UNIVERSITI PUTRA MALAYSIA

VEHICULAR TRAFFIC NOISE PREDICTION AND PROPAGATION MODELLING USING ARTIFICIAL NEURAL NETWORK

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By

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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January 2018

Chairman : Professor Biswajeet Pradhan, PhD
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Noise is a sound of variable frequencies considered as one of the leading causes of environmental challenges faced in many cities due to high traffic volume and has a harmful effect on the population. Discomforting issues such as interference with communication, speech, effects on attention, people's health and well-being, psychological and cardiovascular alterations are some of the major disturbances caused to our environment. This thesis presents a Neural Network (NN) model developed to predict and simulate the propagation of vehicular traffic noise in a dense residential area at the New Klang Valley Expressway (NKVE) in Shah Alam Seksyen 13, Malaysia. The proposed model comprises of two main simulation steps: i) the prediction of the vehicular traffic noise using NN in order to obtain the final noise maps for weekends and weekdays; ii) The simulation of the propagation of the traffic noise emission in the study area using a mathematical model to define the propagation of the study area. By utilizing the Chi-square statistical analysis, the former model was developed with six selected noise predictors. These predictors include the number of motorbikes, the sum of vehicles, car ratio, large vehicles ratio (truck, lorry, and bus), highway density, and a LiDAR derived Digital Surface Model-DSM. The neural network and its hyperparameters were optimized through a systematic optimization procedure based on a grid search approach. In contrast, the noise propagation model was developed based on principle concepts of traffic noise. This model was based on road geometry, barriers, distance, the interaction of air particles, and weather parameters which are applied to Geographic Information System (GIS). The noise measurement was carried out continuously at 15-min intervals and the data were analyzed by taking the minimum, maximum, and averages of every data set recorded during the day. The measurement was carried out four times a day (morning, afternoon, evening, and midnight) all through two-days of the week (Sunday and Monday). The optimal radial basis function NN model was used which comprised of 17 hidden layers with a back-propagation algorithm. The

learning rate of 0.05 and a momentum of 0.9 were used in this experiment. The results showed that the proposed NN model achieves a validation accuracy of 78.4% and an error in noise prediction with less than 4.02 dB. The model also outperforms the Multilayer Perceptron (MLP) model by almost 5% of validation accuracy and 0.3 dB in noise level prediction. In addition, the three most influential parameters on traffic noise were car ratio, the sum of vehicle, and large vehicle ratio. Overall, the proposed models were found to be promising tools for traffic noise assessment in dense urban area of the study area.

Keywords: traffic noise; noise prediction; noise propagation, neural networks, mathematical models.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PREDIKSI BUNYI LALU LINTAS TRAFIK KENDERAAN DAN PEMODELAN MENGGUNAKAN NEURAL NETWORKS

Oleh

AHMED ABDULKAREEM AHMED

Januari 2018

Pengerusi : Profesor Biswajeet Pradhan, PhD
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Hingar adalah pelbagai frekuensi bunyi dan merupakan satu daripada punca utama cabaran persekitaran yang dihadapi di bandar oleh kerana aliran trafik yang tinggi dan mempunyai kesan berbahaya terhadap populasi. Isu isu ketidakselesaan seperti gangguan komunikasi, pertuturan, efek tumpuan, masalah kesihatan dan kesejahteraan, psikologi dan perubahan kardiovaskular merupakan antara punca gangguan utama terhadap alam sekitar kita. Tesis ini memaparkan model Rangkaian Saraf (NN) yang dibangunkan untuk mejangkakan dan mensimulasikan penyebaran bunyi bising lalu lintas dari kenderaan dalam kawasan berpenduduk padat di Lebuhraya Baru Lembah Klang (NKVE), Malaysia. Model yang dicadangkan terdiri daripada dua langkah utama simulasi: i) ramalan bunyi bising lalu lintas dari kenderaan menggunakan NN untuk mendapatkan peta hingar akhir pada hujung minggu dan hari biasa; ii) Simulasi pelepasan penyebaran bunyi bising lalu lintas di kawasan kajian menggunakan model matematik untuk mentakrifkan penyebaran di kawasan kajian. Dengan menggunakan analisis statistik Chi-square, model sedia ada dibangunkan dengan enam pilihan peramal bunyi. Peramal-peramal ini termasuk bilangan motosikal, jumlah kenderaan, nisbah kereta, nisbah kenderaan berat (trak, lori dan bus), ketumpatan lebuhraya, dan Model Permukaan Digital-DSM Dapatan LiDAR. Rangkaian seni bina dan hiperparameternya dioptimumkan melalui prosedur optimasi bersistematik berdasarkan pendekatan carian grid. Sebaliknya, model penyebaran hingar dibangunkan berdasarkan konsep asas hingar lalu lintas. Model ini berlandaskan pada geometri jalan, halangan-halangan, jarak, interaksi zarah udara, dan parameter cuaca yang digunakan pada Sistem Informasi Geografik (GIS). Kiraan hingar telah dijalankan secara berterusan dengan selang 15 minit dan data telah dianalisa dengan mengambil kira minimum, maksimum dan purata setiap data yang direkodkan sepanjang hari. Kiraan telah dilakukan sebanyak empat kali sehari (pagi, tengah hari, petang, dan tengah malam) sepanjang dua hari dalam seminggu (Ahad dan Isnin). Model fungsi asas jejari optimal NN telah digunakan yang terdiri daripada 17 lapisan rahsia dengan algoritma back-propagation. Kadar pembelajaran

sebanyak 0.05 dan momentum sebanyak 0.9 telah digunakan dalam eksperimen ini. Hasil kajian menunjukkan bahawa model NN yang dicadangkan mencapai ketepatan pengesahan sebanyak 78.4% dan kesilapan ramalan hingar kurang daripada 4.02 dB. Model ini juga melepasi model Multilayer Perceptron (MLP) dengan melebihi 5% ketepatan pengesahan dan 0.3dB dalam tahap ramalan hingar. Tambahan pula, tiga parameter hingar lalu lintas paling berpengaruh ialah nisbah kereta, jumlah kenderaan, dan nisbah kenderaan berat. Secara keseluruhannya, model yang dicadangkan didapati dapat dijadikan alat yang meyakinkan untuk penilaian hingar lalu lintas di kawasan berpenduduk padat di kawasan kajian.

