State of the Art Review on Road Traffic Noise Mapping using GIS

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Abstract— Noise pollution generated from vehicles with its influence on life quality and the environment may be considered as a hot topic in scientific research and one of the main concerns of the world, especially in urban areas, regarded as growing problem of communities. Due to explosion of population, industrialization the transportation in urban has been increased to unimaginary heights. Hence, vehicular traffic has been increased and road traffic noise levels are increased simultaneously. In order to implement effective measures against traffic noise, the information about its distribution in the form of Noise maps is imperative. In this study, Noise mapping using Geographical information system (GIS) has been reviewed.

Key words: GIS, Noise, Noise prediction, Road traffic noise, Vehicular traffic

I. INTRODUCTION

Although development in transportation system in economic-social fields is considered very useful for societies but now a days noise pollution is known as one of the main environmental problems in crowded urban districts. Motor vehicle, a significant symbol of modern civilization, not only brings convenient transportation to our society but [1], also contributing about 55% to the total noise. [10]

In many urban areas the public transport system is very inefficient and inadequate, resulting in extraordinary growth of personalized vehicles. Besides this, the heterogeneous nature of traffic, continuously plying on roads, develops the interrupted traffic flow conditions and is directly responsible for traffic congestion which gives rise to road traffic noise pollution. [7]

Traffic noise pollution impacts high population density areas by negatively affecting residents' daily life (e.g., sleep, work and study). Consequently, the quantification and control of traffic noise has become a critical issue. Before proposing noise control policies, noise maps are needed to survey existing distributions of noise levels, examine noise level regulations and identify primary noise sources as Noise mapping is one of the best ways of understanding environmental noise. [8]

II. NOISE MAPPING & IT'S APPLICATION

Measuring the acoustic characteristics of a city is a complex, laborious and expensive task, and noise mapping has been shown to be an efficient way of assessing environmental noise. [12] Noise mapping is the geographic presentation of data related to outdoor sound levels and sound exposure with associated information on impact to the affected population. [9]

Mohammed Taleb Obaidat (2008) has reported in his study that Noise maps could quantify noise levels and their effects based on areas, population density, buildings, and type of buildings. He has also described that Spatial noise contour maps can be used as indicators to identify factors that influence traffic noise levels near roadways, manage the land use planning process, quantify the noise effect on the surrounding neighborhood and developed infrastructure, develop an online traffic noise information system, perform spatial queries to find highest noise disturbance location at any time of the day, and control variation in land prices. [13]

According to Kang-Ting Tsai, Min-Der Lin et. al. (2008), Noise map can be used for following purpose: [8, 17]

- Quantify main sources of noise.
- Clearly illustrate environmental noise exposure to provide a reference for policy makers.
- Facilitate the development of policies for controlling noise and enforcing the control of noise.
- Draft a cost-benefit plan to assist districts desiring to reduce noise levels.
- Adopt theory to examine the effect of environmental improvement plans.
- Improve the enforcement of regional or national plans to decrease new noise resource as well as to protect new noise sensitive and tranquility needed areas.
- Monitor noise reduction schemes and their effectiveness during the enforcement process.
- Monitor changing trends in environmental noise.
- Provide a research platform for studying the effects of noise on the human body.
- Evaluation of population exposure;
- Creation of a database for urban planning with localisation of noisy activities and mixed and sensitive zones.
- Modelling of different scenarios for the future.
- Prediction of impact noise of the projected infrastructure and industrial activities.

III. ROLE OF GIS IN NOISE MAPPING

Geographic Information Systems (GIS) play an important role in noise mapping. An appropriate use of GIS in mapping noise effects provides the possibility to optimize quality and efficiency of noise effect studies. Furthermore, GIS can influence in estimation and exposure of uncertainties. The results of different studies can only be combined or compared if the same indicators for noise exposure and the same assessment methods are used. These effect studies support the decision-making process [2, 11].

