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# Spatial configuration in relation with traffic noise in Dhaka city

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*Abstract:* *Noise pollution is becoming an alarming nuisance in urban life and among different sources of city noise, traffic noise is generally the most omnipresent. One of the major factors to influence the noise is traffic flow. On the other hand, spatial configuration can be analysed through some measures like connectivity, integration, etc. In this research, a correlation analysis between traffic noise and spatial configuration has been done using different attributes such as space syntax, linear regression. Dhaka City Corporation (DCC) area has been taken as study area. First, Axial lines of the street network were identified and their integration values were calculated by using the space syntax methodology. Thereafter, primary data of sound level were collected and mapped. Finally, regression analyses were conducted using the sound level values as the response variable and integration values as predictor variables. The result shows that traffic noise is more related with the global integration i.e. the number of turns for reaching all the axial spaces, which indeed is a significant predictor variable.*

*Key words:* *Traffic noise, Accessibility, Dhaka City, Integration values, Space syntax.*

## 1. Introduction

Noise pollution, a phenomenon which can be described as disturbing or unwanted sound that harms not only the natural environment around us, but also the living things (Husain, 2015). According to WHO, the highest acceptable noise level is 60-65dB and noise levels above 85 dB can cause hearing impairment. Approximately 180 million people in the Asia suffer unacceptable noise levels (>65 dB) and over 10 million people of Dhaka are exposed to noise levels between 55 and 75 dB (Haq, 2012).

During the 70s and the early 80s, noise pollution was not a major concern for the dwellers of Dhaka city. With rapid urbanization and economic development, Dhaka city has become seriously noisy. Although there are many sources of noise, which include industries, construction works and indiscriminate use of loud speakers, motorized traffic is the principal source of creating noise in urban areas (OECD, 1995). With the increase in the number of motorized vehicles in the city, the hazard of noise pollution has increased and exceeded the level of tolerance. It is adversely affecting the environment of this city and causing physical and psychological problems, and thus has become an alarming health hazard. It is reported that the hearing ability of the inhabitants of the City has reduced during the last ten years. About five to seven percent of the patients admitted to the Bangabandhu Sheikh Mujibur Rahman Medical University, Dhaka is suffering from permanent deafness due to noise pollution (Ahmed, 1998). The major factors which, influence the generation of road traffic noise are traffic flow, traffic speed, proportion of heavy vehicles and connection between the roads (Agent & Zeeger, 1980).

The theory of spatial configuration requires us to look at the structure of potential movement sequences, connectivity, changes of direction, intersections between different directions, the presence of alternative sequences linking the same two areas, the occurrence of centres of convergence or domains of exclusion and so on (Peponis, 1997). In a spatial network, components with a higher degree of integration tend to correlate with fewer crimes, higher traffic flow. So highly integrated components have easier navigability that means better accessibility and probably higher traffic flow.

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This paper follows the aforementioned theories and intends to explore the correlation between spatial integration and traffic noise in the major urban settlement of Dhaka City Corporation (DCC).

## 2. Different attributes for the correlation analysis

### 2.1 Traffic Noise

**Noise** can be defined as the level of sound which exceeds the acceptable level and creates annoyance. Frequent exposure to high level of noise hampers physical and mental peace and may cause damage to the health (Alam, 2001).

**Traffic noise** is the collective sound energy emanating primarily from motor vehicles. In developed and developing countries, roadway noise contributes a proportionately large share of the total societal noise pollution. In the U.S., it contributes more to environmental noise exposure than any other noise source (Alam, 2001).