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"In the name of Allah, the most beneficent and the most merciful"

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This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

EIA	Environmental Impact Assessment
NN	Neural Network
GIS	Geographic Information System
LiDAR	Light Detection And Ranging
NKVE	New Klang Valley Expressway
MLP	Multilayer Perceptron
Leq	Equivalent Continuous Level
GPS	Global Position System
ANN	Artificial Neural Networks
BP	Back-Propagation
L–M	Levenberg–Marquardt
UAE	United Arab Emirates
ORNAMENT	Ontario Ministry of Transport Road Traffic Noise Model
BSTN	Basic Statistical Traffic Noise Model
LMA	Levenberg-Marquardt Algorithm
dB	Decibel Level
DSM	Digital Surface Model
DEM	Digital Elevation Model
IDW	Inverse Distance Weighted
RPC	Rational Polynomial Coefficients
GCPs	Field Measured
WS	Wind Speed
SoV	Sum of Vehicles
CR	Car Ratio
HD	Highway Density
MR	Motorbike Ratio
M	Number of Motorbikes
C	Number of Cars
HV	Heavy Vehicles
HVR	Heavy Vehicles Ratio
RBF	Radial Basis Function

BFGS	Broyden–Fletcher–Goldfarb–Shanno
RBFT	Radial Basis Function Training Algorithm
L_{Aeq}	Average Equivalent Noise
E	Noise Emission of Vehicles
C_{rg}	Road Geometry Coefficient
C_b	Barrier Coefficient
C_d	Distance Coefficient
C_{air}	Air Interaction Coefficient
C_w	Weather Coefficient
T	Time
D	Day
L_w	Average Continuous Equivalent Noise For Weekdays And Weekends
L_s	Average Continuous Equivalent Noise For Weekends
L_m	Average Continuous Equivalent Noise For Weekdays
$L_{morning}$	Average Continuous Equivalent Noise For Morning
$L_{afternoon}$	Average Continuous Equivalent Noise For Afternoon
$L_{evening}$	Average Continuous Equivalent Noise For Evening
L_{night}	Average Continuous Equivalent Noise For Night
MAE	Mean Absolute Error
RMSE	Root Mean Square Error
WHO	World Health Organization standards
DOE	Department Of Environment
CPCB	Central Pollution Control Board
IDW	Inverse Distance Weighting
JTG B03-2006	Specifications for Environmental Impact Assessment of Highways
HJ2.4-2009	Technical Guidelines for Noise Impact Assessment
WG-AEN	Working Group on Assessment of Exposure to Noise

CHAPTER 1

INTRODUCTION

1.1 Introduction

Highway networks play a major role in every country's economy and in providing accessibility services to the citizens. Making these infrastructures vital and efficient is a priority in every developing world. However, traffic noise is a major problem on highways contributing to the overall noise pollution. The primary causes of traffic noise are heavy (truck, lorry, and bus) and medium (two and four wheel) cars, motorbikes, and other traffic and road geometrical factors (slope, curves, and intersect). There are different physical and psychological effects for every inappropriate noise level (Morley et al., 2015).

High traffic noise affects the human health and comfort including hearing defects, high blood pressure, irregularity of heart rhythm, and ulcers (Harman et al., 2016; Lee and Fleming, 1996; Ozer et al., 2009; Steele, 2001). In addition, there are other effects such as disorders, sleeplessness and sleep late, irritability and stress. Also, effects on work performance such as reduction in productivity, has also been reported (Ozer et al., 2009). Besides, collecting noise measurements on high-speed highways can be expensive, time-consuming, and dangerous. Therefore, traffic noise models are highly significant and can go a long way in reducing the challenges aforementioned. Furthermore, at the design stage, traffic noise cannot be measured. Thus, it requires traffic noise models to provide data for efficient and comfortable traffic design for the living environment in industrial, commercial, and residential areas. The analysis and modeling of the traffic noise facilitate proper planning of environmentally friendly road networks.

Prediction models of vehicular traffic noise are effectively used as decision-support tools for traffic noise prediction and simulation on highways (Molina et al., 1998). There are many traffic noise prediction models (Steele, 2001), and the early method among them was based on constant speed experiments with zero acceleration and prediction based on the equivalent continuous level (L_{eq}) by considering multiple vehicles for traffic over a specific period (Garg and Maji, 2014; Steele, 2001). The recent methods are mostly based on regression analysis using statistical and soft computing algorithms (Ragettli et al., 2016a; Singh et al., 2016). However, these models are often developed based on experimental data. As such, each of the models is highly affected by the composition of uniqueness of the traffic flow and characteristics of the measurement locations. This main disadvantage of the traffic noise prediction models limits their use universally (Rahmani et al., 2011). The models fail to be generalized due to the local conditions such as vehicle type and weather conditions (Hamad et al., 2017).

Therefore, this study proposes efficient techniques and assessment tools to generate cost-effective traffic noise maps in GIS and evaluates the impacts of the measured/predicted noise on surrounding population and properties. Despite many models that used for predicting traffic noise emissions such as statistical, regression, GIS and GPS techniques in literature, these models varies substantially from one to another. In this approach, road geometry and surrounding environments will be modelled by very high-resolution LiDAR point clouds and satellite images. Major and necessary attribute information will be used together with the produced road geometric model to compute and visualize traffic noise distribution in the study area.

1.2 Problem Statement

Traffic noise is a nuisance generated from highway traffic which contributes to the overall noise pollution in residential and other communal areas around cities. The traffic noise resulted from heavy and medium cars, motorbikes, other traffic as well as road geometry factors lead to physical and psychological impacts to our body system (Ruiz-Padillo et al., 2014); however, these vehicles are necessary for our daily transportation. Thus, the necessity to develop a method to overcome these challenges at the early stages of the construction design of the highways is crucial. This is in line with Environmental Impact Assessment (EIA) requirement that it is compulsory to carry out a noise assessment before any pavement is constructed (Gruen et al., 1995).

Therefore, many models are proposed to predict and propagate noise level to be used for highway designs (Steele, 2001; Reed et al., 2012). Various parameters have been used in different models which affect the accuracy standards between the experimental and the proposed models. Although, these studies showed the feasibility of using Neural Network (NN) for predicting traffic noise in various geographic locations and under different situations. However, their black box nature is the major setback which is highly data-oriented. Thus, this thesis presents a traffic noise prediction model based on NN to improve the performance of such models through architecture and hyperparameter optimization in addition to model parameters selection via statistical analysis.

