Using GIS To Map Noise Levels Along King Street and St Machar Drive, Aberdeen

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Key words: Noise Map, Mobile App, Planning, Environment and GIS.

SUMMARY

Noise pollution, a growing problem in urban areas, has detrimental effects on human health. This project, conducted in Aberdeen, Scotland, addresses this issue by mapping noise levels within a specific area of the city, contributing to European Union's efforts to monitor and mitigate noise pollution.

The project employed a novel, cost-effective approach, converting a smartphone into a sound level meter. Data collection utilized a bicycle, offering advantages over traditional methods. Bicycles provided access to narrow streets and pedestrian zones inaccessible to vehicles, minimized noise contribution for more accurate readings, and aligned with sustainability goals.

The collected data was processed to create a comprehensive noise map, visually representing noise levels and highlighting areas of concern. This map is invaluable for city planners and policymakers, informing decisions on traffic management, residential development, and placement of noise barriers or green spaces. The project demonstrates the feasibility of using readily available technology and sustainable transportation for noise monitoring, with a methodology easily replicated and scaled.

The project's findings have significant implications for public health, urban development, and environmental sustainability. High noise levels are linked to health problems like cardiovascular disease, sleep disturbance, and cognitive impairment in children. Identifying noise hotspots and implementing mitigation strategies creates healthier, more livable cities.

In conclusion, this project offers a valuable contribution to addressing urban noise pollution. Combining innovative data collection with community engagement, it provides a model for future research. The noise map and study insights empower local authorities to make informed decisions promoting a quieter, healthier, and more sustainable urban environment.

1.0 CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Noise, as defined by Cambridge Advanced Learner's Dictionary and Thesaurus (2016), is an unwanted, unpleasant or loud sound. Noise pollution is, therefore, a major problem to the environment, especially in urban areas. Rich and Nielsen (2004), citing European Commission (1996), suggest that about 80 million people suffer from unacceptable levels of traffic noise within the European Union. In order to deal with this menace, steps must be taken towards understanding the situation on ground through the mapping of noise levels. According to European Commission (2005), the European Union (EU) gave a directive on mapping noise across Europe by 2007. In order to effectively comply with the directive, there is a need for local authorities within major cities to establish a noise management policy (European Commission, 2002).

The proliferation of smart phones with amazing data processing capabilities and integrated sensors (such as GPS receiver chips and microphones) provide an extensive platform for using smart phones for GIS projects. Unlike traditional sound measuring devices, smart phones are cheap to acquire. On this background, smart phones can be turned into a sound level meter for measuring noise levels in the environment for planning and decision making purposes (Maisonneuve et al, No Date). Another important thing to note is the level and extent at which sound data can be collected. The use of smart phones provides the flexibility of measuring sound levels at any location within cities. Using a mobile application (App) known as NoiseTube, the phone is able to record sound level data and also track geographic coordinates of the phone's location in real time. After tracking, the data is then sent to a server where it is processed and delivered to the user through an online account.

It must be acknowledged that, even though a number of papers have been published on the theories behind the use of smart phones as sound-measuring devices in mapping noise pollution, not many practical researches have been done in this area. This could stem from the fact that the technology is quite recent. For instance, NoiseTube, which is one of the earliest sound-measuring mobile applications, was initiated in 2008 at the Sony Computer Lab in Paris (NoiseTube, 2015).

In the next chapter, a brief literature review is done on some related works that have been carried out. After that, the methodology employed for this project will be discussed in chapter 3. Chapter 4 presents and discusses the result that was obtained. Finally, chapter 5 brings the report to a conclusion, with a recommendation to consider.

1.2 PROBLEM STATEMENT

The problem statement can be summarized with a simple question; “How much noise are you exposed to?” Presently, the Aberdeen City Council does not have a record of noise levels at every part of the city.

1.3 AIM

The aim of this project is to use GIS to map the level of noise exposure along the King Street and St Machar drive, Aberdeen in order to support the making of informed decisions in controlling noise pollution within the city. The objectives of the project are as follows:

- To conduct noise level measurements within the study area, using a bicycle as a means of transportation
- To validate the processed data which is obtained from NoiseTube server
- To perform a spatial analysis on the validated data
- To produce a noise map of the study area and visualise it in both Google Earth and ArcGIS. This will serve as a basis for further research into the methodology employed.

