Measurement of the Levels of Environmental Noise Pollution at Major Stalling Traffic Points in Minna, Niger State, Nigeria

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Abstract
This study was undertaken so that the levels of environmental noise at the major stalling traffic points in Minna could be determined, such that a Geographic Information System (GIS) layer of environmental noise pollution at these stalling traffic points could be created. The major stalling traffic points of Minna were initially georeferenced, the values archived on the Minna GIS, and then environmental noise levels were measured at all of these stations during the morning, afternoon, and evening hours. The dataset acquired for this survey indicates that all of the stations visited during the morning and afternoon hours experienced high levels of environmental noise: the evening hours had 88.24% "noisy" stations (above the 70dBA safe threshold for environmental noise) and 11.76% "normal" stations (below or equivalent to the 70dBA safe threshold for environmental noise). Thus, for the time of day when traffic warden personnel are active in Minna (morning and afternoon hours), most of them would be continually exposed to high levels of environmental noise. These exposures, however, are over disparate intervals. The final result of this exercise is now a GIS noise level layer at stalling traffic points in Minna.

Keywords: Stalling traffic, GIS layer, georeference, environmental noise, pollution

Introduction
Environmental noise is a constant nuisance that the typical traffic warden at any of the stalling traffic points in Minna would have to deal with: knowing the levels of exposure to this kind of noise should be of interest to the traffic warden personnel and the overseeing authority charged with public health issues, that is, the Niger State Environmental Protection Agency (NISEPA). This study was undertaken with such a target objective in mind. Furthermore, as a result of the current trend in handling georeferenced data, the dataset of this study has been processed and displayed in conformance with the Geographic Information System (GIS) scheme.

Concept of Stalling Traffic Point: For this study, a "stalling traffic point" is defined to be a road junction or node where all practical motor-mobiles (i.e. cars, trucks, motor-tricycles, motor-cycles, etc.) necessarily decelerate upon approaching the junction, for practical safety purposes, and accelerate to change velocity as they exit that junction; the process of acceleration involves a revving of the engines of the motor-mobiles, with associated increase in the exhaust gaseous effluents. Thus, stalling traffic points are formed at intersections of road junctions and major stalling traffic points are formed at intersections of major road junctions.

Concept of Noise: In acoustics, noise can be any undesired sound, either one that is intrinsically objectionable or one that interferes with other sounds that are being listened to. In electronics and information theory, noise refers to those random, unpredictable, and undesirable signals, or changes in signals, that mask the desired information content. Noise in radio transmission appears as static and in television as snow (Encyclopaedia Britannica, 2012). Noise can also be generally considered to be unwanted sound. Sound is what we hear when our ears are exposed to small pressure fluctuations in the air. There are many ways in which pressure fluctuations are generated; typically they are caused by vibrating movement of a solid object. It is apparent the terms 'noise' and 'sound' are interchangeable. Noise can be described in terms of three variables: amplitude (loud or soft); frequency (pitch); and time pattern (variability), www.hmmh.com.

Noise as Environmental Pollution: Pollution is the addition of any substance (solid, liquid, or gas) or any form of energy (such as heat, sound, or radioactivity) to the environment at a rate faster than it can be dispersed, diluted, decomposed, recycled, or stored in some harmless form. The major kinds of pollution are (classified by environment) air pollution, water pollution, and land pollution. Modern society is also concerned about specific types of pollutants, such as noise pollution, light pollution, and even plastic pollution. Although environmental pollution can be caused by natural events such as forest fires and active volcanoes, use of the word pollution generally implies that the contaminants have an anthropogenic source (that is, a source created by human activities). Pollution has accompanied humankind ever since groups of people first congregated and remained for a long time in any one place. Indeed, ancient human settlements are frequently recognized by their pollutants (shell mounds and rubble heaps, for instance). Pollution was not a serious problem as long as there was enough space available for each individual or group. However, with the establishment of permanent settlements by great numbers of people, pollution became a problem, and it has remained one ever since (Encyclopaedia Britannica, 2012). At present, there exist no specific studies targeted at understanding the factors that contribute negatively to impact the health of traffic warden personnel at Minna. These traffic warden personnel spend almost all their active working hours at the major stalling traffic points of Minna town.

The objectives of this study are as follows:

(i) To determine the levels of environmental noise pollution at major stalling traffic points within Minna.

(ii) To create a Geographic Information System (GIS) layer of environmental noise pollution at these major stalling traffic points for Minna town. Naturally, such an environmental noise pollution GIS layer is substrated upon the existence of a GIS database for Minna.

The creation of an environmental noise pollution GIS layer at stalling traffic points for Minna town would contribute immensely to the public health repository database of the Niger State Government. Such a database would form a critical component of the public health policy formulations of the Niger State Government. Also, Jonah et al (2008; 2009; 2010; 2011A; 2011B) have built frameworks for noise pollution studies and they have always recommended continuous noise monitoring studies and mitigation schemes.