Along with the increasing degree of air and water pollution, the inhabitants of Dhaka city are being exposed to high level of noise pollution. According to the journal of Ayaz and Rahman (2011) the acceptable level of noise/sound level in decibel, recommended by Bangladesh Department of Environment (DOE) is given in table 1:

**Table 1: Acceptable noise Levels Recommended by Bangladesh Department of Environment (DOE).**

| Description of area | Noise level dB(A) | |
|---|---|---|
| | Day Time | Night Time |
| i) A sensitive area where quietness is of primary importance such as schools, hospitals, mosques etc. | 45 | 35 |
| ii) Residential areas | 50 | 40 |
| iii) Mixed areas, which are, used as residential areas as well as commercial and industrial purposes. | 60 | 50 |
| iv) Commercial areas | 70 | 60 |
| v) Industrial areas | 75 | 70 |

### 2.2 Space Syntax and Spatial configuration

The term spatial configuration is used to refer to the structure of potential movement and copresence as determined by the placement of boundaries in space and by the connections and disconnections between spaces. It concentrates on the movement sequences, changes of direction, intersections between different directions, and the presence of alternative sequences linking the same two areas, and so on.

The basic idea behind space syntax is that it identifies the spatial configuration of a study area as a network, where nodes represent spatial components or "spaces" and links represent connections between spatial components (Wang and Liao 2006). Through this approach we can then treat the analysis of spatial configuration as a well-established network analysis problem.

There are two basic theories upon which space syntax is based – theory of natural movement and theory of movement economy. Both the theories are based on one central proposition: that the fundamental correlate of the spatial configuration is movement. This is the case both in determination of spatial form by movement and effects of spatial form on movement. It is the reciprocal effect of space and movement (Hillier, 1998).

In an urban settlement consisting of mostly streets, the most obvious "spaces" would be those (preferably longest) straight sections of streets that is visible from one end to the other without obstruction. Hillier (1996) developed the technique of representing those individual "axial spaces" as straight sight-lines, which also represents a possible path of movement, over a map of an urban settlement and called such a drawing an axial map.

To measure the degree of integration or segregation in an urban settlement, the total number of intersections or "turns" is counted when a person gets the shortest ways to go from an axial space to all other axial spaces. If the number of turns required for reaching all the axial spaces in the map is analysed, the analysis is called global integration and is denoted by Rn, as the measure is up to radius "n." Those axial spaces that have fewer numbers of turns to reach all other axial spaces mean they are more accessible and cognitively more intelligible than those with more number of turns in the axial map (Penn 2004).

In space syntax terminology, more accessibility means a higher degree of integration and less accessibility means a higher degree of segregation.

In addition to global integration, space syntax also defines the measurement of local integration. For instance, the local integration measure of radius 3 only calculates the total amount of turns one would encounter when he/she take the shortest paths to travel from an axial space to only those axial spaces that are up to 2 turns away from himself/herself. Such a local integration measure would be denoted by $R^3$.

Concisely, "space syntax" works as a methodology, or a set of techniques for the representation, quantification, and interpretation of spatial configuration in buildings and settlements. Hillier (1996) shows how the key configurational properties represented and analysed by syntax, interact with configurational rules, for example those affecting the shape of the perimeter of a cell or the positioning of partitions inside it.

### 2.3 Linear regression

In a cause and effect relationship, the independent variable is the cause, and the dependent variable is the effect. A least squares linear regression is a method for predicting the value of a dependent or response variable Y, based on the value of an independent or predictor variable X. Only those locational attributes that are numeric are considered. The coefficient of determination (denoted by $R^2$) is a key output of regression analysis. It is interpreted as the proportion of the variance in the dependent variable that is predictable from the independent variable.

- ♦ The coefficient of determination ranges from 0 to 1.
- ♦ An $R^2$ of 0 means that the dependent variable cannot be predicted from the independent variable.
- ♦ An $R^2$ of 1 means the dependent variable can be predicted without error from the independent variable.
- ♦ An $R^2$ between 0 and 1 indicates the extent to which the dependent variable is predictable. An $R^2$ of 0.10 means that 10 percent of the variance in Y is predictable from X; an $R^2$ of 0.20 means that 20 percent is predictable; and so on.

## 3. Research methods

### 3. 1 Study area selection

Table 2 shows the sample places comprising maximum threshold of Noise level that should be maintained. Considering the category of places, the selection of sample places is based on several considerations.

