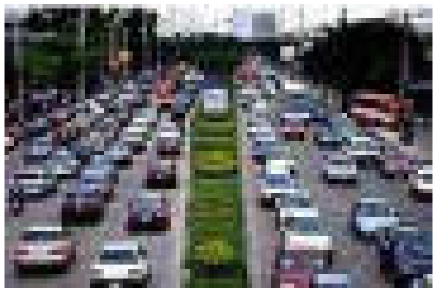

DRONE- a tool for urban traffic noise abatement policy evaluation

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Abstract

Areawide Dynamic ROad traffic NoisE simulator-DRONE, been has developed by the integration of a road traffic noise prediction model (ASJ MODEL-1998) with road traffic simulator (AVENUE) which is further linked with GIS to provide areawide dynamic road traffic noise contour maps. This tool provides an engineering solution for the prediction of road traffic noise in urban network.

Noise reduction in an urban area can be achieved by noise abatement policies. Policy applied in one area can affect the other area. The variation in noise level on an areawide region can be easily displayed in the form of contour maps. The difference between the scenarios can be investigated. This can act as an effective tool for the policy makers to study the areawide variation in noise level, and its effect on different area, even before the implementation of the policy.

This paper presents the application of DRONE in the planning of road traffic noise abatement policy. Contour maps from DRONE can be applied to find the area above the threshold noise level. Road traffic noise pollution problem need to be analyzed and DRONE can help the planner to analyze the problem. Once the problem is analyzed, different action plans need to be formulated. Different transportation and noise abatement policies can be evaluated with DRONE and the results from DRONE can assist policy makers to implement an effective and cost efficient noise abatement policy.

Tools such as DRONE should prove as an effective tool for policy makers to assess the effect of various transportation policies on traffic noise.

Keywords

Areawide noise Simulator – Dynamic noise simulator – DRONE – noise abatement policy – Noise pollution

1. Introduction

Areawide noise prediction models generally do not consider time dependent traffic demand so; they fail to consider inbuilt dynamic traffic characteristics. Most of these models do not consider effect of buildings, and there was a need to provide an engineering solution to the real world problem of estimating noise level in built-up area. Moreover, the models generally do not predict noise over space and time. In order to fulfill the need areawide Dynamic ROad traffic NoisE simulator – DRONE, is developed [1]. It can provide:

- Areawide dynamic road traffic noise contour maps (i.e. road traffic noise prediction over both space and time) and;
- An engineering solution to the real world problem of prediction road traffic noise level in built-up area is also considered in it.

DRONE is developed by integrating traffic simulation model (AVENUE) [2] with noise prediction model (ASJ Model 1998) [3] [4] [5] [6], which is further linked with GIS to provide areawide dynamic road traffic noise contour maps. The model has been verified and validated and has been applied on a real world situation [1].

The main aim of this paper is to present the implementation of DRONE as a tool for urban transport policy evaluation. This paper focuses on the study of the effect of different transportation management and infrastructure policies on variation in road traffic noise level on an areawide network. Noise reduction in an urban area can be achieved by noise abatement policies. Policy applied on one area can affect the other area. The variation in noise level on an areawide region can be easily displaced in the form of contour maps. The difference between the scenarios can be investigated. This can act as an effective tool for the policy makers to study the areawide variation on noise level and its effect on different area, even before the implementation of the policy. In this study different transportation policies are tested, to reduce road traffic noise level on a study area. The effect of the policies on an extended area is also studied.

Remainder of this paper is structured as follows. Following section discuss about a case study, in which first study area is introduced, followed by traffic simulation parameters calibration results. Results of different transportation policies are then discussed and a comparative overview of different scenarios is summarized.

2. Case Study

2.1 Study area

Different transportation policies are applied to reduce the noise level in the CORE AREA. This is 1 km * 1 km around Ikegami-Shinmachi intersection in Kawasaki, Japan. Figure 1 shows the site of the CORE AREA. This area is notorious for both traffic noise and air pollution. Different traffic management policies can cause the traffic to detour and the noise problem can shift to other locations. In order to study the impact of a transportation policy we extend the study area to a bigger area, we call this area as WHOLE AREA. WHOLE AREA is 5 km * 3 km area around Ikegami Shinmachi intersection (see Figure 2).

