels. Representative noise levels cannot be measured by ignoring background noise. If the difference between measured noise level and background noise is more than 10 dB, no correction is needed. In our case, noise level measurement difference was always greater than 10 dB, hence no correction was not required.

Following table shows the correction factor if the difference in noise levels is less than 10 dB.

Table 1

Background Noise Level Correction

TOTAL NOISE LEVEL(dB) minus BACKGROUND NOISELEVEL (dB) dB	VALUE TO SUBTRACT FROM TOTAL NOISE LEVEL TO GET NOISE DUE TO THE SOURCE
8 - 10	0.5
6 - 8	1
4.5 - 6	1.5
4 - 4.5	2
3.5	2.5
3	3

3.6: Procedure for Noise Levels Measurements:

Noise levels were recorded on the selected sites of Islamabad city during the morning as well as in evening peak and off-peak hours using sound level meter. As noise levels varies according to the number of vehicles passing, so the total number of vehicles were also recorded by making a video during measuring the noise levels.

Peak hours selected for the noise level measurements were 08:00 am to 10:00 am in the morning and 5:30 pm to 7:30 pm. Similarly Off-peak hours selected for the noise level measurements were 11:00am to 03:00 pm. Measurements were taken after each 7 seconds resulting in 8 readings in one minute. GPS co-ordinates of the sites were recorded. The number of vehicles was counted from the video in order to find a co-relation between noise levels v/s number of vehicles.

3.7: Formula:

After data collection, data was put in the following formula was used for averaging purpose as noise levels cannot be simply arithmetically be averaged. So that further utilization noise levels can be done for the achievements of our objectives.

$$Leq = 20*\log10*\sum(10\^{}(R1/20)+\ldots 10\^{}(Rn/20)/n$$

R1 = First reading

n = Total number of reading

3.8: Noise Mapping Technique:

An overview of the Interpolation toolset

Tools to predict values at unmeasured locations.

Table no. 2	
Tool	**Description**
IDW	Uses the measured values surrounding the prediction location to predict a value for any unsampled location, based on the assumption that things that are close to one another are more alike than those that are farther apart.
Diffusion Interpolation With Barriers	Uses a kernel that is based upon the heat equation and allows one to use a combination of raster and feature datasets to act as a barrier.
Global Polynomial	Fits a smooth surface that is defined by a mathematical function (a

Interpolation	polynomial) to the input sample points.
Kernel Interpolation With Barriers	A moving window predictor that uses the shortest distance between points so that points on either side of the line barriers are connected.
Local Polynomial Interpolation	Fits the specified order (zero, first, second, third, and so on) polynomial, each within specified overlapping neighborhoods, to produce an output surface.
Moving Window Kriging	Recalculates the Range, Nugget, and Partial Sill semivariogram parameters based on a smaller neighborhood, moving through all location points.
Radial Basis Functions	Uses one of five basis functions to process each measured sample value, thus creating an exact interpolation surface.