Various propagation models have been carried out by many researchers, and in every case, different parameter is considered. Many features affect the spatial patterns of noise propagation in the natural environment. Sound energy absorption in the atmosphere depends on certain features such as air temperature, elevation, humidity and types of traffic flow. The noise levels in the roadway model were modified by the sufficient ground along the propagation path. Thus, the necessity is to develop a noise propagation model to overcome these challenges at the specific study area, especially on high-speed highways which could be dangerous and expensive.

1.3 Objectives of the Study

The current research aims to model traffic noise coming from highways in Shah Alam Seksyen 13, Malaysia and produce noise maps in GIS using LiDAR techniques. The specific objectives are as following:

1. To identify traffic noise predictors and collect relevant data of traffic flow and noise measurements for the noise modeling and mapping.
2. To develop a prediction model for traffic noise estimation using Neural Network model.
3. To develop a mathematical model to measure and predict traffic noise propagation level in the study area from vehicle traffic flow.

1.4 Research Questions

This thesis comprehensively addresses the following research questions:

1. What is the method and instrument to collect, estimate, and prepare input data such as traffic volume, noise measurements?
2. What are the factors used for traffic noise prediction and which is the most efficient model to be employed?
3. What would traffic noise propagation equation be used to develop noise map?

1.5 Significance of the Study

Noise models provide quantitative relationships between traffic volumes and traffic noise, which are important to make predictions on noise levels of newly planned expressways. These methods will be beneficial to government establishments to assess the Environmental Impact Assessment (EIA) that include noise pollution. This is one of the mandatory requirements to be carried out for all new infrastructural projects (Gershon, 2015). Noise pollution assessment by consultancy agencies is costly due to the demands of experts and advanced noise modeling systems. However, GIS-based noise assessment tools are easy to use and inexpensive and can be used by governments, thus, reducing EIA projects budgets.

In addition, noise models also give a general view of greenhouse gas emissions (Woodcock et al., 2009). Traffic noise standards are changing with the increasing of city development. This requires a periodic assessment of traffic noise and potential solutions to be rapidly and easily determined. Noise mapping is a handy tool for generating information about environmental impacts and enabling the visualization of noise pollution in the urban landscape. This could help to improve highway facilities provided for transportation systems in advanced nations such as Malaysia.

Several concerns about traffic noise from residents in urban areas have been reported in newspapers, magazines and other mediums especially for newly planned expressways such as Kinrara–Damansara Expressway (KIDEX). Noise maps generated by GIS with the aid of modeling and simulations can be published online so that residents can have access to them and could check the situations by themselves before and after the construction of such expressways.

1.6 Scope of the Study

This study is limited to evaluation of noise pollution around Tolls in Shah Alam Seksyen 13 for smart roads and efficient traffic noise control for future traffic design and planning. The proposed model is inexpensive and easy-to-use engineering methods for traffic noise impact assessment. Also, the noise maps generated by GIS can be available by which residents can check the situations before and after the construction of such expressways via modeling and simulations.

The research covers noise pollution around the residential, commercial, industrial, public, educational, religious, and other parts of the environment in Shah Alam Seksyen 13. (31 cm) panchromatic resolution and (1.24 m) multispectral resolution image satellite worldview-3 was used to build Geodatabase and cloud points (LiDAR data) to acquire valuable information for the proposed model.

Neural Network (NN) and Chi-square statistical analysis were utilized for the proposed predicted model and propagation model respectively. Parameters such as number of cars, number of heavy vehicles, number of motorbikes, sum of vehicles (Sov), car ratio (CR), heavy vehicle ratio (HVR), motorbike ratio (MR), highway density (HD), a Digital Surface Model (DSM), a Digital Elevation Model (DEM), and wind speed (WS) was employed in the NN model. Also, factors such as wind direction and speed, barriers such as tall buildings, and the interaction of air particles with the noise waves are employed in the propagation model.

1.7 Thesis Outline

This section presents the layout of thesis and the content of each chapter as follow:

Chapter one presents the background to the need for the environmental noise assessment of highway traffic on settlements Shah Alam Seksyen 13 and also the aim and objective of the study. The problem statement and scope of the research work are also presented.

Chapter two presents the literature review on some aspects concerning noise and its effects on inhabitants. Also, research works conducted on prediction and propagation models used in literature is reported in this chapter.

Chapter three present the research methodology employed in this experiments. The procedure used, equipment used, prediction and the propagation models used and the features considered in the experiment to obtain an accurate result is discussed in details.

Chapter four describes the result obtained from the experiments carried out on the prediction and the propagation of noise generated from vehicular traffic along the study area. Various analytical tools used were discussed and compared for optimum result.

Chapter five presents the conclusions and recommendations based on the data obtained and the result of the analysis carried out for further investigation or action.

REFERENCES

Abbott, I. M., Berthinussen, A., Stone, E., Boonman, M., Melber, M., and Altringham, J. (2015). Bats and Roads. Handbook of Road Ecology, 290-299.

Abdullah, M. E., Shamsudin, M., Karim, N., Bahrudin, I. A., and Shah, S. (2009). A study on noise level produced by road traffic in Putrajaya using Soundplan Road Traffic Noise Software.

Aguilera, I., Foraster, M., Basagaña, X., Corradi, E., Deltell, A., Morelli, X., Thomasson, A. (2015). Application of land use regression modelling to assess the spatial distribution of road traffic noise in three European cities. Journal of Exposure Science and Environmental Epidemiology, 25(1), 97-105.

Akel, N. A., Zilberstein, O., & Doytsher, Y. (2004). A robust method used with orthogonal polynomials and road network for automatic terrain surface extraction from LIDAR data in urban areas. International Archives of Photogrammetry and Remote Sensing, ISPRS.

Altringham, J., and Kerth, G. (2016). Bats and roads Bats in the Anthropocene: Conservation of Bats in a Changing World (pp. 35-62): Springer.

Anderson, J. A. (1995). An introduction to neural networks. MIT press.

Arana, M., San Martín, R., San Martin, M., and Aramendía, E. (2010). Strategic noise map of a major road carried out with two environmental prediction software packages. Environmental monitoring and assessment, 163(1), 503-513.

Arroyo, L. A., Johansen, K., Armston, J., and Phinn, S. (2010). Integration of LiDAR and QuickBird imagery for mapping riparian biophysical parameters and land cover types in Australian tropical savannas. Forest Ecology and Management, 259(3), 598-606.