In Figure 1 and Figure 2 each block represents buildings and different colors represent different height of building. The building height varies from 3 meter to 75 meter. The total number of residential buildings in CORE and WHOLE AREA's are 1980 and 32425 respectively. The total number of industrial buildings in CORE and WHOLE AREA's are 469 and 5127 respectively.

Figure 1 **CORE AREA**

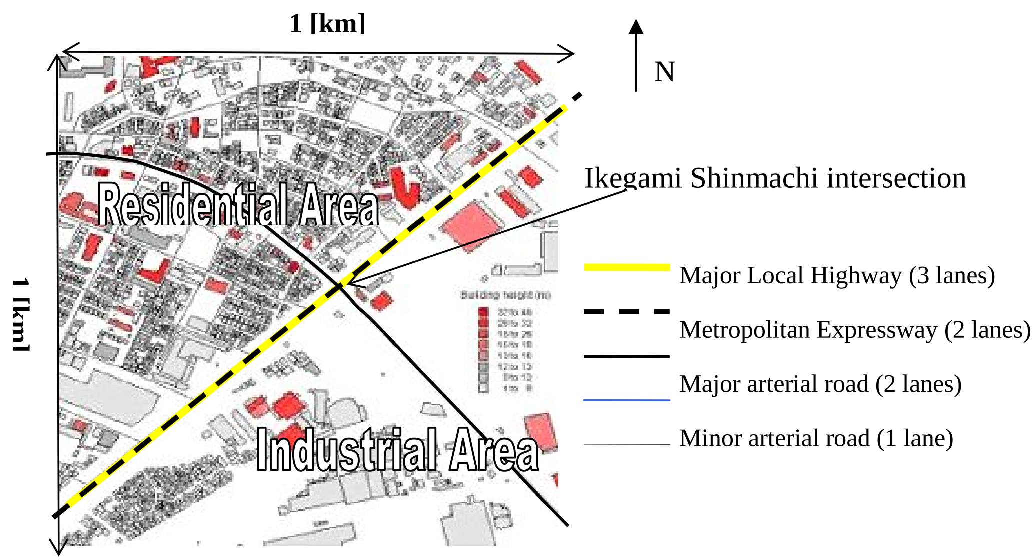


Figure 2 **WHOLE AREA- an extended area around CORE AREA**

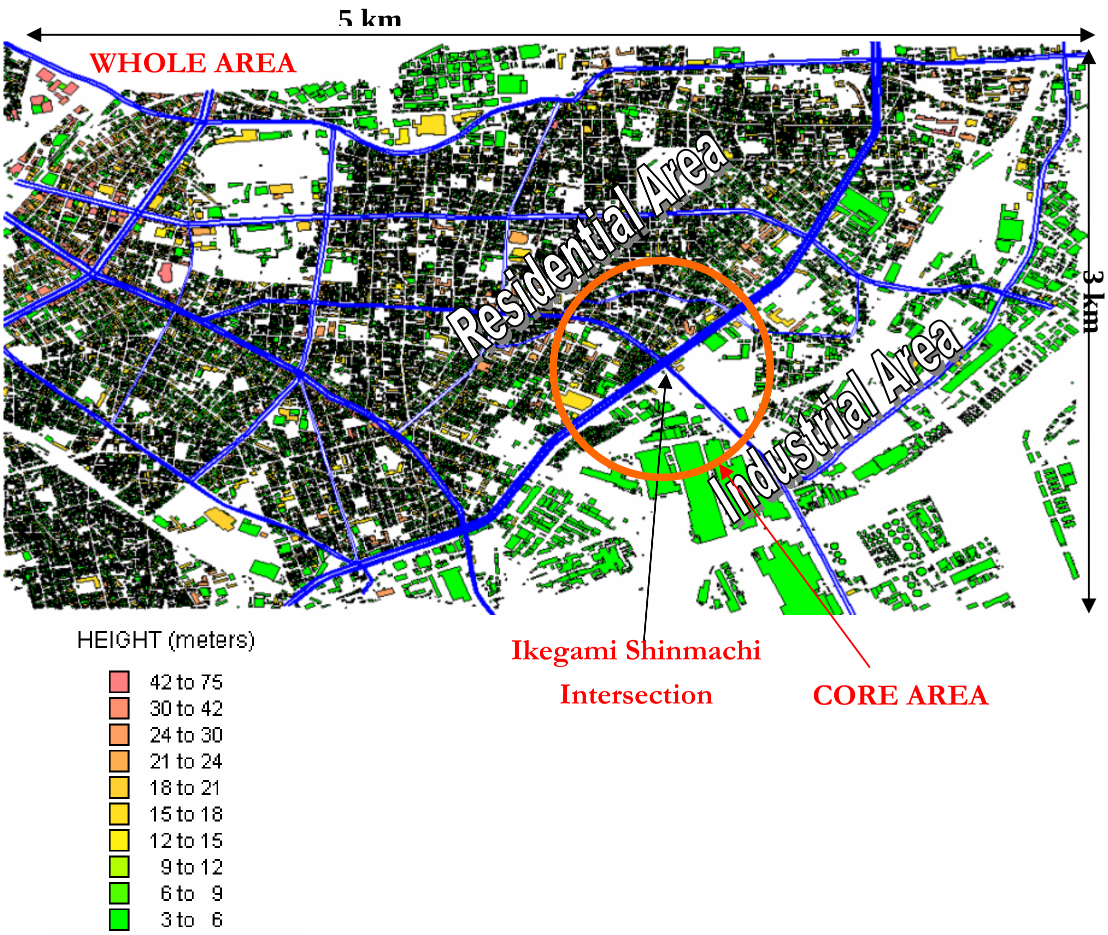
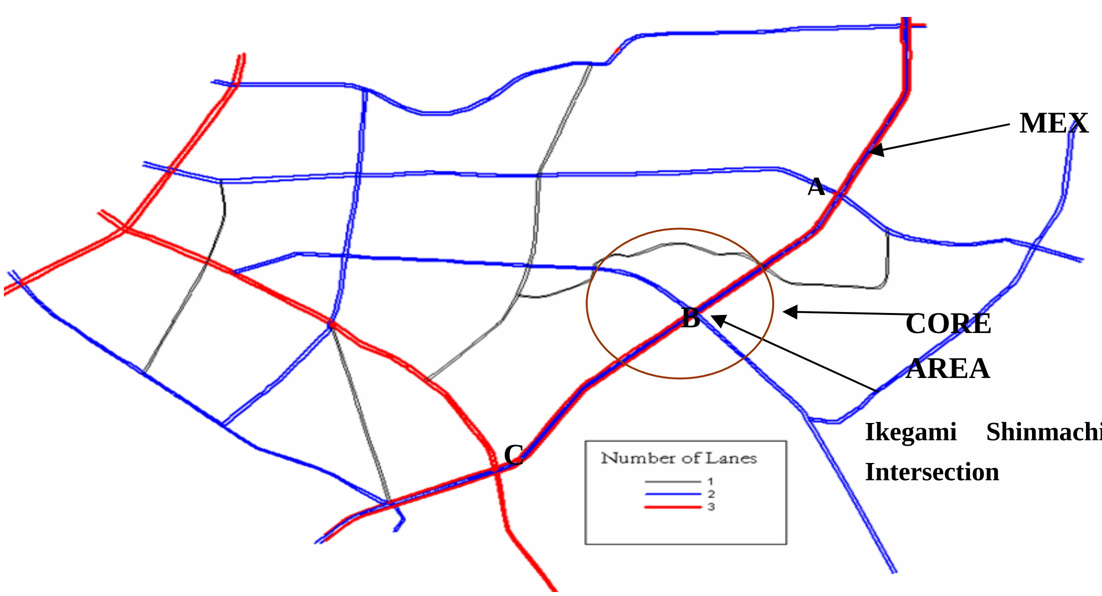


Figure 3 **Major roads, considered for simulation.**



Route No. 18 of Tokyo Metropolitan Expressway (MEX) (2 lanes, both directions) is located along SW-NE diagonal of the study area around Ikegami-Shinmachi intersection. MEX is approximately 9 meter above the highway. One side of MEX is residential area and other side is industrial area. The number of lanes for major road is shown in Figure 3. Apart from these major roads, all other roads are pure residential roads, contributing very little amount of noise (flow is less than 10 vehicles/hour through out the simulation period). For the ease of simplicity, pure residential roads are not considered in the traffic simulation. As shown in Figure 3, Intersections A, B and C are three different locations of the highway through Ikegami Shinmachi area (Intersection B is Ikegami Shinmachi intersection). Different transportation policies are applied along the highway route between intersection A, B and C.

