Paper ID: 277

A GIS- Based Approach for 2D Noise Modeling using 2D City Model

NV Wickramathilaka[1#], DS Munasinghe[2], KP Manuranga[3]

[1]*KDU Southern Campus, Sri Lanka*
[2]*Sabaragamuwa University of Sri Lanka*
[3]*KDU Southern Campus, Sri Lanka*

#nevilvidyamanee@kdu.ac.lk

Abstract: Noise pollution of urban areas is one of serious problem. The local and urban authorities have to consider decision making processes for establishing residential, newly construction of hospitals, schools and maintaining the public places etc. The national environment act, no. 47 of 1980 provides limitation about noise emission of Sri Lanka. Road traffic is a major sources of community noise in metropolitan cities. Road traffic noise mapping is described in this research. The main objective of this research is finding the noise levels where it is less than 63dB and sub objective is finding the suitable interpolation technique for road traffic noise mapping. Noise maps can be used to monitor the issues of noise effects. Most of the noise maps are available today in two dimensional (2D) in which noise effect is presented in x, y plane. The preparing of noise map is depending on noise calculation model and 2D city model. The noise calculation model is based on amount of vehicles and speed, road type and noise absorption from the air etc. But in here considers only number of vehicles, speed of vehicles and noise reduction with the distance for the calculation of noise levels. Digital data layers which are digitized from satellite images, are used to prepare the 2D city model. The spatial analysis methods of GIS (Geographical Information Science) can play an important role to control noise pollution. GIS provides framework to integrate noise calculation models with spatial data. IDW (Inverse Distance Weighted) and Kriging interpolation techniques are used for the interpolation of noise levels. When checking the accuracy of noise levels with sample points, it recognized the IDW which better interpolation technique for noise mapping. There are 73% area is more than 63 dB sound levels and those area can't be used for as silent areas in urban planning.

Keywords: GIS, 2D City Model, Noise Mapping

Introduction

Environmental Pollution such as air, water, hazardous waste and noise pollution always been affecting for the human health. Managing the environmental pollution is a challenge although there are many management techniques the problem remains still same. One of the major environmental pollution is noise pollution. Noise pollution in urban areas and large cities harm for the human health such as sleeping, reading, speaking, communication and human mental works etc. Noise pollution can be categorized as traffic noise, industrial noise, activity noise etc. Road traffic is one of the major source of community noise in metropolitan cities. Most of researches say noise Pollution of a city is 80% in road traffic and so this research is focused only for road traffic noise pollution and preparing the noise map. dB is the unit which used for calculating the noise. There are some rules and regulations for the noise emission in Sri Lanka. It is describing in under "THE NATIONAL ENVIRONMENT ACT, NO. 47 OF 1980". It says that day time noise level which can't be exceeded of urban city about 63dB.When preparing the road traffics noise map, it is based on creating 2D city model, 2D noise model and interpolation technique. The main objective of this research is preparation of 2D noise map for town planning by using GIS as a tool and the sub objective is introducing a better spatial interpolation technique for noise mapping.

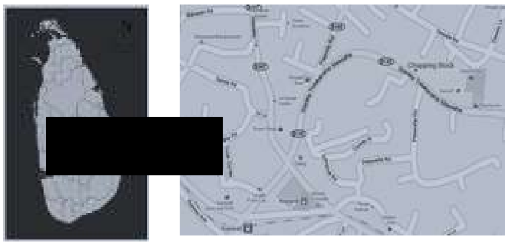


Figure 1. Nugegoda City

Source: Google Earth

The Nugegoda city has high density of motor traffic and this area is highly noise pollution area other than closer cities such as Maharagama and Homagama in Colombo district because of highly urbanize and density of buildings. When considering Nugegoda junction there is highly noise pollution since most of vehicles are passing this junction while travelling to Colombo. When establishing new hospitals, new schools, the engineers face some problems with the noise level in this area.