Asner, G. P., & Mascaro, J. (2014). Mapping tropical forest carbon: Calibrating plot estimates to a simple LiDAR metric. Remote Sensing of Environment, 140, 614-624.

Asensio, C., López, J., Pagán, R., Pavón, I., and Ausejo, M. (2009). GPS-based speed collection method for road traffic noise mapping. Transportation Research Part D: Transport and Environment, 14(5), 360-366.

Asensio, C., Recuero, M., Ruiz, M., Ausejo, M., and Pavón, I. (2011). Self-adaptive grids for noise mapping refinement. Applied Acoustics, 72(8), 599-610.

Ayalew, L., and Yamagishi, H. (2005). The application of GIS-based logistic regression for landslide susceptibility mapping in the Kakuda-Yahiko Mountains, Central Japan. Geomorphology, 65(1), 15-31.

Aziz, S. Q., Lulusi, F. A., Ramli, N. A., Aziz, H. A., Mojiri, A., and Umar, M. (2012). Assessment of Traffic Noise Pollution in Bukit Mertajam, Malaysia and Erbil City, Iraq. Caspian Journal of Applied Sciences Research, 1(1), 1-11.

Baczyński, D., and Parol, M. (2004). Influence of artificial neural network structure on quality of short-term electric energy consumption forecast. IEE Proceedings-Generation, Transmission and Distribution, 151(2), 241-245.

Barber, J. R., Crooks, K. R., and Fristrup, K. M. (2010). The costs of chronic noise exposure for terrestrial organisms. Trends in ecology and evolution, 25(3), 180-189.

Basner, M., Babisch, W., Davis, A., Brink, M., Clark, C., Janssen, S., and Stansfeld, S. (2014). Auditory and non-auditory effects of noise on health. The Lancet, 383(9925), 1325-1332.

Basu, J. K., Bhattacharyya, D., & Kim, T. H. (2010). Use of artificial neural network in pattern recognition. International journal of software engineering and its applications, 4(2).

Basheer, I. A., & Hajmeer, M. (2000). Artificial neural networks: fundamentals, computing, design, and application. Journal of microbiological methods, 43(1), 3-31.

Bastián-Monarca, N. A., Suárez, E., and Arenas, J. P. (2016). Assessment of methods for simplified traffic noise mapping of small cities: Casework of the city of Valdivia, Chile. Science of the total environment, 550, 439-448.

Belojevic, G., Jakovljevic, B., Stojanov, V., Paunovic, K., and Ilic, J. (2008). Urban road-traffic noise and blood pressure and heart rate in preschool children. Environment international, 34(2), 226-231.

Bhaskar, A., Chung, E., Kuwahara, M., and Oshino, Y. (2004). Integration of a road traffic noise model (ASJ) and traffic simulation (AVENUE) for a built-up area.

Brown, A., and Bullen, R. B. (2003). Road traffic noise exposure in Australian capital cities. Acoustics Australia, 31(1), 11-16.

Buckley, S. J., Kurz, T. H., Howell, J. A., & Schneider, D. (2013). Terrestrial lidar and hyperspectral data fusion products for geological outcrop analysis. Computers & Geosciences, 54, 249-258.

Cai, M., Zou, J., Xie, J., and Ma, X. (2015). Road traffic noise mapping in Guangzhou using GIS and GPS. Applied Acoustics, 87, 94-102.

Calixto, A., Diniz, F. B., and Zannin, P. H. (2003). The statistical modeling of road traffic noise in an urban setting. Cities, 20(1), 23-29.

Can, A., Dekoninck, L., Rademaker, M., Van Renterghem, T., De Baets, B., and Botteldooren, D. (2011). Noise measurements as proxies for traffic parameters in monitoring networks. Science of the total environment, 410, 198-204.

Carrier, M., Apparicio, P., and Séguin, A.-M. (2016). Road traffic noise in Montreal and environmental equity: What is the situation for the most vulnerable population groups? Journal of Transport Geography, 51, 1-8.

Cho, D. S., Kim, J. H., and Manvell, D. (2007). Noise mapping using measured noise and GPS data. Applied Acoustics, 68(9), 1054-1061.

Chang, K. T. (2006). Geographic information system. John Wiley & Sons, Ltd.

Çolakkadıoğlu, D., and Yücel, M. (2017). Modeling of Tarsus-Adana-Gaziantep highway-induced noise pollution within the scope of Adana city and estimated the affected population. Applied Acoustics, 115, 158-165.

Corns, A., & Shaw, R. (2009). High resolution 3-dimensional documentation of archaeological monuments & landscapes using airborne LiDAR. Journal of Cultural Heritage, 10, e72-e77.

Daruis, D. D. I., Awang, N. W., Deros, B. M., and Ismail, A. R. (2014). The effects of night-time road traffic noise on discomfort-A case study in Dungun, Terengganu, Malaysia. Iranian Journal of Public Health, 43(3), 58.

Dayhoff, J. E., & DeLeo, J. M. (2001). Artificial neural networks. Cancer, 91(S8), 1615-1635.

De Kluijver, H., and Stoter, J. (2003). Noise mapping and GIS: optimising quality and efficiency of noise effect studies. Computers, Environment and Urban Systems, 27(1), 85-102.

Diniz, F., and Zannin, P. (2004). Noise impact caused by electrical energy substations in the city of Curitiba, Brazil. Science of the Total Environment, 328(1), 23-31.

Directive, E. (2002). Directive 2002/49/EC of the European parliament and the Council of 25 June 2002 relating to the assessment and management of environmental noise. Official Journal of the European Communities, L, 189(18.07), 2002.

Eason, S. A. (2013). Strategic Noise Mapping with GIS for the Universitat Jaume I Smart Campus: best methodology practices.

Evans, J. S., and Hudak, A. T. (2007). A multiscale curvature algorithm for classifying discrete return LiDAR in forested environments. IEEE Transactions on Geoscience and Remote Sensing, 45(4), 1029-1038.

Fang, C.-F., and Ling, D.-L. (2003). Investigation of the noise reduction provided by tree belts. Landscape and urban planning, 63(4), 187-195.

Farcaş, F., and Sivertunb, Å. (2010). Road traffic noise: GIS tools for noise mapping and a case study for Skåne region (Vol. 34, pp. 1-10).