The following section discusses the data collected for simulation, followed by results.

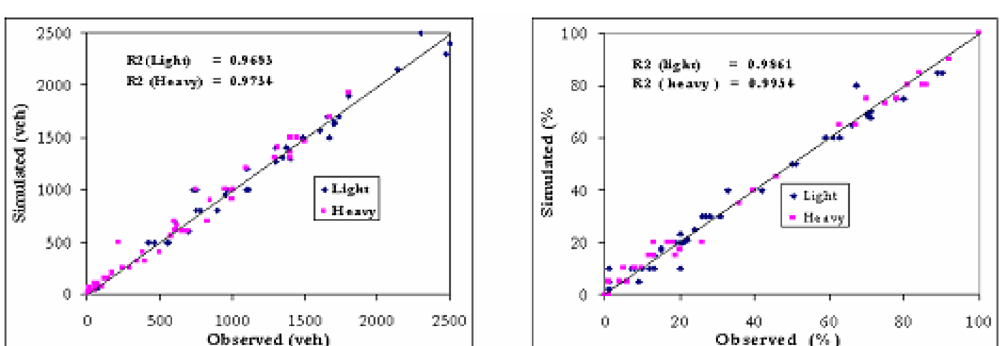
2.2 Traffic Simulation

Data for the traffic inflows at each boundary node of WHOLE AREA and tuning ratio at intersections was gathered for the morning peak hour (7:00 am ~ 10:00 am). Based on the throughput data, dynamic Origin and Destination matrix was evaluated by spreadsheet calculations. Signal parameters at the signalized intersection were also obtained.

The following section discus the simulation parameter calibration results.

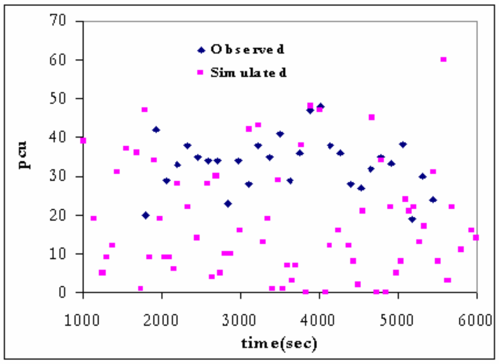
The observed versus simulated throughputs at the major intersections were compared. As shown in Figure 4 (a) the correlation coefficient for observed versus simulated throughput for both light (R^2 = 0.968) and heavy vehicle (R^2 = 0.973) is quite satisfactory. Figure 4 (b), represents observed versus simulated turning ratios at major intersection, the correlation coefficient for both light (R^2 = 0.986) and heavy vehicles (R^2 = 0.995) is quite satisfactory. From this, we can conclude that the traffic simulator has properly reproduced the observed traffic conditions.

Figure 4 **Observed Vs simulated (a) throughput in the study area (b) turning ratios at major intersections**



(a) (b)

Figure 5 **Observed versus Simulated queue volume (pcu)**



To ensure that the simulated traffic behaves the same way as the observed traffic, observed queue volume and simulated queue volume on links at some intersections were compared as shown in Figure 5. From the figure, we can conclude that traffic simulator is able to represent the real traffic behavior. The links on which we have observed congestion are also represented as congested links on the simulation result. Moreover, the simulated queue volume is quite comparable with that of observed one. We do not expect one to one correlation in this case as the definition for a vehicle to be a part of queue is entirely different for traffic simulator, AVENUE and field observation.

As the simulated flow and its behavior is close to the real world traffic on the network. We can assume that the traffic simulation is now ready to predict different traffic scenarios.