Firstly, the places should be very important and lively nodal points and must be accessible to the motorized vehicles and public movement. Secondly, they have to be located within the city corporation boundary and finally, should be distributed in the locations with as varied morphological characteristics as possible (Figure 01). Selected areas of sample points are categorized into three zones. Commercial areas (C/A), Residential areas (R/A) and Mixed areas.

| Type of Places | Places | Acceptable max. Noise level (dB) |
|---|---|---|
| Commercial Areas (C/A) | Gabtoli, Technical, Mirpur 1, Mirpur 10, Agargaon, Asad Gate, Farmgate, Karwan Bazar, Bijoy Shoroni, Gulistan (Zero Point), Notun Bazar, Nilkhet, Paltan, Mohakhali, Motijhil | 70 |
| Residential Areas (R/A) | Bashundhara, Gulshan 2, Shantinagar, Uttara | 50 |
| Mixed Areas | Shahbagh, Shahid minar area, Shamoli, Badda, Banani | 60 |

***Table 2:*** *Selected areas for sample points with acceptable maximum noise level.*

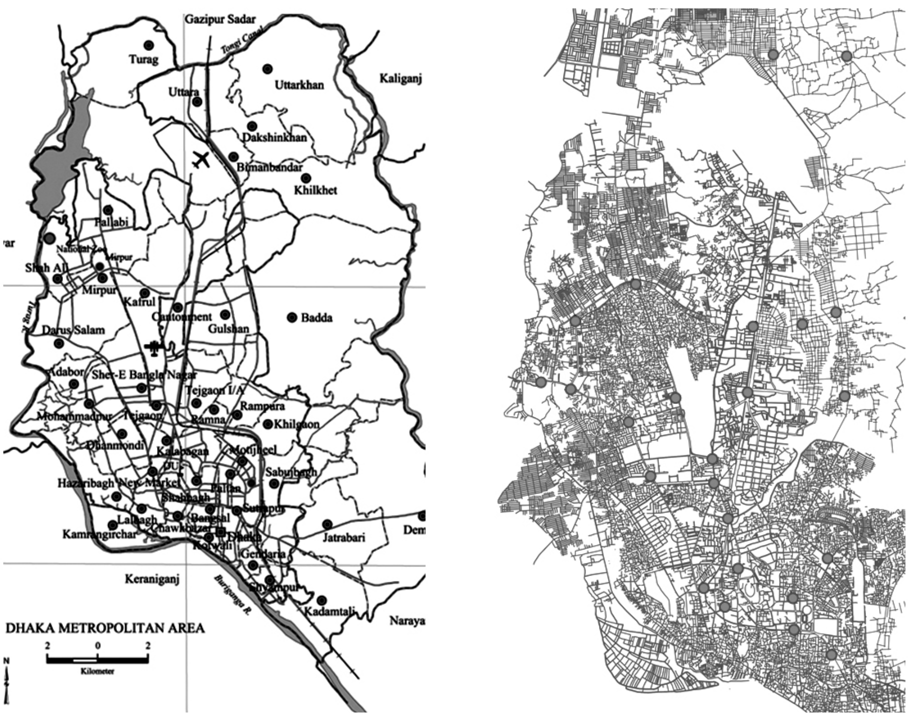


***Figure 1:*** *Dhaka city corporation map (Left panel) and map showing major points as sample points (right panel)*

## 3.2 Primary sound data acquisition

A standard sound level meter- Extech 407730 and a laptop- DELL Inspiron n5110 containing recording software 'Audacity' were used to analyse the noise level in decibel (dB) in the sample places of Dhaka city. The sound samples were recorded from each place 3 times (3 minutes each time), in the morning between (9am-12pm), in the afternoon (1pm-3pm), and at evening /night (5pm-8pm) for working and non-working days. The samples were taken approximately 6 feet away from the road. To make certain that the data gathered were not anomalies, the total operation of sound recording had been restated for a second time. Table 3 shows the analysis of sound data of sample places for working and non-working days.