Foraster, M., Deltell, A., Basagaña, X., Medina-Ramón, M., Aguilera, I., Bouso, L., . . . Slama, R. (2011). Local determinants of road traffic noise levels versus determinants of air pollution levels in a Mediterranean city. Environmental research, 111(1), 177-183.

Fratarcangeli, F., Murchio, G., Di Rita, M., Nascetti, A., & Capaldo, P. (2016). Digital surface models from ZiYuan-3 triplet: performance evaluation and accuracy assessment. International Journal of Remote Sensing, 37(15), 3505-3531.

Gardner, M. W., and Dorling, S. (1998). Artificial neural networks (the multilayer perceptron)—a review of applications in the atmospheric sciences. Atmospheric environment, 32(14), 2627-2636.

Garg, N., and Maji, S. (2014). A critical review of principal traffic noise models: strategies and implications. Environmental impact assessment review, 46, 68-81.

Garg, N., Mangal, S., Saini, P., Dhiman, P., and Maji, S. (2015). Comparison of ANN and analytical models in traffic noise modeling and predictions. Acoustics Australia, 43(2), 179-189.

Gershon, R. (2015). Street-level noise in an urban setting: Assessment and contribution to personal exposure.

Gislason, T., Bertelsen, R. J., Real, F. G., Sigsgaard, T., Franklin, K. A., Lindberg, E., . . . Benediktsdottir, B. (2016). Self-reported exposure to traffic pollution in relation to daytime sleepiness and habitual snoring: a questionnaire study in seven North-European cities. Sleep Medicine, 24, 93-99.

Goodchild, M. F. (1992). Geographical information science. International journal of geographical information systems, 6(1), 31-45.

Goodwin, S. E., and Shriver, W. G. (2011). Effects of traffic noise on occupancy patterns of forest birds. Conservation Biology, 25(2), 406-411.

Griffiths, I., and Langdon, F. J. (1968). Subjective response to road traffic noise. Journal of Sound and Vibration, 8(1), 16-32.

Gruen, A., Agouris, P., and Li, H. (1995). Linear feature extraction with dynamic programming and globally enforced least squares matching Automatic Extraction of Man-Made Objects from Aerial and Space Images (pp. 83-94): Springer.

Gualtieri, G., and Tartaglia, M. (1998). Predicting urban traffic air pollution: a GIS framework. Transportation Research Part D: Transport and Environment, 3(5), 329-336.

Guedes, I. C. M., Bertoli, S. R., and Zannin, P. H. (2011). Influence of urban shapes on environmental noise: a case study in Aracaju—Brazil. Science of the Total Environment, 412, 66-76.

Gulliver, J., Morley, D., Vienneau, D., Fabbri, F., Bell, M., Goodman, P., . . . Fecht, D. (2015). Development of an open-source road traffic noise model for exposure assessment. Environmental Modelling and Software, 74, 183-193.

Hamedianfar, A., Shafri, H. Z. M., Mansor, S., & Ahmad, N. (2014). Improving detailed rule-based feature extraction of urban areas from WorldView-2 image and lidar data. International Journal of Remote Sensing, 35(5), 1876-1899.

Halim, H., and Abdullah, R. (2014). Equivalent Noise Level Response to Number of Vehicles: A Comparison Between a High Traffic Flow and Low Traffic Flow Highway in Malaysia From Sources to Solution (pp. 149-152): Springer.

Halim, H., Abdullah, R., Ali, A. A. A., and Nor, M. J. M. (2015). Effectiveness of existing noise barriers: comparison between vegetation, concrete hollow block, and panel concrete. Procedia Environmental Sciences, 30, 217-221.

Halonen, J. I., Vahtera, J., Stansfeld, S., Yli-Tuomi, T., Salo, P., Pentei, J., . . . Lanki, T. (2012). Associations between nighttime traffic noise and sleep: the Finnish public sector study. Environmental health perspectives, 120(10), 1391.

Hamad, K., Khalil, M. A., and Shanableh, A. (2017). Modeling roadway traffic noise in a hot climate using artificial neural networks. Transportation Research Part D: Transport and Environment, 53, 161-177.

Harman, B. I., Koseoglu, H., and Yigit, C. O. (2016). Performance evaluation of IDW, Kriging and multiquadric interpolation methods in producing noise mapping: A case study at the city of Isparta, Turkey. Applied Acoustics, 112, 147-157.

Hepworth, P., Trow, J., and Hii, V. (2006a). Reference settings in noise mapping software–a comparison of the speed of calculation for different software. Paper presented at the Proceedings of Euronoise.

Hepworth, P., Trow, J., and Hii, V. (2006b). user controlled settings in noise mapping software-the effects on calculation speed and accuracy. Euronoise Tampere, Finland.

Héroux, M.-E., Babisch, W., Belojevic, G., Brink, M., Janssen, S., Lercher, P., Preis, A. (2015). WHO Environmental noise guidelines for the European Region.

Hilbert, C., and Schmullius, C. (2012). Influence of surface topography on ICESat/GLAS forest height estimation and waveform shape. Remote Sensing, 4(8), 2210-2235.

Hu, Y. (2004). Automated extraction of digital terrain models, roads and buildings using airborne LiDAR data (Vol. 69).

Iniesta, R., Stahl, D., & McGuffin, P. (2016). Machine learning, statistical learning and the future of biological research in psychiatry. Psychological medicine, 46(12), 2455-2465.

Jahandar, N., Hosseinpour, A., and Sahraei, M. A. (2012). Traffic noise under stop and go conditions in intersections–a case study. World Academy of Science, Engineering and Technology, 62, 465-468.

Johansen, K., Tiede, D., Blaschke, T., Arroyo, L. A., & Phinn, S. (2011). Automatic geographic object based mapping of streambed and riparian zone extent from LiDAR data in a temperate rural urban environment, Australia. Remote Sensing, 3(6), 1139-1156.

John, H., Andrew, J., and Kevin, H. (2005). BUMP–the Birmingham updated noise mapping. Acta Acustica United With Acustica, 1, 66-68.

Khaiwal, R., Singh, T., Tripathy, J. P., Mor, S., Munjal, S., Patro, B., and Panda, N. (2016). Assessment of noise pollution in and around a sensitive zone in North India and its non-auditory impacts. Science of the Total Environment, 566, 981-987.

King, E., and Rice, H. (2009). The development of a practical framework for strategic noise mapping. Applied Acoustics, 70(8), 1116-1127.