2.3 Traffic Noise Assessment

In order to reduce noise level in CORE AREA, we focus on the following different scenario:

1) Current condition with sound wall along MEX (BASE)
2) Banning of heavy vehicles (HV) along highway route (A⇔B, in Figure 3) (CASE-1)
3) Imposing speed limit of 30 km/hr from 60 km/hr along highway route (A⇔B, in Figure 3) (CASE-2)
4) Use of Sound wall along residential side of highway (route A⇔B⇔C, in Figure 3) (CASE-3)
5) Use of drainage asphalt on whole network (CASE-4)
6) Current condition with no sound wall along MEX (BASE with no sound wall along MEX, CASE-5)

CASE-1 and CASE-2 are related to different traffic management policies, so different traffic simulations results in different flows.

Dynamic contour maps are generated for each case. The areawide noise level prediction discussed in this paper is for LAeq-15min from 7:00 am to 7:15 am. The noise level is at 1.2 meter above the ground. In the contour maps the blue region corresponds to the noise level below threshold noise (which is assumed to be at 55 dB(A) for residential area and 60 dB(A) for industrial area). All non-blue regions are “AFFECTED” region, i.e. area above threshold noise level. Green, yellow, orange and red portion represents increasing intensity of noise above threshold noise level respectively. Noise impact for each case is studied by considering the noise level at residential and industrial buildings above their corresponding threshold noise level. If a residential building has noise exposure above 55 dB(A) then it is considered as an “AFFECTED” building, similarly if an industrial building has a noise exposure above 60 dB(A) then it is considered as an “AFFECTED” building.

2.4 Results

Contour map shown in Figure 6 corresponds to the BASE condition, i.e. current traffic and infrastructure condition. In this condition, MEX has two-meter sound wall (both sides) throughout its length. All the scenarios are compared with the base condition in terms of change in percentage of buildings affected with respect to base case.

Figure 9, Figure 10 and Figure 11 represent the impact of different scenarios relative to BASE case for all buildings, only residential buildings and only industrial buildings respectively. Percentages of buildings affected in different scenarios are quantified in Table 1 to Table 5

Though vehicle noise level is decreases by reduction in the speed of the vehicles, but there can be detour of the vehicles which can adverse the situation. Imposing speed limit along highway section (CASE-2) increases the percentage of residential buildings affected in CORE-AREA from 16% to 24%.

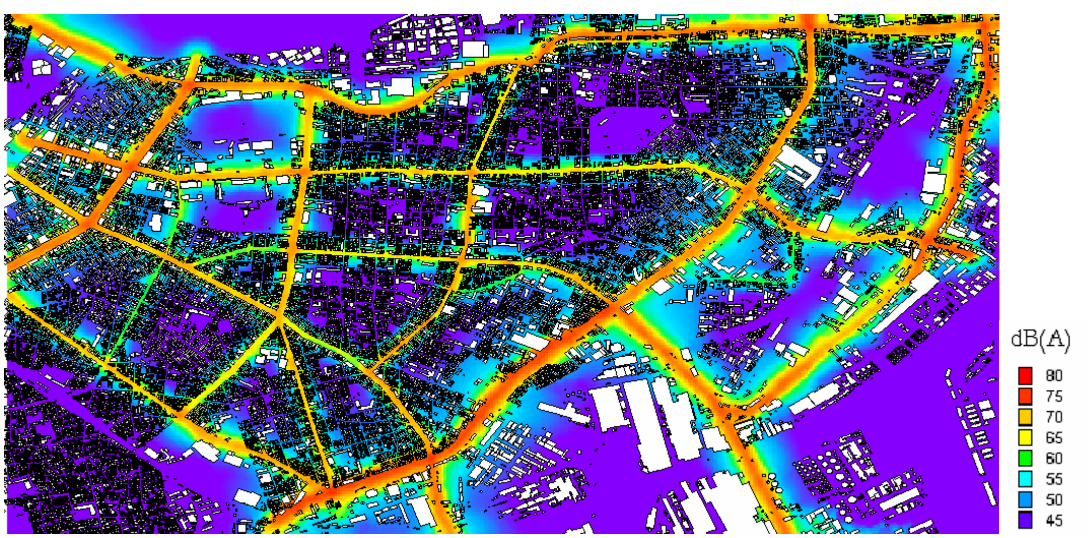
Table 6, gives a comparative over view of different measures relative to noise reduction and cost of implementing and maintaining the measure. The noise level reduction is high if we have noise reduction infrastructure, such as sound wall and drainage asphalt. However, such measures require huge amount of investment, and maintenance. On the other hand, managing traffic does not require substantial investment, but the noise problem from one area may shift to other area. Policy makers may assign different weights to different criteria and based on multi-criteria-analysis, effective and cost efficient noise reduction measure can be implemented.