Hadzi-Nikolova M., Mirakovaski D. et. al. has described in his study that GIS provides a powerful set of tools for storing and retrieving, transforming and displaying spatial data from the real world for particular set purposes. GIS facilitates the visual presentation of the noise effects and an additional tool for analysing the results. The integration of GIS with noise prediction models provides

fast and accurate assessment of the environmental impact of noise. [6]

Murphy Enda; Rice Henry J.; Meskell, Craig (2006) has discussed the exact role of GIS in environmental noise studies in their study work. GIS mapping package ArcMap within ArcGIS offers centralized data management facility, which is compatible with commercial noise software such as Predictor. In that Grid co-ordinate information and noise emission values can be stored centrally. This is extremely helpful in building shapefiles and road polylines associated with attributes like traffic flow, building height, average speed etc. They have also discussed that with the help of ArcScene 3-dimentional visualisation analysis of noise results for any study area is possible to enhance visualization of spatial data. 3D animation has the potential to be a very important visualisation tool in terms of educating and informing the public about the impact of environmental noise in individual localities. Individuals can interactively navigate the noise environment by using a 'Flythrough' tool in ArcScene. They have explained three different types of data interpolation methods used for generating noise rasters in ArcMap – Nearest Neighbour, Inverse Distance Weighting (IDW) and Kriging by generating noise maps of Inner Dubin to compare standard deviation by all these three methods. [14]

F. Farcas, A. Sivertun in their study shown the tools that generate noise maps based on the available mathematical equations from Nordic Prediction Method for Road noise calculation. The noise prediction method was implemented as one of several extensions of ArcGIS Desktop, a state-of-the art GIS software package developed by ESRI. Seven tools like Noise calculation of roads, for roads and buildings, at generated receiver points, with population as receiver points, at building facades, for different receiver heights and population exposure to noise were implemented to analyze noise levels varying from entire regions like Skane to several streets in detail. Detailed noise maps were also build up for smaller areas in the city of Lund. [4]

Mohammed Taleb Obaidat (2008) has discussed numerous advantages of GIS usage in noise studies like: Increasing the quality of the study on noise pollution, Supporting environment management, Decreasing the cost of noise studies, Forming a link between geographical and geometrical information of the surrounding environment and the noise prediction model, Calculating the impact of noise on the environment, Providing a monitoring and quantifying noise tool, Presenting, storing, managing, manipulating, analyzing, and visualizing capabilities of the database etc. [13]

IV. Previous Studies on Road Traffic Noise Mapping using GIS

Studies on traffic map were carried out early in foreign countries. [20] Noise mapping was initially developed in Europe and has been extensively applied and developed since the issuance of the Environmental Noise Directive. For example, Birmingham produced a city-scale noise map in 2000, Britain published the world's largest official noise map - ''London Road Traffic Noise Map'' in 2005, Madrid created a noise map using over 4000 points of noise-monitoring results, Norway has used a noise map and population statistics to control noise, Over 500 towns in Germany are equipped with noise maps and Italy, Netherlands and Turkey have conducted noise map research using GIS. In addition to the aforementioned European countries, Japan, South Korea, Brazil and the United States have also embarked on noise map research. In these countries, environmental noise simulation software, such as ''Cadna/A'', ''Soundplan'' and ''Lima'', are primarily used. Usually, the Calculation of Road Traffic Noise from the UK (CRTN) and the Richtlinien fur Den Larmschutzan Strassen (RLS90) traffic noise evaluation/estimation models are used in these software. [12] These software are based on GIS only.