Singh et al (2012) measured and assessed the noise levels produced by various dental equipment in different areas of a dental institution and they recommended improvements if noise levels were not within permissible limits. They measured sound levels at three different areas of a dental institution where learning and teaching activities are organized. The sound level was measured using a sound level meter known as 'decibulolmeter'. In each area they assessed the noise level at two positions-one, at 6 inches from the operators ear and second, at the chair side instrument trolley. They also assessed noise levels from a central location of the clinic area when multiple equipments were in operation simultaneously. Their result indicated that dental laboratory machines, dental hand-piece, ultrasonic scalers, amalgamators, high speed evacuation, and other items produce noise at different sound levels which is appreciable. The noise levels generated varied between 72.6 dB in pre-clinics and 87.2 dB in prosthesis laboratory. The results are comparable to the results of other studies which are conducted elsewhere. Although the risk to the dentists is lesser, but damage to the hearing is possible over prolonged periods. They also concluded that higher noise levels are potentially hazardous to the persons working in such environments especially in the laboratory areas where noise levels are exceeding the permissible limits.

Abiodun (2011) assessed noise pollution to ascertain noise levels of some noise-prone areas within Lagos metropolis with the aim of establishing baseline data for future noise management planning and monitoring. They conducted noise measurements at 11 different locations based on predominant land use types fortnightly between the hours of 0700 and 2000 daily in replicates (28 times) annually for two years. They recorded noise at two levels: L10 and L90 representing the highest and the residual noise levels using sound level meter (TES – 1350A). Similarly, the volumes of traffic were determined within the same period in all the locations fortnightly. They also determined the number of flight within the same period at Ikeja domestic airport fortnightly. Their results showed that the mean L10 noise level recorded for various locations during the study period were as follows: the highest noise level was recorded between the hours of 1300 and 1500 for Apapa Industrial Centre (AIC) and Idumota Commercial Centre (ICC) while for Government Reservation Area (GRA) it occurred at 700 and 1800 hours daily. Herbert Macaulay Road (HMR), Ikeja Domestic Airport (IDA), Ijora Railway Station (IRS), and Apapa Seaport (AS) recorded irregular occurrence of highest noise level, which on some occasions exceeded the WHO, and FME specified noise level. One-way analysis of variance of pooled data showed significant difference in the mean noise level at various locations given four homogenous groups while there was no significant difference between the mean noise level and time ($p > 0.05$). However, two-way analyses of variance indicated significant interaction of times and locations on noise. They therefore recommended that there should be legislation to control noise pollution, and Government should pass the "Noise Pollution Control Act" to meet special Nigeria conditions, and prescribe noise limits for vehicular traffic, aircrafts, and industrial commercial and other activities. They further recommended the ban of honking of horns in certain areas, sirens, and public loudspeakers at religious gathering.

According to Kurakula (2007), noise pollution of urban areas is one of serious factors that the local agencies and state authorities have to consider in decision making processes. The spatial analysis and geostaticstical methods of GIS played an important role to control noise pollution. GIS provided framework that integrated noise calculation models with spatial data which was used for building noise maps. Noise maps were used to assess and monitor the influence of noise effects. It also stated that noise maps within GIS have been developed in most of the European Countries. European Commission has approved the Directive called 'Environmental Noise Directive 2002/49/EC' for noise mapping. Most of the noise maps that are available today and also that suggested by EU are in two dimensional (2D) in which noise effect is presented in x,y plane. 2-D noise maps are built with the noise levels of one particular height. In reality, noise travels in all direction. Residents living in high rise buildings are also severely affected by traffic noise. A developed 3-D noise maps showed influence of noise in all direction. 3-D city model was used to build 3-D noise maps. The research work developed a methodology that built 3-D noise models that analyzes the three dimensional effect of noise pollution within a GIS. A case study was illustrated using a 3-D city model of Delft, the Netherland. This involved building simple 3-D city model, generation of 3-D observation points (that represent the virtual microphones) and noise calculation using standard noise calculation models. Fictitious data was used to calculate the noise levels of the study area. Appropriate spatial interpolation methods (TIN, IDW, Natural Neighborhood and Kriging) were used to develop noise surface. 2 ½-D noise models were built using 2-D interpolation technique. In the research two 2 ½-D noise models were built: one using complex 3-D city model and the other using simple 3-D city model. 3-D noise models were built by using 3-D IDW interpolation method. The results showed that the quality and accuracy of noise models can be improved with high density of observation points. The observation points selected in straight line with evenly spacing showed good visualization of acoustic situation. The results also demonstrate that TIN and IDW performs as well or better than the other interpolation methods. 2 ½-D noise models were used for decision making process to control noise effect and to take appropriate noise mitigation measures. 3-D noise models were used for scientific studies such as to study the phenomena of noise behavior.