Klæboe, R., Engelien, E., and Steinnes, M. (2006). Context sensitive noise impact mapping. Applied Acoustics, 67(7), 620-642.

Ko, J. H., Chang, S. I., and Lee, B. C. (2011). Noise impact assessment by utilizing noise map and GIS: A case study in the city of Chungju, Republic of Korea. Applied Acoustics, 72(8), 544-550.

Kong, C., Xu, K., & Wu, C. (2006). Classification and extraction of urban land-use information from high-resolution image based on object multi-features. Journal of China University of Geosciences, 17(2), 151-157.

Kumar, K., Parida, M., & Katiyar, V. K. (2012). Road traffic noise prediction with neural networks-a review. An International Journal of Optimization and Control, 2(1), 29.

Kumar, P., Nigam, S. P., & Kumar, N. (2014). Vehicular traffic noise modeling using artificial neural network approach. Transportation Research Part C: Emerging Technologies, 40, 111-122.

Kumar, V., and Kumar, S. (2017). A Regression model of traffic noise intensity in metropolitan city using artificial neural networks. International Journal of Research and Engineering, 3(12), 27-30.

Künzli, N., Perez, L., and Rapp, R. (2010). Air Quality and Health. European Respiratory Society. World Health Organization.

Kurakula, V., Skidmore, A., Kluijver, H., Stoter, J., Dabrowska-Zielinska, K., and Kuffer, M. (2007). A GIS-based approach for 3D noise modelling using 3D city models. MSc proposal, University of Southampton, UK.

Lam, K.-C., and Ma, W.-C. (2012). Road traffic noise exposure in residential complexes built at different times between 1950 and 2000 in Hong Kong. Applied Acoustics, 73(11), 1112-1120.

Law, C.-w., Lee, C.-k., Lui, A. S.-w., Yeung, M. K.-l., and Lam, K.-c. (2011). Advancement of three-dimensional noise mapping in Hong Kong. Applied Acoustics, 72(8), 534-543.

Lee, C. S., and Fleming, G. G. (1996). Measurement of highway-related noise: Federal Highway Administration.

Lee, S.-W., Chang, S. I., and Park, Y.-M. (2008). Utilizing noise mapping for environmental impact assessment in a downtown redevelopment area of Seoul, Korea. Applied Acoustics, 69(8), 704-714.

Lefsky, M. A., Cohen, W. B., Parker, G. G., and Harding, D. J. (2002). Lidar remote sensing for ecosystem studies: Lidar, an emerging remote sensing technology that directly measures the three-dimensional distribution of plant canopies, can accurately estimate vegetation structural attributes and should be of particular interest to forest, landscape, and global ecologists. BioScience, 52(1), 19-30.

Li, B., Tao, S., Dawson, R., Cao, J., and Lam, K. (2002). A GIS based road traffic noise prediction model. Applied Acoustics, 63(6), 679-691.

Lohmann, A., and McMurran, G. (2009). Resident-defined neighborhood mapping: Using GIS to analyze phenomenological neighborhoods. Journal of prevention and intervention in the community, 37(1), 66-81.

Luo, J., Siemers, B. M., and Koselj, K. (2015). How anthropogenic noise affects foraging. Global change biology, 21(9), 3278-3289.

Maisonneuve, N., Stevens, M., Niessen, M. E., and Steels, L. (2009). NoiseTube: Measuring and mapping noise pollution with mobile phones. Information technologies in environmental engineering, 215-228.

Maisonneuve, N., Stevens, M., and Ochab, B. (2010). Participatory noise pollution monitoring using mobile phones. Information Polity, 15(1, 2), 51-71.

Makarewicz, R., and Gałuszka, M. (2011). Road traffic noise prediction based on speed-flow diagram. Applied Acoustics, 72(4), 190-195.

Manvell, D. (2005). Current trends in environmental noise calculation software in Europe. Paper presented at the Proceedings of INCE–Japan autumn conference.

Manvell, D., Marcos, L., Stapelfeldt, H., and Sanz, R. (2004). SADMAM–Combining measurements and calculations to map noise in Madrid. Paper presented at the Proceedings of the Internoise, 33rd International Congress and Exposition on Noise Control Engineering. Prague, Czech Republic.

Melgani, F., & Bruzzone, L. (2004). Classification of hyperspectral remote sensing images with support vector machines. IEEE Transactions on geoscience and remote sensing, 42(8), 1778-1790.

Merchan, C. I., and Diaz-Balteiro, L. (2013). Noise pollution mapping approach and accuracy on landscape scales. Science of the Total Environment, 449, 115-125.

Mestre, V., Horonjeff, R., and Fidell, S. (2016). Accounting for non-zero asymptotic annoyance prevalence rates in community tolerance level analyses. The Journal of the Acoustical Society of America, 139(4), 2007-2007.

Mishra, R. K., Kumar, A., & Kumar, K. (2017, February). Application of artificial neural network in traffic noise pollution modeling. In Communication and Computing Systems: Proceedings of the International Conference on Communication and Computing Systems (ICCCS 2016), Gurgaon, India, 9-11 September, 2016 (p. 469). CRC Press.

Mokhtarzade, M., and Zoej, M. V. (2007). Road detection from high-resolution satellite images using artificial neural networks. International journal of applied earth observation and geoinformation, 9(1), 32-40.

Molina, M., HERN, J., and CUENA, J. É. (1998). A structure of problem-solving methods for real-time decision support in traffic control. International Journal of Human-Computer Studies, 49(4), 577-600.

Monazzam, M. R., Karimi, E., Abbaspour, M., Nassiri, P., and Taghavi, L. (2015). Spatial traffic noise pollution assessment–A case study. International journal of occupational medicine and environmental health, 28(3), 625-634.

Morley, D., de Hoogh, K., Fecht, D., Fabbri, F., Bell, M., Goodman, P., . . . Gulliver, J. (2015). International scale implementation of the CNOSSOS-EU road traffic noise prediction model for epidemiological studies. Environmental pollution, 206, 332-341.

Nadya, S., Dawal, S., Tuan Ya, T., and Hamidi, M. (2010). A Study of Occupational Noise Exposure among Toll Tellers at Toll Plaza in Malaysia. Paper presented at the Proceedings of the International MultiConference of Engineers and Computer Scientists.