**Working Days**

| Place | Mean (dB) | Max (dB) | Average (dB) |
|---|---|---|---|
| Gabtoli | 76.25 | 92.6 | 84.425 |
| Technical | 73.95 | 87.65 | 80.8 |
| Mirpur 1 | 77.52 | 87.5 | 82.51 |
| Mirpur 10 | 76.72 | 87.52 | 82.12 |
| Agargaon | 75.6 | 81.2 | 78.4 |
| Bijoy Shoroni | 77.35 | 91.52 | 84.435 |
| Farmgate | 73.2 | 87.4 | 80.3 |
| Karwan Bazar | 75.2 | 86.2 | 80.7 |
| Shahbagh | 76.5 | 85.25 | 80.875 |
| Shahid minar | 68.5 | 82.5 | 75.5 |
| Paltan | 73.5 | 86.5 | 80 |
| Gulistan | 73.2 | 87.5 | 80.35 |
| Motijhil | 77.5 | 90 | 83.75 |
| Nilkhet | 71.5 | 88.5 | 80 |
| Asad gate | 78.5 | 84.2 | 81.35 |
| Shamoli | 77.5 | 92.15 | 84.825 |
| Mohakhali | 74.25 | 96.5 | 85.375 |
| Shantinagar | 68.5 | 83.2 | 75.85 |
| Banani | 70.5 | 84.5 | 77.5 |
| Gulshan 2 | 73.2 | 84.5 | 78.85 |
| Badda | 77.2 | 93 | 85.1 |
| Notun Bazar | 74.35 | 86.2 | 80.275 |
| Basundhara | 77.52 | 80.52 | 79.02 |
| Uttara | 75.5 | 83.5 | 79.5 |

**Non-Working days**

| Place | Mean (dB) | Max (dB) | Average (dB) |
|---|---|---|---|
| Gabtoli | 60.2 | 87.5 | 73.85 |
| Technical | 59.52 | 85.75 | 72.635 |
| Mirpur 1 | 61.5 | 87.5 | 74.5 |
| Mirpur 10 | 66.5 | 82.5 | 74.5 |
| Agargaon | 65 | 89.4 | 77.2 |
| Bijoy Shoroni | 55.6 | 76.2 | 65.9 |
| Farmgate | 66.3 | 85.6 | 75.95 |
| Karwan Bazar | 65.2 | 74.5 | 69.85 |
| Shahbagh | 63.2 | 81 | 72.1 |
| Shahid minar | 57.6 | 78.5 | 68.05 |
| Paltan | 72.2 | 87.1 | 79.65 |
| Gulistan | 72.3 | 84.2 | 78.25 |
| Motijhil | 73.5 | 89.1 | 81.3 |

| Place | Mean (dB) | Max (dB) | Average (dB) |
|---|---|---|---|
| Nilkhet | 72.6 | 84.5 | 78.55 |
| Asad gate | 69.5 | 84.5 | 77 |
| Shamoli | 66.5 | 85.4 | 75.95 |
| Mohakhali | 63.4 | 85.4 | 74.4 |
| Shantinagar | 58 | 76.5 | 67.25 |
| Banani | 79.7 | 86.5 | 83.1 |
| Gulshan 2 | 74.5 | 86.5 | 80.5 |
| Badda | 67.8 | 86.4 | 77.1 |
| Notun Bazar | 67.6 | 86.55 | 77.075 |
| Basundhara | 72.6 | 80.4 | 76.5 |
| Uttara | 64.8 | 89.4 | 77.1 |

***Table 3:*** *Sound data of Working and Non-working days.*

### 3.3 Space syntax analysis

In this study, the methods of performing the space syntax analysis include:

a) Create an axial map of Dhaka City Corporation by identifying the axial spaces and drawing the axial lines over an official topographical map using computer aided drafting software Autodesk AutoCAD and spatial analysis software UCL DepthMap (Space Syntax Laboratory).

b) Calculate global and local integration measures of sample points by axial analysis using UCL DepthMap.

### 3.4 Regression analysis

In this step, a regular (stepwise) linear regression is performed. The response variable is the Average Traffic Noise Level value (TNL value) generated from the mean and maximum values in working and non-working days and the predictor variables are global integration (RN) and local integration (R3).

**TNL_Value = ƒ(RN, R3)**

R, a free software environment for statistical computing and graphics, is the tool for the regression analysis.