The Area of Study: This study is centred on Minna town, the stations of interest being the major stalling traffic points: forty (40) such locations have been identified. These are Jafar Mairiga Junction, F.U.T. Minna Junction, Mypa Junction, Bahago Junction, Zarumai Roundabout, Government House Junction, Mustapha Junction, Government Day Junction, Emir's Palace Junction, Kuta Road/Obasanjo Complex Roundabout, Unity Bank Junction, Mobil Roundabout, I.B.B. Road Roundabout, Central Bank Junction, F.R.S.C. Junction, David Mark Road Roundabout, N.S.T.A. Junction, MTN Junction, Top Medical Junction, Muazu Babangida Junction, Abdulsalam Motor Park Junction, Royal Wood/Conoil Junction, City Gate Roundabout, Mandela Road/Talba Farm Junction, Shiroro Hotel Junction, Morris Fertilizer Junction, Kpakungu Roundabout, Cemetery Roundabout, Kure Modern Market Junction, Federal Secretariat Junction, Dutsen Kura Junction, Arayan Junction, London Street Junction, Okada Road Junction, General Hospital Junction, Sabon Gari Junction, Peda Junction, Kuta Motor Park Junction, Flamingo Junction, and Dana Pharmaceutical Roundabout. These major stalling traffic points are, for practical purposes, not evenly-spaced but are easily identified within the Minna built-up town centre. As expected of a typical traffic node, motor-mobiles are the primary sources of SO_2 at these locations. The Minna built-up town centre (from the Maryam Babangida Girls Science Secondary School in the north to the Abdulkareem Lafene State Secretariat in the south, and the southwest-northeast Kpakungu-Maitumbi axis), was covered for this study.

Survey Procedures

Site Selection: The areal extent of Minna town was earmarked for this survey, initially to cover all of Maikunkele to Chanchaga and all of the outlying neighbourhoods of Kpakungu to the outlying neighbourhoods of Maitumbi. However, because of the need to create a Geographic Information System (GIS) layer of sulphur dioxide signature substrated on an existing Minna GIS, and because the existing Minna GIS was substrated on the acquired analogue map of Fig. 1 the areal extent selected for this study covered the Maryam Babangida Girls Science Secondary School in the north to the Abdulkareem Lafene State Secretariat in the south, and the southwest-northeast Kpakungu-Maitumbi axis.