2D noise map is built with the traffic noise levels. The noise levels are travelled to the every direction of the space. It is important to develop 3D noise maps that can be shown influence of noise in all directions. But mapping the traffic noise is very difficult as 3D. It must be considered the heights of the buildings and preparing the noise observation points in 3D space are very cost effective and time consuming process. So 2D noise levels are only considered here for preparing a 2D noise map. Traffic noise is generated from engine of vehicles, the friction between ground and the air. Generating of noise levels are depended on traffic volume, type and speed of vehicles, roads and the noise reflectance. For avoiding such kind of complex situations, vehicle are grouped as light, medium and heavy vehicles and assumed that traffic noise level for an observation point is effected by only speed of vehicles and traffic volume.

Methodology

The digital data layers of survey department are used for preparing the 2D city model of Nugegoda area. GIS is used as a tool for preparing the 2D city model. The noise observation points are designed with respect to the 2D city model. The validation noise model is formed from the dBvision‟s noise expert Mr. Henk de Klujijver on December 15, 2011, model. The number of vehicles, speed of vehicles and noise reduction with the distance are considered for noise levels. The IDW and Kriging interpolation methods are used for preparing the noise interpolation. Risk analysis is done for using GIS techniques and high risk noise area and low risk noise area is found under The National Environment Act, No. 47 of 1980.

2D city map was obtained from using 1:10000 digital data layers in GIS vector format. Considering the vector format of road, land use and building layer were very easy for overlapping and finding the relationship between the layers using GIS as a tool. Figure 3, 4, 5 describe the road layer, building layer and land use layer of Nugegoda city.

Figure 3. Road Layer
Source: Survey Department, 2012

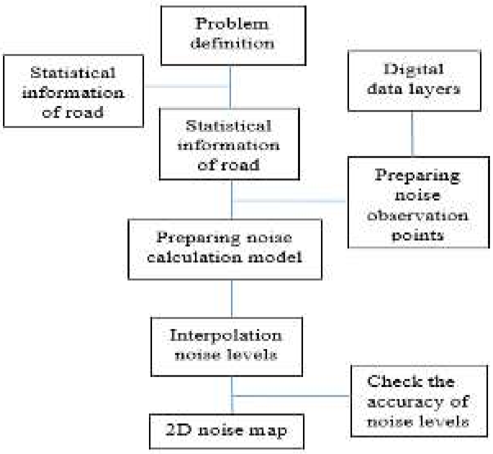


Figure 2. Flow Chart

A. Digital Data Layers

Figure 4. Building Layer
Source: Survey Department, 2012

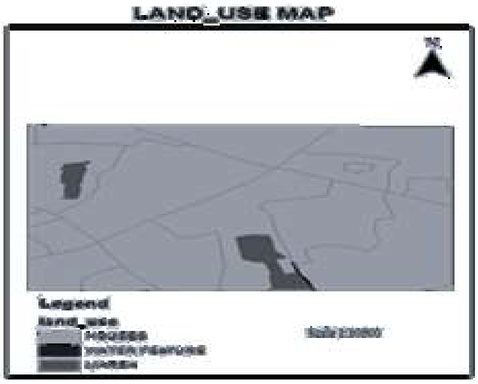
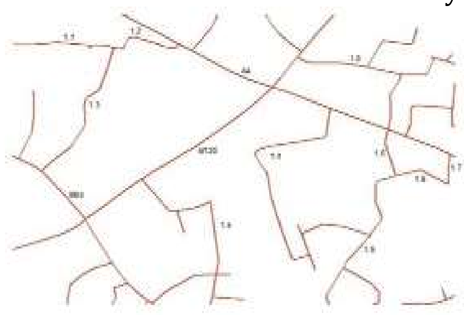