## 4. Results

The Axial maps of Dhaka City Corporation in Figure 2 and Figure 3 explain integrated axial lines by denoting colors using spatial analysis software UCL DepthMap (Space Syntax Laboratory). Table 4 shows the global & local integration values of the selected points of DCC area. Here, Kawran Bazar has the highest global integration (RN) Value, while Basundhara has the lowest. The figures are 1.25 and 0.63 respectively. On the other hand, Uttara has the highest local integration (R3) Value (4.63) and Gabtoli has the lowest (2.43).

According to the analysis, Shahbag, Asadgate, Bijoy Shoroni have higher global integration values, whereas, Gabtoli, Uttara, Mirpur 1 have moderate RN values. There are some higher locally integrated areas also found in the UCL DepthMap analysis. Banani, Shahid minar areas have higher R3 values, while Technical, Basundhara, Paltan have lower integration values. Some major places such as Farmgate, Shamoli, Gulistan are highly integrated both globally and locally with higher RN and R3 values.

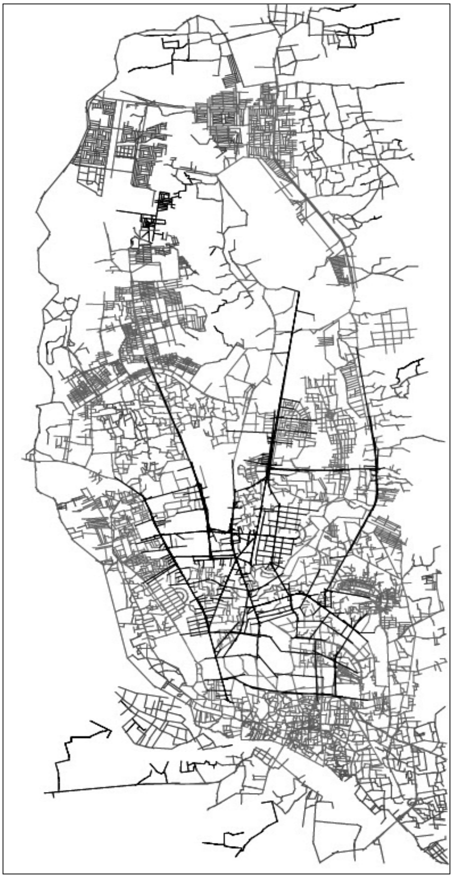

***Figure 2:*** *Axial map (2016) of Dhaka city with Global Integration (RN)*

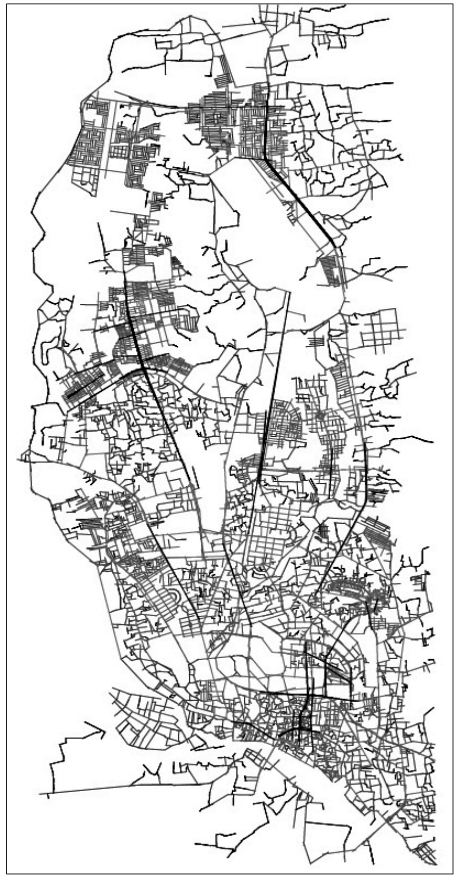

***Figure 3:*** *Axial map (2016) of Dhaka city with Local Integration (R3)*

| Place | Global In. (RN) | Local In. (R3) |
|---|---|---|
| Gabtoli | 0.80 | 2.43 |
| Technical | 0.91 | 2.44 |
| Mirpur 1 | 0.94 | 4.33 |
| Mirpur 10 | 1.02 | 3.97 |
| Agargaon | 1.07 | 3.86 |
| Bijoy Shoroni | 1.19 | 3.84 |
| Farmgate | 1.20 | 3.97 |
| Karwan Bazar | 1.25 | 3.85 |
| Shahbagh | 1.12 | 3.24 |
| Shahid minar | 0.94 | 3.94 |
| Paltan | 1.06 | 2.949 |
| Gulistan | 1.00 | 3.74 |