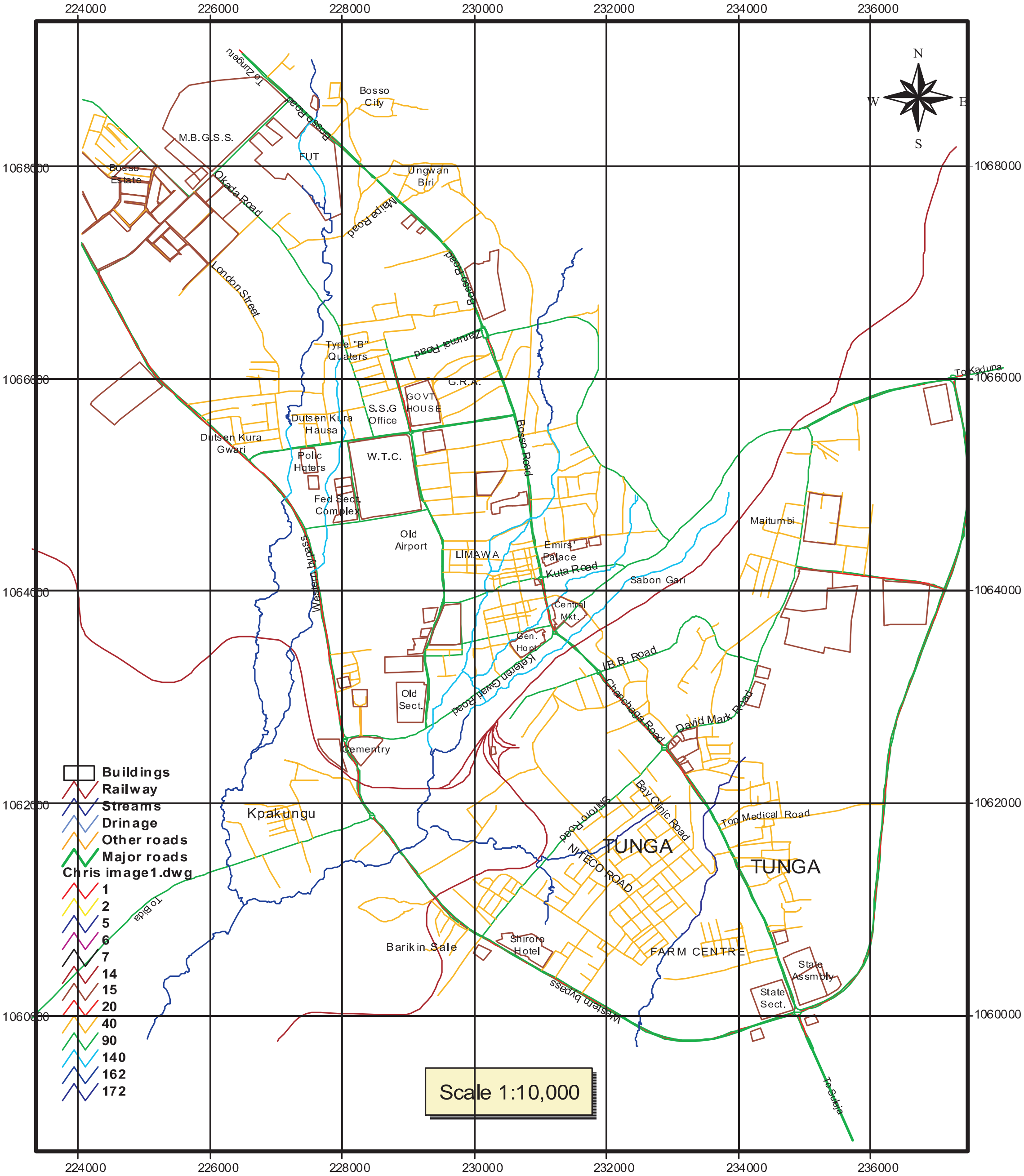

Fig. 1 Analogue map of Minna (Source: Datanet Services)

Survey Tools: Field Compass; The common field compass was used extensively during the course of this survey as a key direction-finder. Since the map of Fig.1 has a directional icon indicating the four cardinal points, the compass enabled the survey party to confirm that the vicinity of Maryam Babangida Girls Science Secondary School (the most northern of the stations of interest) is truly northward of the staging or muster point for this survey, i.e. the Federal University of Technology, Minna's Bosso Campus. The compass was also used in tandem with the hand-held Global Positioning System (GPS) unit to eliminate any doubt whatsoever as to whether the study group members were on an exact straight course, when this information was desired.

Hand-held Global Positioning System (GPS) Unit; The Garmin etrex hand-held Global Positioning System (GPS) unit was employed chiefly for georeferencing of stations of interest during the course of this survey; it was also used in tandem with the field compass, for a minor role sort of, to confirm a defined "rectilinear" direction. Actually, the aforementioned existing Minna GIS, specific to this study, was created by reliance on georeferencing information acquired by means of the Garmin etrex hand-held (GPS) unit, thus ensuring a modicum of fidelity.

Noise Level Meter: The noise level meter employed for this survey is the EXTECH 407736 Sound Level Meter. This noise level meter is for high accuracy measurements that meet the ANSI (American National Standards Institutes) and IEC (International Engineering Consortium) 651 Type II standards. This digital sound level meter offers 1.5dB accuracy for noise level readings, and this unit includes a large-digit LCD display with a built-in calibration check to ensure accurate readouts.

Noise Level Measurements at Stalling Traffic Points: Obviously, the kind of noise level of interest for this survey was the environmental noise on the A-weighting mode; this is the kind of noise for which the EXTECH 407736 Sound Level Meter was designed to measure. A measurement using noise level meter proceeded by using the 'A' function in the noise level meter, and the specification used was 35-95dB. The microphone wind screen was used when applicable in other to have accurate results, because blowing winds are a source of unwanted sound. At each of the stalling point of interest, three different values of the noise level at that instant were measured and recorded.

Dataset of Study: The body of acquired data for this study is shown in Tables 1-3.

Table 1. Dataset for morning hours (i.e. interval of 0001-1159 hours)

Station No.	Conventional Location	X-value (UTM)	Y-value (UTM)	Average Noise Value (dBA)	Noise Level Threshold (dBA)
1	Jafar Mairiga Junction	0228437	1068754	76.00	70.00
2	F.U.T. Junction	0228819	1068379	78.22	70.00
3	Maipa Junction	0229357	1067847	78.87	70.00
4	Bahago Junction	0230096	1066785	75.37	70.00