Figure 5. Land Use Layer

Source: Survey Department, 2012

B. Statistical Information of Road

It is very important for designing the 2D noise map which Vehicle amount, vehicle speed and vehicle type were taken to the account to solve the problems. Vehicle amount was collected under three categories like as light, medium and heavy vehicles. Light vehicles were considered which engine capacity is less than 2000cc (cc is the measurement of vehicle engine capacity) engine and three wheels and motor bikes were not considered for this research since dB value of them is not more effected for the noise pollution . Cars were taken to the account of light vehicles. Medium vehicles were considered which engine capacities are 2000cc-3000cc. Vans, cabs, jeeps were taken as the medium vehicles. Heavy vehicles were considered which engine capacity is more than 3000cc. Statistic data about vehicles (vehicle amount and speed) were taken from manually about eight days from 7.00am to 10.00am. The entire statistic data were taken for every Monday morning because of highly vehicle traffic is occurred on Monday. Then



average vehicle amount was taken of a day from 7.00am to 10.00am. Figure 6 describes the road network of the Nugegoda city and roads were identified using numerical numbers.

Figure 6. Road Network Nugegoda
Source: Survey Department, 2012

Number of vehicles were counted by manually and average speed of vehicles in Nugegoda city were observed by using a vehicle speed gun.

	A4	B120	B84	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
L	4623	2995	2674	128	46	32	52	21	167	12	8	6	9
M	726	402	264	60	27	23	36	9	56	7	5	4	3
H	391	297	106	4	3	0	5	1	12	0	0	0	0

Table 1. Number of vehicles

L-Light Vehicles, M-Medium Vehicles, H-Heavy Vehicles
Table 2. Average Speed of vehicles

	A4	B120	B84	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
	Speed(kmh^{-1})												
L	15	17	18	15	15	15	15	15	15	15	15	15	15
M	12	15	16	13	13	13	13	13	13	13	13	13	13
H	10	11	13	10	10	10	10	10	10	10	10	10	10

L-Light Vehicles, M-Medium Vehicles, H-Heavy Vehicles

C. Preparation of Road Traffic Noise Model

Noise calculation is not very easy. The main problem is how to identify a suitable noise model. The noise computation methods are designed to give an accurate traffic noise levels and can be implemented for any area for noise simulation. Kalutara North area was selected for preparing the road traffic noise model. Speed of vehicles and number of vehicles were considered here. Vehicles were categorized into three groups .Eight vehicles were used for each group for preparing road traffic noise model. Vehicle speed was observed using Vehicle Speed Gun. Figure 7, 8, 9 describe the Noise Levels with speeds.

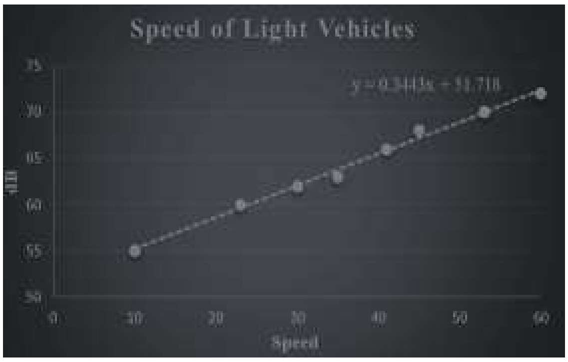


Figure 7. Speed of Light Vehicles

Figure 8. Speed of Medium Vehicles

Figure 9. Speed of Heavy Vehicles

Figure 10. Noise Reduction with Distance

By using statistical information of roads and noise reduction with distances the following noise calculation model was prepared.

L =Light Vehicle, M = Medium Vehicle, H = Heavy Vehicle, Average Speed of Light Vehicles =LV Average Speed of Medium Vehicles =MV, Average Speed of Heavy Vehicles =HV, dB Levels from Light Vehicle =dB (L), dB Levels from Medium Vehicle=dB (M), dB Levels from Heavy Vehicle =dB (H), Total Light Vehicles =TL, Total Medium Vehicles =TM, Total Heavy Vehicles =TH

dB (L) = 0.3443(LV) + 51.718...(1)

dB (M) = 0.4278(MV) + 59.173...(2)

dB (H) = 0.3382(HV) + 68.693...(3)