2.4.1 Importance of areawide consideration

If heavy vehicle flow is banned along highway, then there is a shift of heavy vehicle towards arterial roads, and significant number of light vehicles shifts from arterial road towards highway. If we compare the contour map (Figure 7) with that of BASE case contour map (Figure 6), then we can see that there is a decrease in the intensity of noise level in CORE AREA, but there is an increase in intensity of noise level in WHOLE AREA. Same is reflected in terms of change in percentage of buildings affected with respect to BASE case. This case demonstrates the importance of areawide consideration. There is a decrease in percentage of buildings affected in CORE area, but the problem has shifted to whole area.

Figure 6 **Contour Map for BASE condition**

Figure 7 **Contour Map when HV is ban along highway route (A ⇔ B) (CASE-1)**



2.4.2 Importance of Sound Wall along MEX (CASE-5)

The intensity of noise when there is no sound wall along MEX (see Figure 8), is quite high compared to when there is two meter sound wall along MEX (BASE condition, Figure 6) . In fact, the affected area extends to a larger distance on both sides of MEX. This indicates that the sound wall along MEX has a greater contribution in reducing the noise level in the area around MEX, due to the traffic on the MEX. This case is to demonstrate the importance of sound wall along MEX.

Figure 8 **Contour map for BASE flow condition with no Sound Wall along MEX**

Figure 9 **Impact of different scenarios relative to BASE case for all buildings**

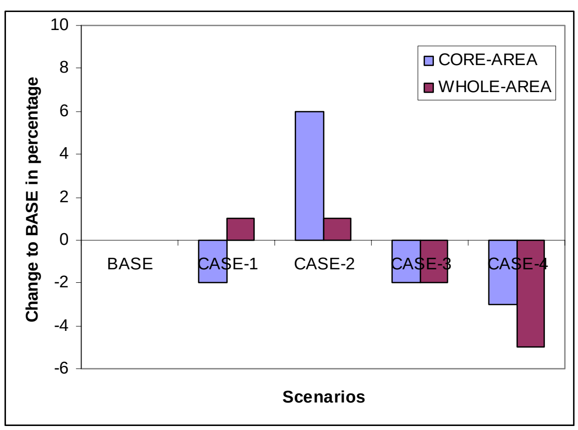


Figure 10 **Impact of different scenarios relative to BASE case on residential buildings**

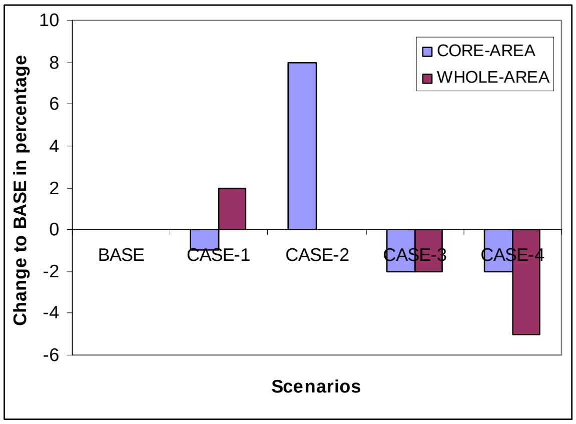


Figure 11 **Impact of different scenarios relative to BASE case on industrial buildings**