Nedic, V., Despotovic, D., Cvetanovic, S., Despotovic, M., & Babic, S. (2014). Comparison of classical statistical methods and artificial neural network in traffic noise prediction. Environmental Impact Assessment Review, 49, 24-30.

Olafsen, S., Negreira, J., Johansson, A.-C., Hiselius, P., Holmberg, D., Brunskog, J., . . . Ouis, D. (2016). Indoor Noise From Urban Railbound Transport.

Orem, C. A., & Pelletier, J. D. (2015). Quantifying the time scale of elevated geomorphic response following wildfires using multi-temporal LiDAR data: An example from the Las Conchas fire, Jemez Mountains, New Mexico. Geomorphology, 232, 224-238.

Organization, W. H. (2014). http://www. who. int/mediacentre/factsheets/fs340/en. url> http://www. who. int/mediacentre/factsheets/fs241/en/</url.

Ouis, D. (2001). Annoyance from road traffic noise: a review. Journal of environmental psychology, 21(1), 101-120.

Ozer, S., Yilmaz, H., Yeşil, M., and Yeşil, P. (2009). Evaluation of noise pollution caused by vehicles in the city of Tokat, Turkey. Scientific Research and Essays, 4(11), 1205-1212.

Ozkurt, N., Sari, D., Akdag, A., Kutukoglu, M., and Gurarslan, A. (2014). Modeling of noise pollution and estimated human exposure around İstanbul Atatürk Airport in Turkey. Science of the Total Environment, 482, 486-492.

Pamanikabud, P., and Tansatcha, M. (2003). Geographical information system for traffic noise analysis and forecasting with the appearance of barriers. Environmental Modelling and Software, 18(10), 959-973.

Pamanikabud, P., and Tansatcha, M. (2009). Geoinformatic prediction of motorway noise on buildings in 3D GIS. Transportation Research Part D: Transport and Environment, 14(5), 367-372.

Pamanikabud, P., and Tansatcha, M. (2010). 3D analysis and investigation of traffic noise impact from a new motorway on building and surrounding area. Applied Acoustics, 71(12), 1185-1193.

Pamanikabud, P., and Vivitjinda, P. (2002). Noise prediction for highways in Thailand. Transportation Research Part D: Transport and Environment, 7(6), 441-449.

Parish, Y. I., and Müller, P. (2001). Procedural modeling of cities. Paper presented at the Proceedings of the 28th annual conference on Computer graphics and interactive techniques.

Parris, K., and Schneider, A. (2009). Impacts of traffic noise and traffic volume on birds of roadside habitats. Ecology and society, 14(1).

Paunović, K., Jakovljević, B., and Belojević, G. (2009). Predictors of noise annoyance in noisy and quiet urban streets. Science of the total environment, 407(12), 3707-3711.

Paviotti, M., and Vogiatzis, K. (2012). On the outdoor annoyance from scooter and motorbike noise in the urban environment. Science of the total environment, 430, 223-230.

Pijanowski, B. C., Villanueva-Rivera, L. J., Dumyahn, S. L., Farina, A., Krause, B. L., Napoletano, B. M., . . . Pieretti, N. (2011). Soundscape ecology: the science of sound in the landscape. BioScience, 61(3), 203-216.

Pinto, F. A. d. N. C., and Mardones, M. D. M. (2009). Noise mapping of densely populated neighborhoods—example of Copacabana, Rio de Janeiro—Brazil. Environmental monitoring and assessment, 155(1-4), 309-318.

Popp, C. (2003). Noise abatement planning in German-experiences and consequence of the EU directive on the assessment of environmental noise. Acta Acustica United With Acustica, 1, 65-67.

Priddy, K. L., and Keller, P. E. (2005). Artificial neural networks: an introduction (Vol. 68): SPIE press.

Quek, C., Pasquier, M., & Lim, B. B. S. (2006). POP-TRAFFIC: A novel fuzzy neural approach to road traffic analysis and prediction. IEEE Transactions on Intelligent Transportation Systems, 7(2), 133-146.

Ragettli, M. S., Goudreau, S., Plante, C., Fournier, M., Hatzopoulou, M., Perron, S., and Smargiassi, A. (2016a). Statistical modeling of the spatial variability of environmental noise levels in Montreal, Canada, using noise measurements and land use characteristics. Journal of Exposure Science and Environmental Epidemiology, 26(6), 597-605.

Ragettli, M. S., Goudreau, S., Plante, C., Fournier, M., Hatzopoulou, M., Perron, S., and Smargiassi, A. (2016b). Statistical modeling of the spatial variability of environmental noise levels in Montreal, Canada, using noise measurements and land use characteristics. Journal of exposure science and environmental epidemiology, 26(6), 597-605.

Rahmani, S., Mousavi, S. M., and Kamali, M. J. (2011). Modeling of road-traffic noise with the use of genetic algorithm. Applied Soft Computing, 11(1), 1008-1013.

Rana, R., Chou, C. T., Bulusu, N., Kanhere, S., and Hu, W. (2015). Ear-phone: A context-aware noise mapping using smart phones. Pervasive and Mobile Computing, 17, 1-22.

Ranjbar, H. R., Gharagozlou, A. R., and Nejad, A. R. V. (2012). 3D analysis and investigation of traffic noise impact from Hemmat highway located in Tehran on buildings and surrounding areas. Journal of Geographic Information System, 4(4), 322.

Reed, S. E., Boggs, J. L., and Mann, J. P. (2012). A GIS tool for modeling anthropogenic noise propagation in natural ecosystems. Environmental Modelling and Software, 37, 1-5.

Rovithis, E., Kirtas, E., Marini, E., Bliziotis, D., Maltezos, E., Pitilakis, D., ... & Savvaidis, A. (2016, August). Assessment of seismic loading on structures based on airborne LiDAR data from the Kalochori urban area (N. Greece). In Fourth International Conference on Remote Sensing and Geoinformation of the Environment (pp. 96880M-96880M). International Society for Optics and Photonics.

Ruiz-Padillo, A., Torija, A. J., Ramos-Ridao, Á., and Ruiz, D. P. (2014). A methodology for classification by priority for action: selecting road stretches for network noise action plans. Transportation Research Part D: Transport and Environment, 29, 66-78.

Ryu, H., Park, I. K., Chun, B. S., and Chang, S. I. (2017). Spatial statistical analysis of the effects of urban form indicators on road-traffic noise exposure of a city in South Korea. Applied Acoustics, 115, 93-100.