Chapter 4

Results and Discussion

4.1 Peak hour map:

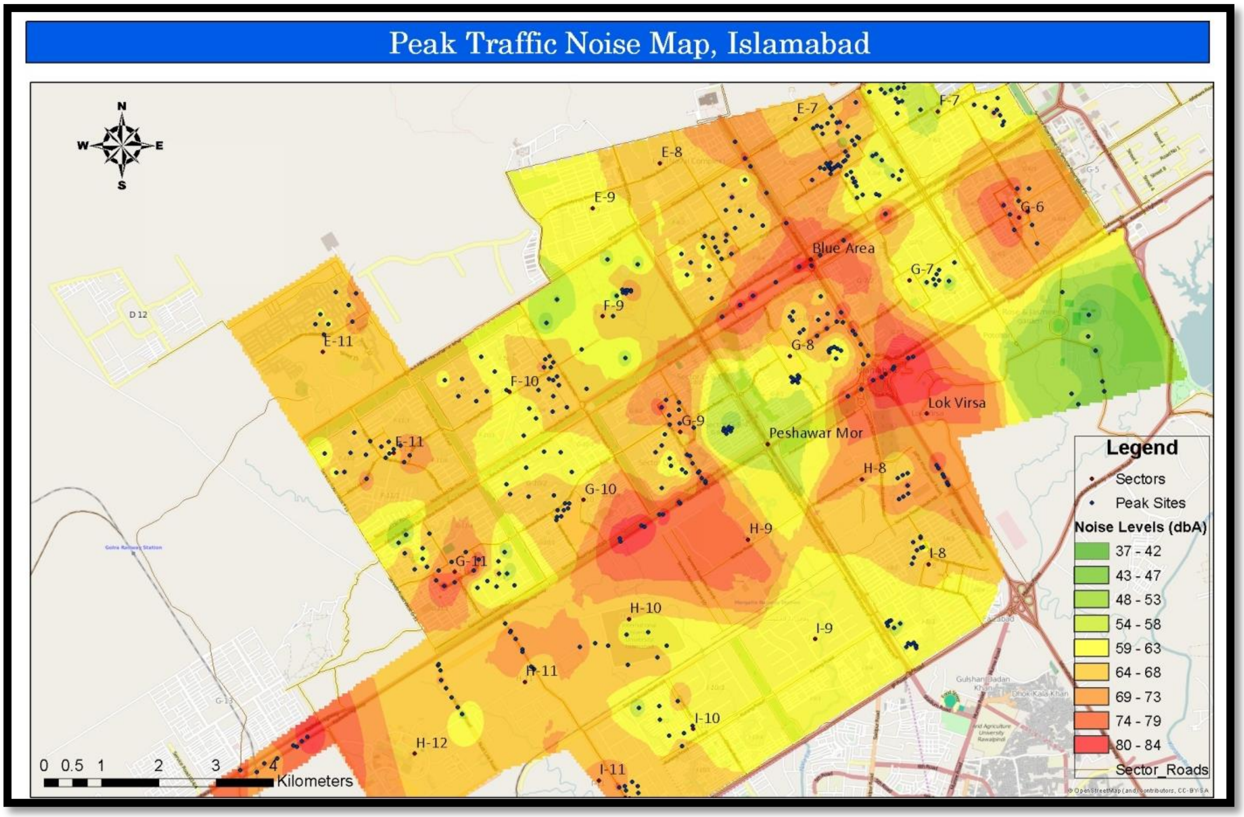

Fig 9: Peak hours Map

(08:00-10:00am and 05:30-7:30pm)

- Most of the sites have high traffic noise levels during peak hours.
- Golra mor, Faqeer Aipee road, G-11 Markaz, Kashmir highway (G-9-G-10), Blue area, Zero point, G-6 lie in the range of (69-84 dBA) shows that these sites have high levels of traffic noise.
- Residential sites during peak hours have a range of (59-68 dBA) depicting that these sites have a comparatively lower noise levels than the highways.
- Traffic noise levels in sensitive sites including F-9 park, tennis play ground, Daman-e-Koh, etc range from (59-68 dBA).
- Peshawar mor is showing a low level of noise because the measurements on this site was not taken due to the ongoing construction of the Metro Bus project

4.2: Off-Peak hours map:

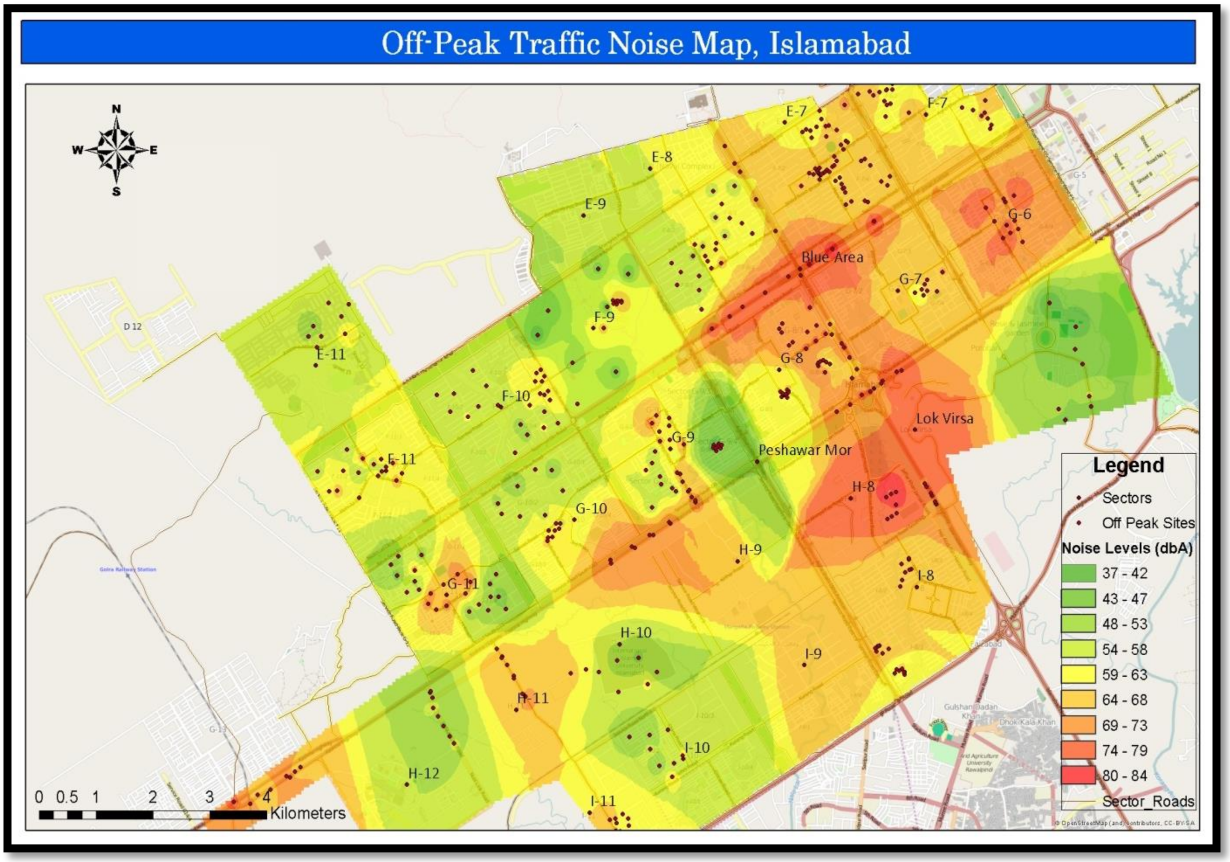

Fig 10: Off-Peak hours Map

(11:00am-3:00pm)

- From the off-peak map it can be deduced that most of the sites have comparatively low traffic noise levels during their off-peak hours.
- Results from the traffic noise levels measured at off-peak hours on Golra mor, Faqeer Aipee road, G-11 Markaz, Kashmir highway (G-9-G-10), Blue area, Zero point, G-6 and Islamabad highway lies in the range of (69-84 dBA) shows that these sites have high levels of traffic noise due to high traffic flow.
- Residential sites during off-peak hours have noise levels ranging (48-58 dBA) depicting that these sites have noise levels in safe limit.
- Traffic noise levels in sensitive sites including F-9 park, tennis play ground, Daman-e-Koh, etc range from (37-58 dBA).

4.3: Correlation between Noise levels and traffic flow rate:

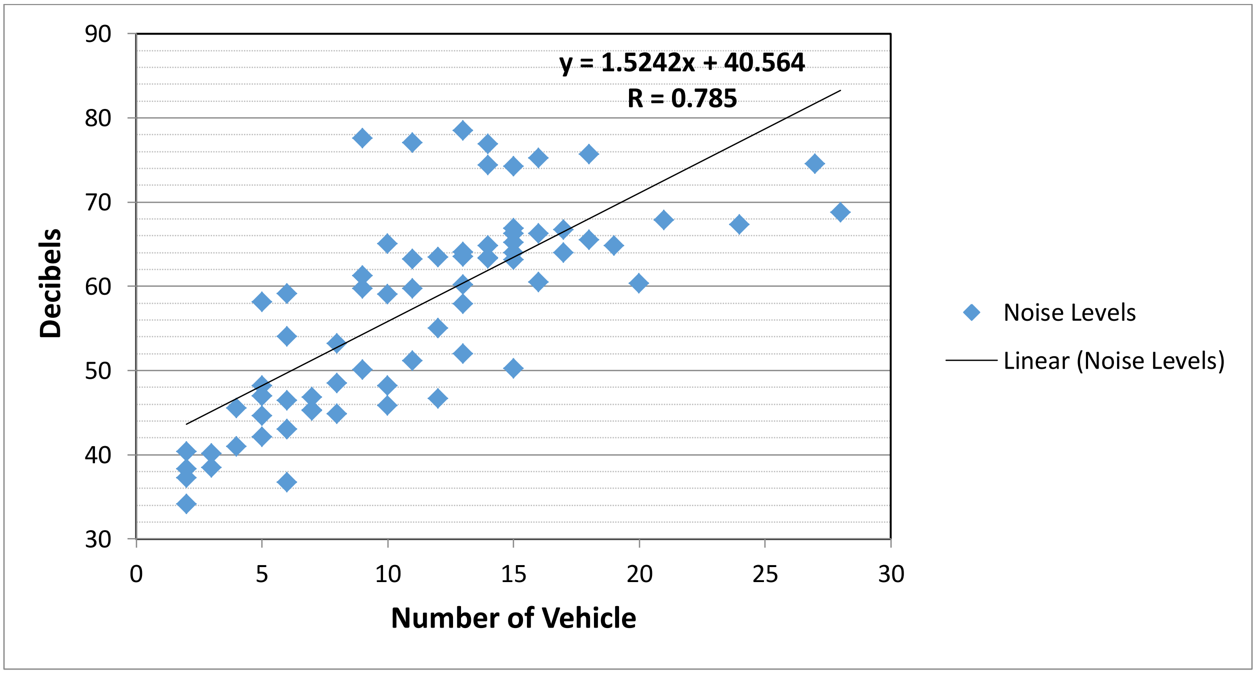

Fig 11: Correlation between noise levels and number of vehicles

Another objective of our study was to develop a co-relation between noise levels against vehicular flow rate. The comparison of noise data is plotted in the form of chart so that it makes convenient to differentiate the traffic noise. As we classified our study sites in the following four categories i.e residential areas, commercial areas, sensitive areas and the highways, so by plotting noise levels and traffic flow rate against each classified area a co-relation was derived. The correlation value is 0.785, which shows a weak correlation between number of vehicles and the noise levels. From the above result, we can say that noise levels are not only a function of number of vehicles. There are several other factors e.g speed of vehicle, condition of vehicle, temperature etc. which can be included to improve the correlation.

Chapter 5

Conclusion and recommendations

5.1: Conclusions:

- Commercial and highway sites have noise levels above the safe limits.
- Residential sites have comparatively lower noise levels.
- Sensitive sites have higher levels of noise during peak hours.
- Correlation between noise levels and number of vehicles depends on other factors e.g vehicular speed, condition of the road and vehicle, temperature, humidity, wind velocity, wind direction etc.

5.2: Recommendations:

- Traffic noise levels are not only a function of vehicular flow rate but also depends on many variables e.g vehicular speed, condition of the road and vehicle, temperature, humidity, wind velocity.
- Co-relation between traffic noise levels and vehicular flow rate can be improved by using advanced vehicle recognition software, image processing software and using speed gun.
- Human error can be avoided by using advanced noise level meters which have built in storage for noise level measurements.
- Sound barriers can be implied on noise sensitive sites.

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Appendix:

Noise Data for sites:

Peak hrs		Off Peak hrs	
Noise Levels	Number of Vehicles	Noise Levels	Number of Vehicles
56.3494835	12	48.00137754	8
58.29837184	15	52.27608376	10
66.30310274	11	50.30863895	9
60.17697405	16	44.67819197	6
49.97971062	7	41.19865221	4
61.07808465	17	46.53843047	5
58.16737709	13	47.14859661	5
54.34689235	14	50.88687906	7
Peak hrs		Off Peak hrs	
Noise Levels	Number of Vehicles	Noise Levels	Number of Vehicles
56.4028429	10	49.22428102	5
65.2996865	13	55.17564347	7
68.0845539	11	44.27191362	3
53.34661319	8	46.33331807	5
49.38449821	7	51.02542128	7
63.17970113	13	65.12743965	9
67.01536193	16	49.18486243	7
64.19888978	10	50.28056282	6