5	Zarumai Roundabout	0230163	1066569	71.58	70.00
6	Government House Junction	0230450	1065782	78.13	70.00
7	Mustapha Junction	0230495	1065592	76.71	70.00
8	Government Day Junction	0230563	1065262	77.07	70.00
9	Emir's Junction	0230640	1064527	86.70	70.00
10	Kuta/Obasanjo Complex Roundabout	0230697	1064238	92.46	70.00
11	Unity Bank Junction	0230733	1064057	85.10	70.00
12	Mobil Roundabout	0230818	1063729	86.09	70.00
13	IBB Round about	0231211	1063359	87.16	70.00
14	Central Bank Junction	0231416	1063093	82.00	70.00
15	FRSC Junction	0231649	1062823	85.96	70.00
16	David Mark roundabout	0231810	1062633	82.33	70.00
17	NSTA Junction	0232004	1062388	87.15	70.00
18	MTN Junction	0232045	1062306	89.53	70.00
19	TOP Medical Junction	0232312	1061850	86.70	70.00
20	Muazu Babangida Junction	0232408	1061644	89.84	70.00
21	Abdulsalam Park Junction	0232786	1060830	84.61	70.00
22	Royal Wood/Conoil Junction	0232828	1060673	85.79	70.00
23	Tall gate Round about	0232995	1060170	82.30	70.00
24	Mandela/Farm Junction	0231434	1060097	86.76	70.00
25	Shiroro Hotel Junction	0230174	1060852	87.62	70.00
26	Morris Junction	0229616	1061440	84.96	70.00
27	Kpakungu Roundabout	0229184	1062006	88.30	70.00
28	Cemetery Roundabout	0228933	1062725	98.40	70.00
29	Main Market Junction	0228751	1063873	83.52	70.00
30	Federal Secretariat Junction	0228570	1064679	95.13	70.00
31	Dutsen Kura Junction	0228065	1065344	82.00	70.00
32	Arayan Junction	0226707	1067122	80.40	70.00

Table 2. Dataset for Afternoon Hours (i.e. interval of 1201-1859 hours)

Station No.	Conventional Location	X-value (UTM)	Y-value (UTM)	Average Noise Value (dBA)	Noise Level Threshold (dBA)
1	Jafar Mairiga Junction	0228437	1068754	92.00	70.00
2	F.U.T. Junction	0228819	1068379	84.70	70.00
3	Maipa Junction	0229357	1067847	89.50	70.00
4	Bahago Junction	0230096	1066785	81.50	70.00
5	Zarumai Roundabout	0230163	1066569	88.90	70.00
6	Government House Junction	0230450	1065782	94.70	70.00
7	Mustapha Junction	0230495	1065592	93.20	70.00
8	Government Day Junction	0230563	1065262	94.30	70.00
9	Emir's Junction	0230640	1064527	74.70	70.00
10	Kuta/Obasanjo Complex Roundabout	0230697	1064238	74.40	70.00
11	Unity Bank Junction	0230733	1064057	78.60	70.00
12	Mobil Roundabout	0230818	1063729	93.20	70.00
13	IBB Round about	0231211	1063359	81.10	70.00
14	Central Bank V	0231416	1063093	92.50	70.00
15	FRSC Junction	0231649	1062823	82.00	70.00
16	David Mark roundabout	0231810	1062633	81.90	70.00

Table 3. Dataset for Evening Hours (i.e. interval of 1901-2359 hours)

Station No.	Conventional Location	X-value (UTM)	Y-value (UTM)	Average Noise Value (dBA)	Noise Level Threshold (dBA)
1	N.S.T.A. Junction	0232004	1062388	74.10	70.00
2	MTN Junction	0232045	1062306	78.10	70.00
3	TOP Medical Junction	0232312	1061850	86.10	70.00
4	Muazu Babangida Junction	0232408	1061644	83.50	70.00
5	Abdulsalam Park Junction	0232786	1060830	78.90	70.00
6	Royal Wood/Conoil Junction	0232828	1060673	74.50	70.00
7	Tall gate Round about	0232995	1060170	74.60	70.00
8	Mandela/Farm Junction	0231434	1060097	73.20	70.00
9	Shiroro Hotel Junction	0230174	1060852	75.30	70.00
10	Morris Junction	0229616	1061440	79.30	70.00
11	Kpakungu Roundabout	0229184	1062006	83.30	70.00
12	Cemetery Roundabout	0228933	1062725	73.20	70.00
13	Main Market Junction	0228751	1063873	77.84	70.00
14	Federal Secretariat Junction	0228570	1064679	78.80	70.00
15	Dutsen Kura Junction	0228065	1065344	77.40	70.00
16	Arayan Junction	0226707	1067122	61.70	70.00
17	London Street Junction	0227312	1067596	63.52	70.00

Data Analysis and Creation of A Geographic Information System (GIS) Layer of Noise Levels

Noise Level Analyses: For this study, a noise level threshold of 70dBA was selected: the American public health agency (www.ncbi.nlm.nih.gov) indicated that levels appreciably above 70 A-weighted decibels are associated with hearing loss and other concomitant noise-induced negative health effects like attention deficiency syndrome, high blood pressure, restlessness, discomfort, pains, annoyance(s), etc. Average noise levels for the three readings at each of the stalling point were computed and tabulated, see Tables 1-3. From these tables, it could easily be inferred that, at any of the major stalling traffic points, average noise value in dBA greater than 70 is non-desirable, whilst any value below 70 dBA is tolerable.

Creation of a Noise Level Geographic Information System (GIS) Layer for Major Stalling Traffic Points at Minna: The noise level GIS layer for this study was substrated on the existing Minna Geographic Information System (MGIS). The composite GIS noise level maps for the morning, afternoon, and evening hours at the stalling traffic points are as shown in Figs 2-4.