1.4 STUDY AREA

The study area is chosen along a section of the King Street and St Machar drive in Aberdeen, Scotland. Its southern end is located at Castle gate, Aberdeen. Heading northwards, it passes by the headquarters of FirstGroup, the Pittodrie Stadium, and the University of Aberdeen up to the roundabout near Seaton post office. It continues westwards along the St Machar drive to the Students’ Infohub (Hub) at the University of Aberdeen. (See figure 1). The entire length of the study area is approximately 2.6km, with an average width of 10m.

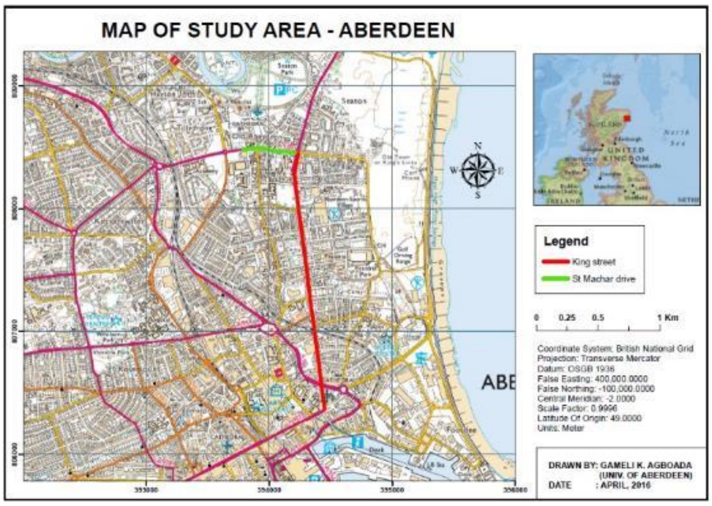

Figure 1: Map of Study Area

2.0 CHAPTER 2: LITERATURE REVIEW

D'Hondt et al (2012), in their research on evaluating participatory sensing as an alternative to standard techniques for environmental monitoring, sought to proof that people-centric works. In other words, environmental data measurement or participatory techniques, using the smart phone, can achieve the same accuracy as standard noise mapping techniques. Both approaches were explored and the resulting noise maps were found to have comparable error margins. With regards to the people-centric approach, data collection was done by volunteers on foot. However, the data collection approach used in this current project employs a bicycle as a means of transportation. Secondly, the layout of the study areas also differ, while D'Hondt et al conducted their research within a 1km^2-area in Antwerp, this current project chose a 2.6km road corridor in Aberdeen.

Leao et al (2014) undertook a project where a more recent mobile phone application known as "2Loud?" was used in monitoring traffic-noise exposure in Australia. In that project, the main aim was to measure the level of exposure to night-time and indoor noises. The results obtained reveal that many participants were exposed to potentially harmful levels of night time noise. Comparing the two projects, this current project is more interested in measuring noise levels during the day. In addition to that, different sound-measuring mobile applications were used for data collection.

Similar to what Leao et al did in Australia, another project, titled, "Monitoring Exposure to Traffic Noise with Mobile Phones in China: A Review of Context" was carried out by Leao and Zhou (2014). The only differences between the two projects can be seen in terms of patterns of urbanisation, cultural and political backgrounds that exist within the study areas. Looking at the three projects that are under review, a common feature among them is participatory sensing; data collection in all three cases involve group of people. This current project however did not use the participatory sensing approach.

3.0 CHAPTER 3: METHODOLOGY

3.1 DATASETS AND EQUIPMENT

The following base maps were acquired and used for the project: a 1:25,000 scale colour raster map and a street map covering the study area (shapefile format) from EDINA Digimap. In addition, the equipment and software that were used are as follows: a smart phone (Samsung Galaxy Core Prime Duos), bicycle, a pocket sound level meter (Castle GA215) with a Calibrator, NoiseTube mobile application, Idrisi TerrSet, ArcGIS Desktop and Google Earth Pro. Figure 2, 3, 4 and 5 illustrate some of the equipment used in executing the project.