| Place | Global In. (RN) | Local In. (R3) |
|---|---|---|
| Motijhil | 0.95 | 3.34 |
| Nilkhet | 1.04 | 3.05 |
| Asad gate | 1.20 | 3.72 |
| Shamoli | 1.06 | 3.71 |
| Mohakhali | 1.08 | 3.26 |
| Shantinagar | 1.08 | 3.46 |
| Banani | 1.16 | 4.19 |
| Gulshan 2 | 0.98 | 3.40 |
| Badda | 1.04 | 3.38 |
| Notun Bazar | 1.02 | 3.44 |
| Basundhara | 0.63 | 2.55 |
| Uttara | 0.83 | 4.63 |

***Table 4:*** *Sample points of selected areas with its Integration values.*

In figure 4, Scatter charts to carry out a linear regression analysis by least-square method shows the relationship between Global and Local Integration (R3-RN), TNL value-RN for working days and non-working days, TNL value-R3 for working days and non-working days. Here, some variables are normally distributed in the chart like TNL value-RN in working days having good correlation. On the other hand, TNL value-R3 for non-working days are distributed scattered in the chart.

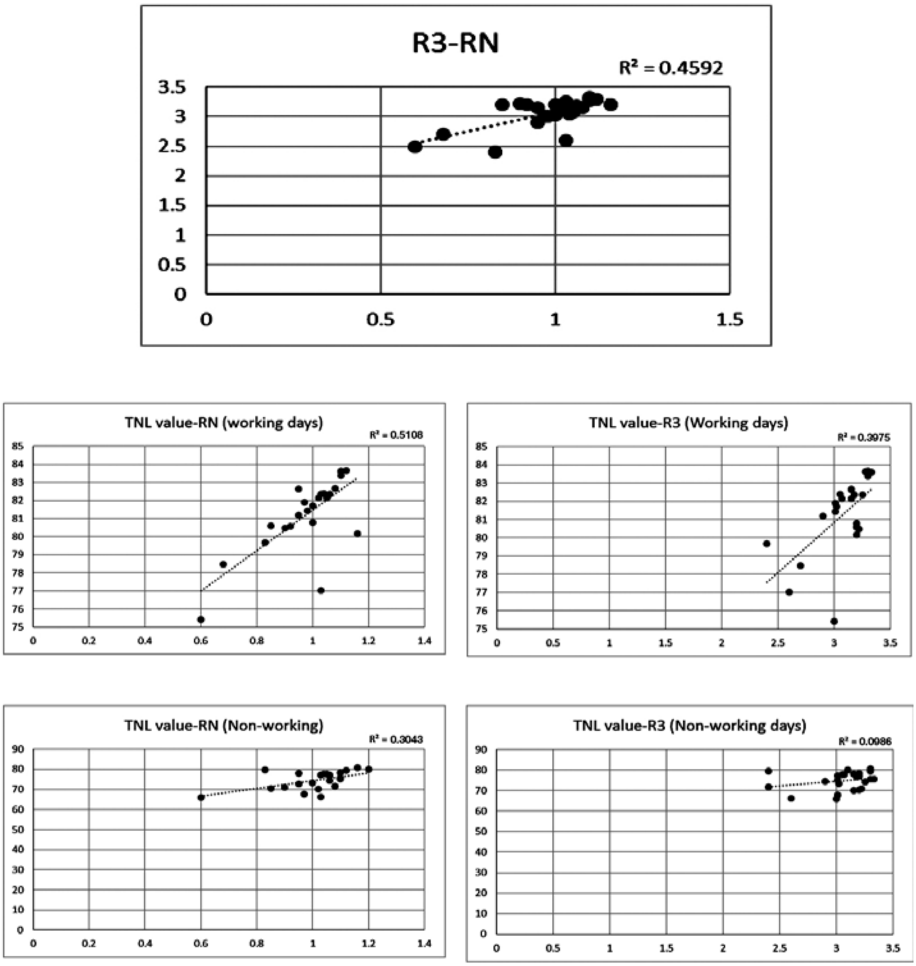


***Figure 4:*** *Scatter chart analysis of the variables for working and non-working days.*

| | RN | R3 | TNL value |
|---|---|---|---|
| RN | 1.0000 | 0.4592 | 0.5108 |
| R3 | 0.4592 | 1.0000 | 0.3975 |
| TNL value | 0.5108 | 0.3975 | 1.0000 |

***Table 5:*** *Correlation coefficients of the regression variables (Analysis for Working days).*

| | RN | R3 | TNL value |
|---|---|---|---|
| RN | 1.0000 | 0.4592 | 0.3043 |
| R3 | 0.4592 | 1.0000 | 0.0986 |
| TNL value | 0.3043 | 0.0986 | 1.0000 |

***Table 6:*** *Correlation coefficients of the regression variables (Analysis for Non-Working days).*

Table 5 and 6 summarize the final regression model to determine the correlation between Traffic noise level values and global and local integration. The result reveals among all the variables, determination coefficient R2 of TNL value-RN is the maximum in the chart.

Around 51% time global integration value (RN) can predict the traffic noise level (TNL) and around 38% time the TNL values will be determined by Local integration values (R3) in working days. Average prediction rate is determined here for TNL values by local integration values (R3) in working days.

In non-working days the Traffic Noise Level can be predicted by Global Integration values (RN) about 31% and by local integration values (R3) around 0.9% time.

## 5. Discussion and Conclusion

This study, however, concentrated on sound data of the sample places and the global and local integration measures of the same points in Dhaka City Corporation rather than on the other variables. The sources of the noise considered here are both motorized and non-motorized vehicles along with the pedestrians. No attempt has been made to study the socioeconomic, political and historical contexts of the sample places.