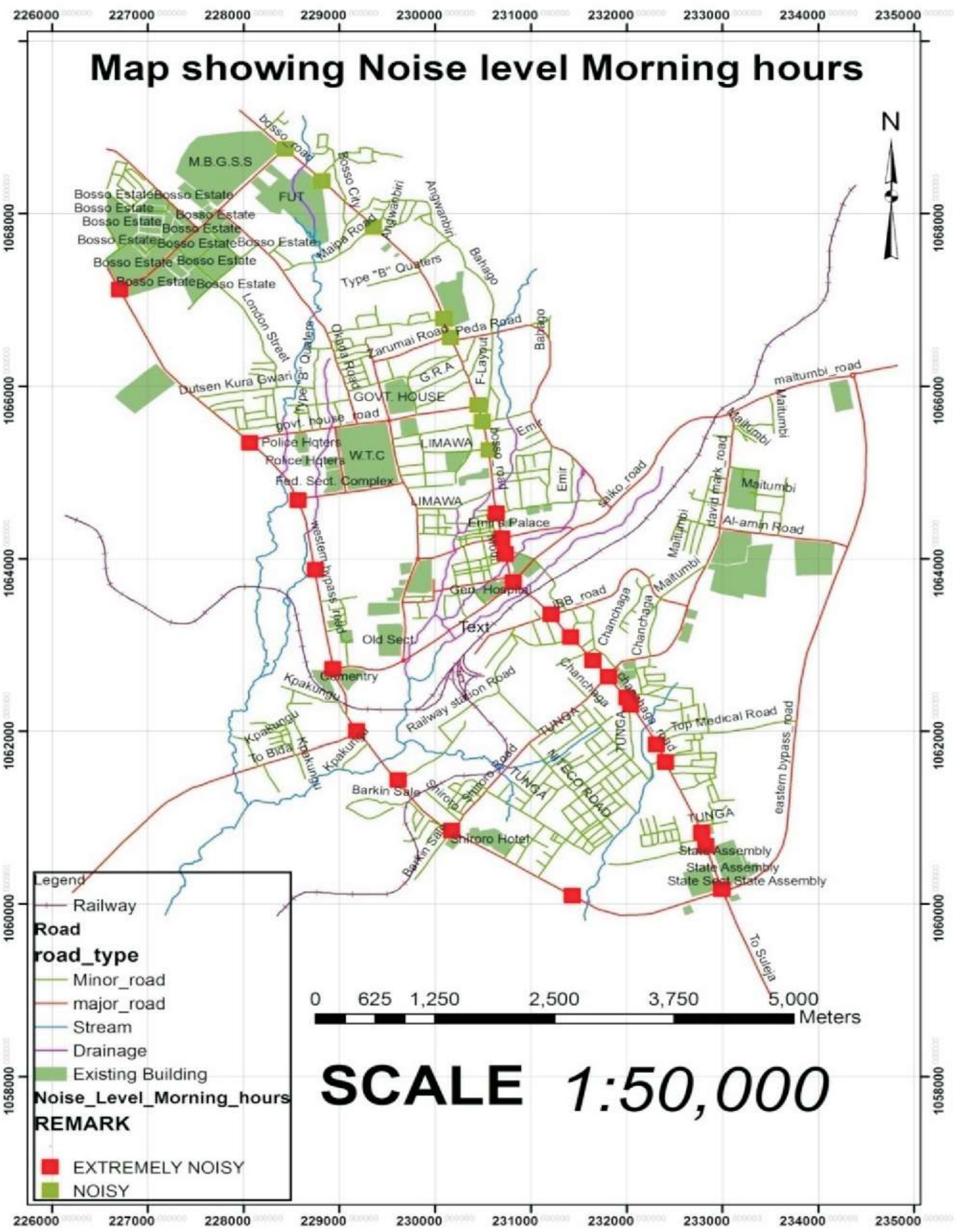

Fig.2, Composite GIS noise level map for the morning hours. (The red and green squares at the identified major stalling traffic points visited during the morning hours indicate "extremely noisy" and "noisy" levels, all above the 70dBA threshold.)