Total Light Vehicles =TL

Total Medium Vehicles =TM

Total Heavy Vehicles =TH

dB Levels from Total Light Vehicles = dB (TL)

dB Levels from Total Medium Vehicles =dB (TM)

dB Levels from Total Heavy Vehicles =dB (TH)

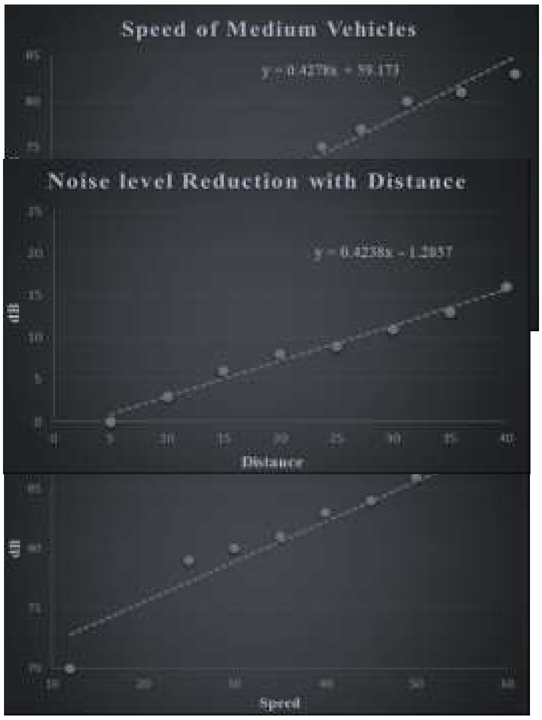
Decibel adding equation for same noise sources..(*)

= L_s + 10 log (n)..(*)

n = number of sources, L_s = signal level from each single source (dB)

dB (TL) = dB (L) + 10Log10 (TL)...(4)

dB (TM) = dB (M) + 10Log10 (TM)...(5)



dB (TH) = dB (H) + 10Log10 (TH)...(6)

Substituting values for dB (L), dB (M) and dB (H) from equations (1), (2) and (3)

dB (TL) = (0.3443 (LV) + 51.718) +10Log10 (TL)...(7)

dB (TM) = (0.4278 (MV) + 59.173) + 10Log10 (TM)...(8)

dB (TH) = (0.3382 (HV) + 68.693) + 10Log10 (TH)...(9)

Decibel adding equation for different noise sources...(**)

$$E = 10\text{Log}\left(10^{\frac{E_{Tl}}{10}} + 10^{\frac{E_{Tm}}{10}} + 10^{\frac{E_{Th}}{10}}\right)$$ ...(**)

Calculating noise levels from all Light, Medium and Heavy Vehicles by using equation (7), (8), and (9)

dB (T) = dB (TL) + dB (TM) + dB (TH)

dB (T) =10Log10(10(dB (TL)/10) + 10(dB (TM)/10) + 10(dB (TH/10))

dB Levels Reduction with Distance = dB (R)

Distance from center line of road to noise observation points = D

dB (R) = 0.4238(D) - 1.2857...(10)

Final noise levels of observation point = F (dB)

F (dB) =dB (T) – dB (R)....(***)

D. Preparation Noise Observation Points

Noise observation points were designed parallel to the road and for designing high density of points the small gaps were maintained between the observation points.

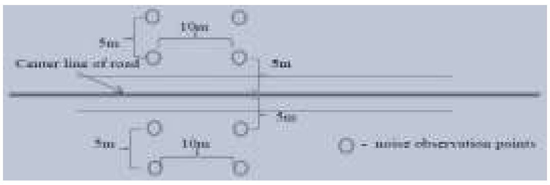


Figure 12. Dimension of Noise Observation Points

Assumed that noise is not penetrated through the cement walls and buildings. So it was considered when design noise observation point with respect to the 2D noise model.

Figure 13. Noise Observation Points in Arc GIS

E. Interpolation of Noise Levels

The noise levels were found using noise model which was created by MATLAB software. The Kriging and IDW interpolation techniques were used for noise interpolation. The output cell size was taken 1m.