Sanik, M. E., Prasetijo, J., Rahman, A., Ashraf, M., and Abdullah, F. A. (2013). Traffic noise model of suburban residential areas along FT50 federal route.

Santini, S., Ostermaier, B., and Adelmann, R. (2009). On the use of sensor nodes and mobile phones for the assessment of noise pollution levels in urban environments. Paper presented at the Networked Sensing Systems (INSS), 2009 Sixth International Conference on.

Schaub, A., Ostwald, J., and Siemers, B. M. (2008). Foraging bats avoid noise. Journal of Experimental Biology, 211(19), 3174-3180.

Schweizer, I., Meurisch, C., Gedeon, J., Bärtl, R., and Mühlhäuser, M. (2012). Noisemap: multi-tier incentive mechanisms for participative urban sensing. Paper presented at the Proceedings of the Third International Workshop on Sensing Applications on Mobile Phones.

Seong, J. C., Park, T. H., Ko, J. H., Chang, S. I., Kim, M., Holt, J. B., and Mehdi, M. R. (2011). Modeling of road traffic noise and estimated human exposure in Fulton County, Georgia, USA. Environment international, 37(8), 1336-1341.

Siemers, B. M., and Schaub, A. (2011). Hunting at the highway: traffic noise reduces foraging efficiency in acoustic predators. Proceedings of the Royal Society of London B: Biological Sciences, 278(1712), 1646-1652.

Singh, D., Nigam, S., Agrawal, V., and Kumar, M. (2016). Modelling and Analysis of Urban Traffic Noise System Using Algebraic Graph Theoretic Approach. Acoustics Australia, 44(2), 249-261.

Singh, D., Nigam, S. P., Agrawal, V. P., & Kumar, M. (2016). Vehicular traffic noise prediction using soft computing approach. Journal of environmental management, 183, 59-66.

Stapelfeldt, H., and Manvell, D. (2005). Optimising uncertainty and calculation time. Paper presented at the Forum Acusticum. Budapest Hungary.

Steele, C. (2001). A critical review of some traffic noise prediction models. Applied Acoustics, 62(3), 271-287.

Stoter, J., De Kluijver, H., and Kurakula, V. (2008). 3D noise mapping in urban areas. International Journal of Geographical Information Science, 22(8), 907-924.

TAHLYAN, D., and OHRI, A. GIS Based Simplistic Noise Prediction Model for Urban Areas. International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD), 1(5), 75-82.

Tandel, D., Nihalani, S., and Parmar, N. (2016). Developing Road Traffic Noise Prediction Model for Different Categories of Roads In Vadodara City.

Tansatcha, M., Pamanikabud, P., Brown, A., and Affum, J. K. (2005). Motorway noise modelling based on perpendicular propagation analysis of traffic noise. Applied Acoustics, 66(10), 1135-1150.

Theebe, M. A. (2004). Planes, trains, and automobiles: the impact of traffic noise on house prices. The Journal of Real Estate Finance and Economics, 28(2-3), 209-234.

Tsai, K.-T., Lin, M.-D., and Chen, Y.-H. (2009). Noise mapping in urban environments: A Taiwan study. Applied Acoustics, 70(7), 964-972.

Vogiatzis, k. (2013). Environmental noise and vibration monitoring and assessment of major road transportation networks: the case of Elefsina (Athens)–Korinthos Motorway (2008–2011). International Journal of Sustainable Development and Planning, 8(2), 173-185.

Wang, S. C. (2003). Artificial neural network. In Interdisciplinary computing in java programming (pp. 81-100). Springer US.

Ware, J., Kort, E. A., DeCola, P., & Duren, R. (2016). Aerosol lidar observations of atmospheric mixing in Los Angeles: Climatology and implications for greenhouse gas observations. Journal of Geophysical Research: Atmospheres, 121(16), 9862-9878.

Wawa, E. A., and Mulaku, G. C. (2015). Noise Pollution Mapping Using GIS in Nairobi, Kenya.

Wedge, S. W., and Rutledge, D. B. (1992). Wave techniques for noise modeling and measurement. IEEE Transactions on Microwave Theory and Techniques, 40(11), 2004-2012.

Wei, W., Van Renterghem, T., De Coensel, B., and Botteldooren, D. (2016). Dynamic noise mapping: A map-based interpolation between noise measurements with high temporal resolution. Applied Acoustics, 101, 127-140.

Werbos, P. J. (1974). Beyond regression.

Williams, K., Olsen, M. J., Roe, G. V., & Glennie, C. (2013). Synthesis of transportation applications of mobile LiDAR. Remote Sensing, 5(9), 4652-4692.

Woodcock, J., Edwards, P., Tonne, C., Armstrong, B. G., Ashiru, O., Banister, D., ... & Franco, O. H. (2009). Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport. The Lancet, 374(9705), 1930-1943.

Yang, G. Y.-C. (1995). Geological mapping from multi-source data using neural networks: Geomatics Engineering, University of Calgary.

Yasdi, R. (1999). Prediction of road traffic using a neural network approach. Neural computing & applications, 8(2), 135-142.

Yilmaz, G., and Hocanli, Y. (2006). Mapping of noise by using GIS in Şanliurfa. Environmental monitoring and assessment, 121(1), 103-108.

Yilmaz, I., & Kaynar, O. (2011). Multiple regression, ANN (RBF, MLP) and ANFIS models for prediction of swell potential of clayey soils. Expert systems with applications, 38(5), 5958-5966.

Yusoff, S., and Ishak, A. (2005). Evaluation of urban highway environmental noise pollution. Sains Malaysiana, 34(2), 81-87.

Zannin, P. H. T., and de Sant'Ana, D. Q. (2011). Noise mapping at different stages of a freeway redevelopment project–A case study in Brazil. Applied Acoustics, 72(8), 479-486.

Zazo, S., Molina, J. L., & Rodríguez-Gonzálvez, P. (2015). Analysis of flood modeling through innovative geomatic methods. Journal of Hydrology, 524, 522-537.

Zhao, J., and Qin, Q. (2014). Highway traffic noise prediction based on GIS. Paper presented at the Remote Sensing of the Environment: 18th National Symposium on Remote Sensing of China.

Zhou, Y., and Qiu, F. (2015). Fusion of high spatial resolution WorldView-2 imagery and LiDAR pseudo-waveform for object-based image analysis. ISPRS Journal of Photogrammetry and Remote Sensing, 101, 221-232.