The spatial distribution of the global and local integration, as shown in Figure 2 and Figure 3 suggests that, the places with higher global integration have higher noise level in both working and non-working days. For instance, the RN value and the TNL value of Mohakhali area are higher than the values of Motijhil area. On the other hand, some highly local integrated areas with lower RN values have a lower noise level in working and non-working days. The Shahid Minar area is immensely connected to the surrounding areas rather than the connection with the central road network system. Therefore, the R3 value of this area is higher than Paltan area which is highly connected with major road network in Dhaka city and has higher TNL value. To a degree, it can be stated, global integration is included as the most significant predictor variable in the regression model which is more acceptable to explain the prediction of the traffic noise level in Dhaka city.

The traffic noise level which has been discussed in this study can be reduced to a certain degree by considering some design measures. Bush and shrubs are much effective as sound barriers. For example, dense plantation of minimum 100 feet depth will provide only 7 to 11 dBs of sound attenuation (Egan, 1972). Constructing barriers can also be effectively used to reduce outdoor noise, particularly high frequency sound such as vehicle tire whine. Apart from these, awareness among vehicle owners, use of hydraulic horn instead of air horn, unnecessary use of sound producing objects and use of absorptive materials on the surrounding building surfaces could be adopted as guidelines to mitigate the existing situation.

Nevertheless, some of the assumptions are not met pertinently, the results of the spatial configuration analysis for predicting traffic noise, bring the assumptions of space syntax theory out into the light. Highly integrated areas in Dhaka city tend to correlate with higher traffic values especially in working days. Also, globally integrated areas with high values are good predictors for traffic noise in non-working days.

In a nutshell, the findings of this study will be significant in that integration value of spatial configuration being an effective explanatory or predictor variable for determining traffic noise in a major urbanized city like Dhaka. The outcome of this study could be a guidance for the decision makers to do further researches and to distribute urban components properly for preventing traffic noise not only in Dhaka city but also in the other urbanized cities in Bangladesh.

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