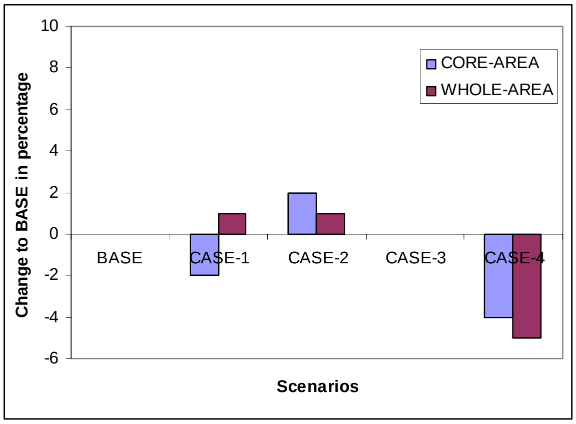


Table 1 **Percentage of building affected in CORE and WHOLE AREA's**

Scenario	CORE AREA	WHOLE AREA
BASE	17%	16%
CASE 1	15%	17%
CASE 2	*23%*	17%
CASE 3	15%	14%
CASE 4	14%	11%
CASE 5	81%	38%

Table 2 **Percentage of residential building affected in CORE AREA**

Scenario	**>55 dB(A)**	**>=60 dB(A)**	**>=65 dB(A)**	**>= 70 dB(A)**
BASE	**16%**	11%	8%	4%
CASE 1	**15%**	10%	7%	3%
CASE 2	**24%**	14%	9%	4%
CASE 3	**14%**	11%	8%	4%
CASE 4	**14%**	10%	5%	2%
CASE 5	**83%**	64%	29%	7%

Table 3 **Percentage of industrial building affected in CORE AREA**

Scenario	**>55 dB(A)**	**>=60 dB(A)**	**>=65 dB(A)**	**>= 70 dB(A)**
BASE	29%	**18%**	9%	2%
CASE 1	26%	**16%**	7%	1%
CASE 2	30%	**20%**	11%	3%
CASE 3	29%	**18%**	9%	2%
CASE 4	22%	**14%**	5%	1%
CASE 5	93%	**72%**	45%	10%

Table 4 **Percentage of residential building affected in WHOLE AREA**

Scenario	**>55 dB(A)**	**>=60 dB(A)**	**>=65 dB(A)**	**>= 70 dB(A)**
BASE	**16%**	8%	4%	1%
CASE 1	**18%**	10%	5%	2%
CASE 2	**16%**	9%	4%	1%
CASE 3	**14%**	8%	4%	1%

CASE 4	**11%**	6%	2%	1%
CASE 5	**36%**	21%	9%	2%

Table 5 **Percentage of Industrial building affected in WHOLE AREA**

Scenario	**>55 dB(A)**	**>=60 dB(A)**	**>=65 dB(A)**	**>= 70 dB(A)**
BASE	25%	**17%**	9%	3%
CASE 1	26%	**18%**	10%	4%
CASE 2	27%	***18%***	11%	4%
CASE 3	25%	**17%**	9%	3%
CASE 4	20%	**12%**	5%	1%
CASE 5	66%	**47%**	25%	6%

Table 6 **Comparative overview for different policies**

Measure	**Cost Implantation**	**Cost Maintanance**	**NOISE REDUCTION**					
			RESIDENTIAL AREA		**INDUSTRIAL AREA**		**CORE-AREA**	**WHOLE AREA**
			CORE-AREA	**WHOLE AREA**	**CORE-AREA**	**WHOLE AREA**		
Restrict HV	NIL	NIL	Medium	Negative Impact	High	Medium	Medium	Negative Impact
Impose Speed Limit	NIL	NIL	Negative Impact	Negative Impact	High	Medium	Negative Impact	Negative Impact
Sound wall	HIGH	MEDIUM	High	High	High	High	High	High
Drainage Asphalt	HIGH	HIGH	High	High	High	High	High	High

3. Summary

This paper presents the implementation of DRONE as an instrument to policy makers. The study in this section show that a noise abatement policy can reduce noise level in an area, but study of variation of noise on a larger area may result in a shift of the problem to other areas. Policies such as banning of heavy vehicle can reduce the problem in the subject area by 2%, but increased noise in other area particularly residential area by 2%. Greater reduction of noise can be achieved by noise reducing pavement but the cost may be high. The output from DRONE can be input to number of models dealing with hedonic pricing and economic evaluation of health cost associated with pollution. The inclusion of such factors in the social cost benefit analysis of a project will have a dramatic impact on the planning of a project. Therefore, it is important to evaluate the effectiveness of a measure to its cost benefit. A tool such as DRONE should prove to be a very useful for policy makers.

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