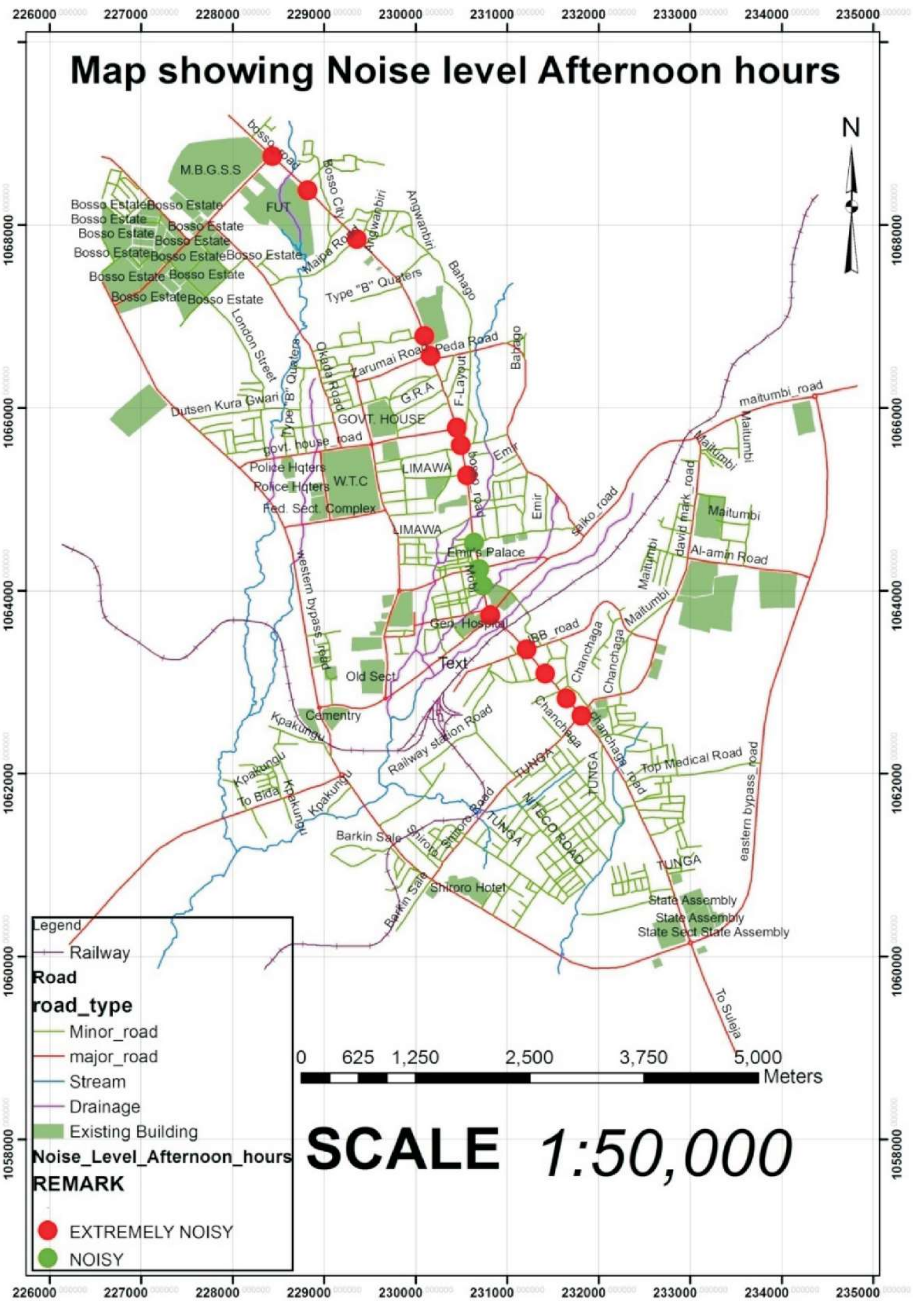

Fig.3. Composite GIS map for the afternoon hours. (The red and green circles at the identified major stalling traffic points visited during the afternoon hours indicate "extremely noisy" and "noisy" levels, all above the 70dBA threshold.)