Azam Gholami, Parvin Nasiri et. al. (2012) analyzed spatial characteristics of traffic noise in the urban district through measuring sound at 41 stations with residential, medical, educational, commercial-residential, and commercial uses in area 3 of district 6 of Tehran. Parameters including SPL, L_{min}, L_{max}, L_{eqav} were measured during three intervals ranged from 7-9 am (peak traffic hours), 11-13 (non-peak traffic hours) and 5-7 pm (peak traffic hours) in fall, 2010. Desired locations were distinguished on the map via GPS to prepare point map in GIS. To demonstrate the effect of noise mapping on investigating the environmental noise, noise maps were produced according to the obtained data using spline interpolation method in ArcGIS. The maximum and minimum average of noise level in this analysis were respectivelymeasured77.7 dB(A) from 7 a.m. to 9 a.m. at Qaem Maqam and Motahari intersection with commercial use and 57.8 dB(A) 5 p.m. to 7 p.m. in Seda & Sima school with educational use which are respectively 17.7 dB(A) and 2.8 dB(A) more than the standard level based on the quantities published by Iran's Department of Environment(DOE). [1]

D. Banerjee, S. K. Chakraborty et. al. (2009) have compute the temporal and spatial distribution of road traffic induced noise pollution in an urban environment by monitoring and mapping for Asansol city of West Bengal, India for 35 locations classified as industrial, commercial, residential, sensitive and mixed areas according to the national regulatory standards. They have used both graphical and statistical software and GIS tools for preparation of noise contour maps. In the present investigation, multispec (Purdue Research Foundation, USA) – a multispectral image data analysis system was used along with GRAM++ (C.S.R.E., IIT-Bombay, India) GIS software. They have created noise contour maps in Roadnoise- 2000 (Atkins) and also Surfer-6.02 (Golden Software Group). Maps were created using interpolation (ordinary kriging) method. [3]

Guzel yilmaz, yuksel hocanli (2006) conducted their study in Sanliurfa city of Turkey. Continuous weekly data were obtained in 11 measurement points. Measurements have been done in the reference point at 5-min intervals and in the other points during daylight between 11:00–13:00 o'clock for one week. The highest noise value was measured as 82 dB. By using mean of 5minute noise data in GIS environment, line source map was prepared with the help of ArcGIS 8.1 by interpolation method. [5]

Hadzi-Nikolova M., Mirakovaski D. et. al. prepared the noise map for parts of the city Stip, as a small urban area in the centre of the East Macedonia is delivered as a visual information of the acoustic behaviour. For this purpose, the SoundPLAN software is used. The small and medium sized agglomerations (up to 100,000 inhabitants) as well as model generation and data administration are performed by the SoundPLAN as single software. [6]

Kang-Ting Tsai, Min-Der Lin et. al. (2008) analyzed the spatial characteristics of urban environmental noise by using noise maps produced at 345 noise monitoring stations in Tainan, Taiwan. Noise data were collected at varying intervals: morning, afternoon, and evening in both summer and winter. The spatial distributions of the noise levels during each time interval were evaluated and visualized by geographic information systems. The analytical results indicated that the highest and lowest average noise levels were 69.6 dB(A) and 59.3 dB(A) during summer mornings and winter evenings, respectively. Comparison of monitored noise levels with regulatory standards revealed that noise standard violations, which usually occur on summer evenings, are as high as 23 dB(A). Furthermore, the results of noise exposure analysis showed that over 90% of the Tainan City population are exposed to unacceptable noise as defined by US Department of Housing and Urban Development. The ordinary Kriging method was adopted in this study for spatial interpolation of noise data to measure noise distribution and to prepare noise level contours. [8]

Ming Cai, Jingfang Zou et. al. (2014) studied first, as speed density relation is used to estimate the traffic volume from GPS data collected from floating cars. Meanwhile, the attributes of the roads and buildings are automatically exported from GIS. Second, a single vehicle noise emission model is combined with a noise propagation model to formulate a regional traffic noise calculation model that accounts for the traffic noise attenuation in an urban area. The accuracy of the developed algorithm is validated by conducting a traffic noise monitoring experiment in several districts of Guangzhou with different road types. The results show that the average error between the estimated and measured values is below 2.0 dB. The calculation results were projected on to GIS map to create day and night traffic noise maps for Guangzhou, China. [12]