F. Validation of 2D Noise Map

In noise calculation model all the noise levels were calculated by using MATLAB program. But it must be considered with the actual noise levels (check points) in the field. To plot the check points which were directly collected from the field used coordinates of them. The hand held GPS was used for collecting the check points. By using check points, the accuracy of IDW and Kriging interpolation values were compared. The RMSE (Root Mean Square Error) of IDW and Kriging was taken with respect to the check points.

Results and Discussion

The Kriging and IDW provide the raster surface as final result. The power of interpolation function was used as two degree. If it was used higher order polynomial function the surface will be so smooth but unpredictable oscillations will be occurred. To reduce those problems higher order polynomial function was not used. For preparing noise interpolation which Kriging and IDW method is better because of high density of noise observation points and those techniques give continuous and more exact surfaces. The noise levels were categorized as four classes like as 30-50, 50-70, 70-90, 90-110.When comparing the IDW and Kriging Interpolation noise levels with check

Figure 14. Final Noise Map

points the RMSE (Root Mean Square Error) was as Rmse IDW=1.923 and Rmse Kriging=2.837.

For the final noise map the IDW interpolation noise map was reclassified in to 2 classes such as less than 63dB and more than 63dB.When considering the final noise map the total area is 639072m^2 and 105064m^2 is less than 63 dB area. The 16.44% area is less than 63 dB noise emission from study area.

Conculsion

Because of considering only the Speed and number of vehicles and noise reduction with the distances, the Rmse value was high. If considering the environmental conditions for noise levels such as wind speed, pressure and reflectance noises from the buildings the accuracy of the noise levels may be increased. The 2D city model is mostly used for the noise mapping because of it is very flexible method for the noise interpolation. The Preparing 2D city model is less time consuming and cost effective method. The roads, buildings and land uses are considered for the 2D city noise model. Normally the 3D city model gives the good cartographic visualization than 2D city model. The fly over in Nugegoda city was not considered here because of 2D city model was used here.2D noise map provides some facilities for developing urban planning. The high risk, medium risk and low risk noise area can be abstracted from the 2D noise map along the horizontal surfaces. When creating newly schools, hospitals, libraries in Nugegoda city area, the <63dB area can be used. When examining the noise map there are high noises in road junctions so those area can be used only for the commercial activities. Major roads have high noise pollution and minor roads have low noise pollution. If the road traffic is reduced it can be helped for reducing the noise pollution.

References

D. Butler, "Noise Management: Sound and Vision," Na- ture, Vol. 427, No. 6974, 2004, pp. 480-482.

G. Belojevic, B. Jakovlevic and O. Aleksic, "Subjective Reactions.

Traffic Noise with Regard to Some Person- alit Traits," Environmental.

Hamid Reza Ranjbar1, Ali Reza Gharagozlou2, Ali Reza Vafaei Nejad1 1Department of Environment and Energy, Science and Research Branch.

S. Rahmani. M. Mousavi and M. J. Kamali, "Modeling of Road-Traffic Noise with the Use of

Genetic Algo- rithm," Applied Soft Computing, Vol. 11, No. 1, 2011, pp. 1008-1013.

V. K Kurakula and M .Kuffer 3D noise modeling for urban Environmental Planning and Management," REAL CORP, Vol. 432, No. 1, 2008, pp. 517-523.

Acknowledgements

I would like to thank lectures of faculty of Geomatics in Sabaragamuwa university of Sri Lanka. It is time to remind the remarkable contribution of GIS branch of Survey department for giving all digital data layers for creating 2D city model. Finally, I wish to express my sincere thanks & gratitude to all the people who helped us in many ways.

Author Biography

I have Studied BSc Surveying Sciences (GIS and Cartography). I have an interest for visualizing environmental problems by using GIS and cartography. Arc GIS provides very important mapping environment with cartographic visualization for spatial mapping. Here I have prepared a 2D noise map for urban planning. In future I will hope for preparing 3D city noise map for the purposes of urban planning.