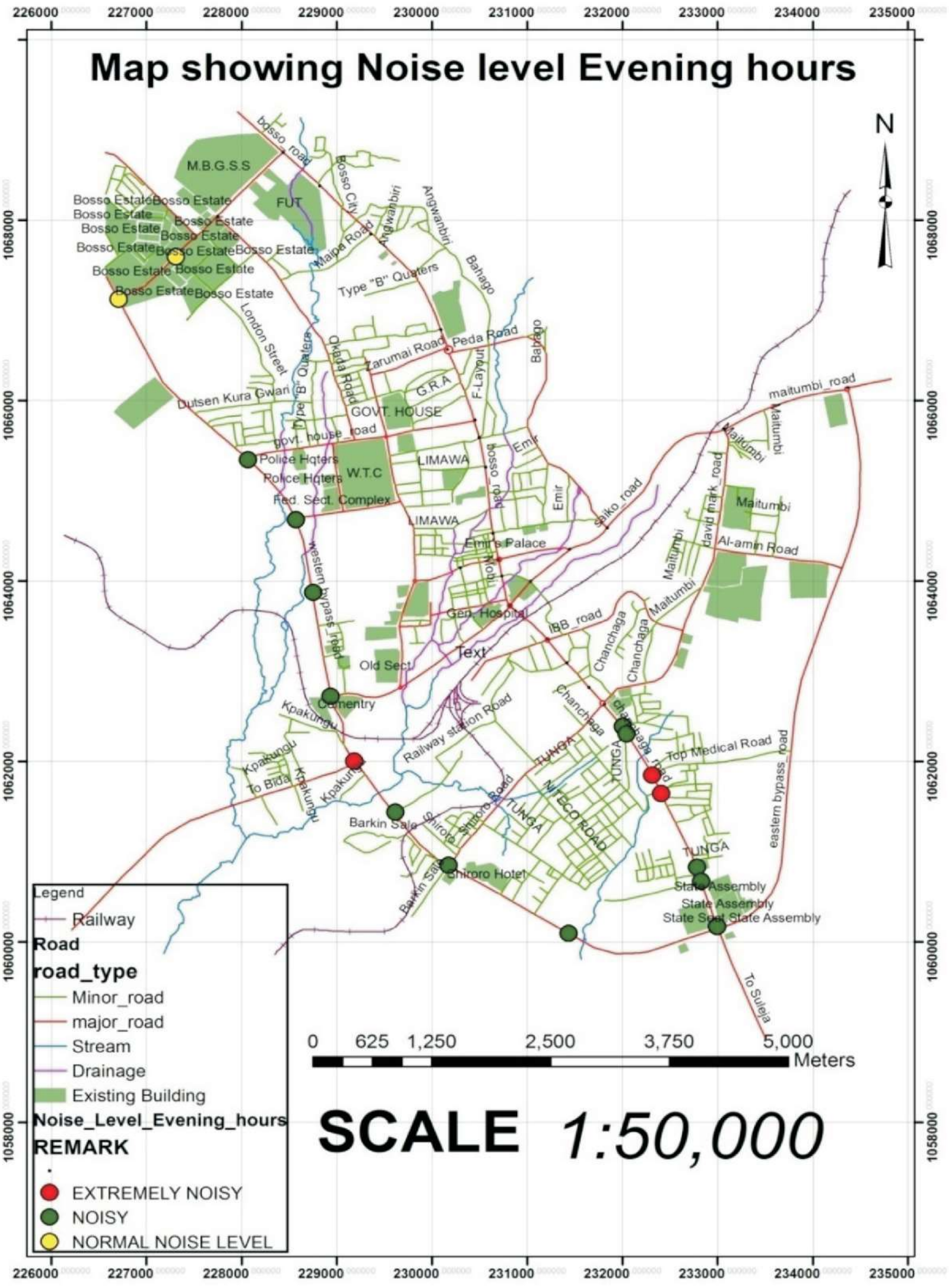

Fig.4. Composite GIS map for the evening hours. (The red, green, and yellow circles at the identified major stalling traffic points visited during the evening hours indicate "extremely noisy," "noisy," and normal levels: red and green circles all above the 70dBA threshold; yellow circle below the 70dBA threshold.)

Discussion, Conclusion, and Recommendation

Discussion: For this study, "morning hours" surveys were those carried out between the 00:01a.m.-11:59a.m interval, "afternoon hours" surveys were carried out between the 12:01p.m.-06:59p.m interval and "evening hours" surveys were carried out between the 07:01p.m.-11:59p.m interval. The dataset acquired for this survey indicates that all of the stations visited during the morning and afternoon hours experienced high levels of environmental noise: the evening hours had 88.24% "noisy" stations and 11.76% "normal" stations. Based on the MGIS, noise-level GIS layers for the morning, afternoon, and evening hours were created for the stalling traffic points of Minna that were visited at those time intervals: these are the composite maps of Figs 2-4; yellow colour code was assigned to noise levels below the threshold of 70dBA ("normal"), green colour code was assigned to noise levels between 70-80dBA ("noisy"), whilst red colour code was assigned to noise levels above 90dBA ("extremely noisy"). [This protocol was easy to design because the American public health agency (www.ncbi.nlm.nih.gov) indicated that levels appreciably above 70 A-weighted decibels are associated with hearing loss and other concomitant noise-induced negative health effects like attention deficiency syndrome, high blood pressure, restlessness, discomfort, pains, annoyance(s), etc.].

The adoption of the yellow colour code for noise levels below the threshold of 70dBA, the green colour code for noise levels between 70-80dBA, and the red colour code for noise levels above 90dBA could also be easily comprehended by an examination of Tables 1-3.

Conclusion: The result of this survey shows that for the time of day when traffic warden personnel are active in Minna (morning and afternoon hours), most of them would be continually exposed to high levels of environmental noise. The good news is that these exposures are over disparate intervals (i.e. not continuous); this fact is obviously due to the comparatively light vehicular traffic in Minna town in relation to other major cities. The final result of this exercise is now a GIS noise level layer at stalling traffic points in Minna: this GIS noise level layer is now a veritable audit mechanism tool for stalling traffic points at Minna.

Recommendation: Since exposure to environmental noise at the major stalling traffic points in Minna is over disparate intervals, there is no cause for alarm as yet. What could be done, for now, is the archival of the result of this survey for future reference purpose and the continual monitoring of these noise levels.

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