Nasim Akhtar, Kafeel Ahmad et. al. (2012), in their study, attempted to prepare noise maps for various important locations of Delhi city using GIS and Predictor software. Critical locations have been identified in preliminary survey for noise level measurements. The noise levels in terms of L_{10}, L_{50}, L_{90} and Leq have been measured using digital Sound Level Meter (Larson and Davis, USA, Model – 831) during working days and under ideal meteorological conditions. The original map of Delhi has been scanned and registered/geo-referenced to specify its location by inputting coordinates. Arc-GIS have been used to create digitized map of Delhi city. Thereafter, the collected data of noise levels for various locations have been given as input parameters in predictor software for the generation of noise maps for Delhi city. The equivalent noise levels measured at various locations have been ranging from 53 dB(A) to 83 dB(A). The prepared noise maps show the variation of noise levels (Leq) at different locations, which indicates the presence of traffic in terms of number and category of vehicles. [15]

Seul KOO, Jae-Hoon EO, Hwan-Hee YOO (2012) has analyzed the noise measuring network data from 2002 to 2009 in Jinju city of Korea in order to analyze the characteristics of land use zoning-based noise distribution in urban area with the use of GIS. Distribution of the mean noise level of different areas by time level and mean noise in daytime and nighttime by year were analyzed. They have used spline interpolation method in GIS compare the present status and the noise value in the corresponding district by indicating the noise distribution chart on the whole of the target districts by overlapping with aerial image. On the basis of analysis, they conclude that all of land use zoning except industrial area were exceeding the noise environment standard. Out of it, the noise in residential area tended to be increased continuously. [16]

Wazir Alam (2011) has carried out the study the noise pollution scenario of Guwahati city at various locations, i.e. commercial zones, residential zones and silence zones (educational institutions and hospitals and nursing homes). Noise map were prepared using ArcGIS 9.3.1 software for better visual information of the noise environment of Guwahati City and its diurnal variations using krigging interpolation technique. It was observed from the study that, places with high traffic congestion, narrow roads, heavy constructional activities and poor traffic management areas are more vulnerable to high noise levels. Some of the educational institutions, hospitals and nursing homes are also in the grip of high noisy environment. Highest noise levels ranging between 80-90 dB (A) recorded in commercial locations, 65-75 dB (A) in residential areas, 65-75 dB(A) in silence zone in the city. It was also observed that higher noise level in the city is due to rapid and unplanned urbanisation resulting in great influx of people from all parts of the region and country, improper management of city roads and traffics, lack of sufficient parking spaces and exponential growth of both private and public vehicles in the city. [18]

Zhilin Pan, Jianjun Zhu (2011) has proposes a new kind of traffic noise analysis method based on the extensive traffic noise data obtained from Huidong county, Guangdong province of China. Plane traffic noise maps are made by a traditional method and compared with the real noise distribution. The results indicate that they do not match in the old city zone. In addition; integrated with factors such as acoustic characteristics, streets' shape, and building heights; CadnaA software was employed to determine the plane traffic noise distribution. [19]

ZOU Jingfang, CAI Ming et. al. (2011) have adopted video identification and artificial statistical methods to obtain the information of traffic flow and vehicle speed by carrying out 24 hours traffic flow investigation for the whole road network of Chancheng district. Then combined with the GIS (geographical information system) and based on the FHWA model, an urban traffic noise simulation system was developed independently to calculate the traffic noise of the district. Traffic noise map were prepared using software Surfer to map the day-night traffic noise of the district. Noise reduction measures such as "odd-even" traffic restriction and installing sound barriers were also assessed. [20]

V. CONCLUSION

The noise map itself provides baseline data for town planners, engineers and others for planning and execution of their projects. Spatial maps are vital for city planning and traffic engineers for the purpose of zoning, land use, land pricing and traffic management.

It is recommended from previous studies that Urban traffic planning procedure followed by town planners, developers, elected officials, government agencies should consider the analysis of noise maps as an important part of the town planning and traffic management.

It is also recommended that online and real time traffic noise based information system must be developed and practiced as it is already has been in practice for different parameters like humidity, ambient air temperature, rainfall etc.

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