Figure 2: Samsung Galaxy Core Prime Duos
[Source:https://www.google.co.uk/#q=samsung+galaxy+core+prime+duos+price&tbm=isch&imgrc=CeDHW0W23YVXiM%3A]

Figure 3: Bicycle used for data collection

Figure 4: A pocket sound level meter (Castle GA215)

Figure 5: A Calibrator

3.2 DATA ACQUISITION

3.2.1 Reconnaissance Survey

A reconnaissance survey (recce) was conducted by walking the entire 2.6km study area; it started from the Hub and ended at Castle gate, Aberdeen. The purpose was to study the route and also appreciate the activities that happen along the corridor. During the recce, the NoiseTube App was tested and cursory risk assessment for the actual data collection exercise was performed as well.

3.2.2 Data Collection

Starting from the Hub, the NoiseTube App was initiated and the phone's microphone was turned toward the middle of the street. An average bicycle speed of 8km/hr was maintained within the bicycle lane throughout the journey. In order to capture a representative measurements, data was collected both ways during mornings, afternoons and evenings for five consecutive days, including weekends. Figure 6 demonstrates how the data was collected. At the end of every trip, the App was stopped and the recorded measurements are automatically upload into a NoiseTube server for processing. The interface of the App is shown in figure 7. The processed data is then sent from the server into an online account that was earlier created by the user. See figure 8 for login page of NoiseTube online account. Following that, the data were downloaded from the online account; a total of 25 files were downloaded. They came in .kml and .txt formats (See figure 9). Figure 10 shows the downloaded data being visualise in Google Earth Pro.

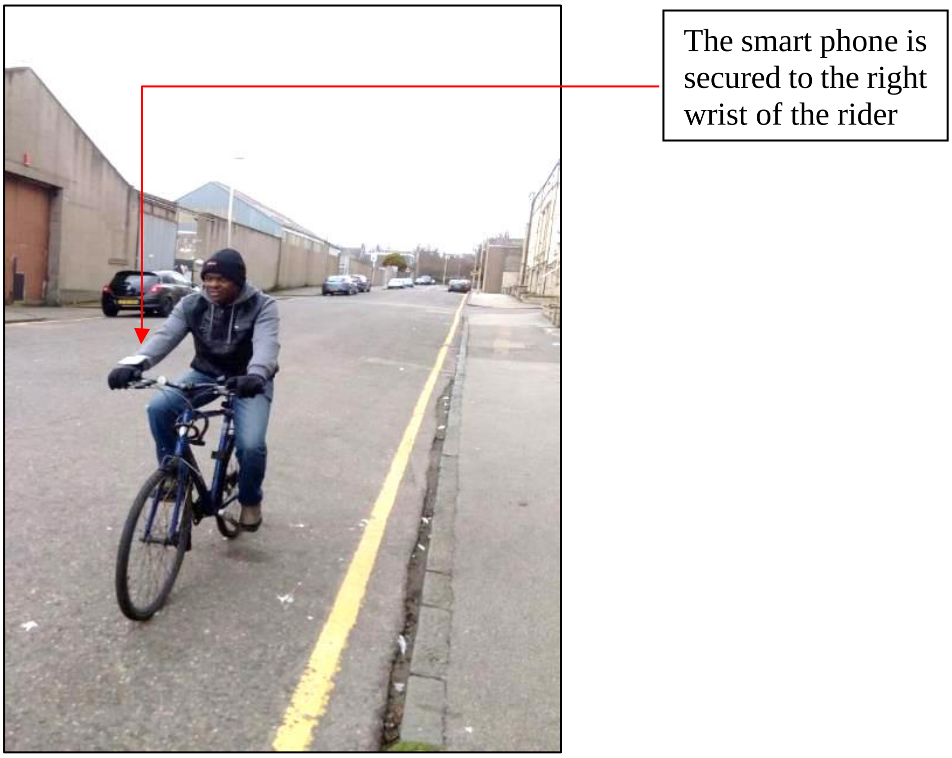

Figure 6: How noise was collected

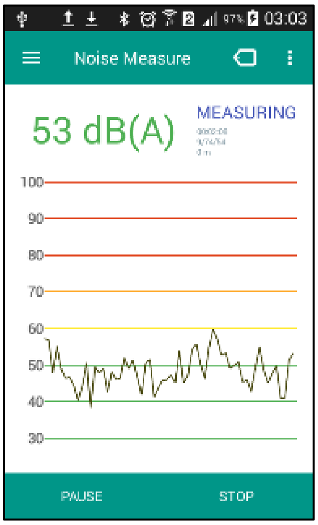

Figure 7: Interface of NoiseTube App

Figure 8: Login page of NoiseTube Online Account

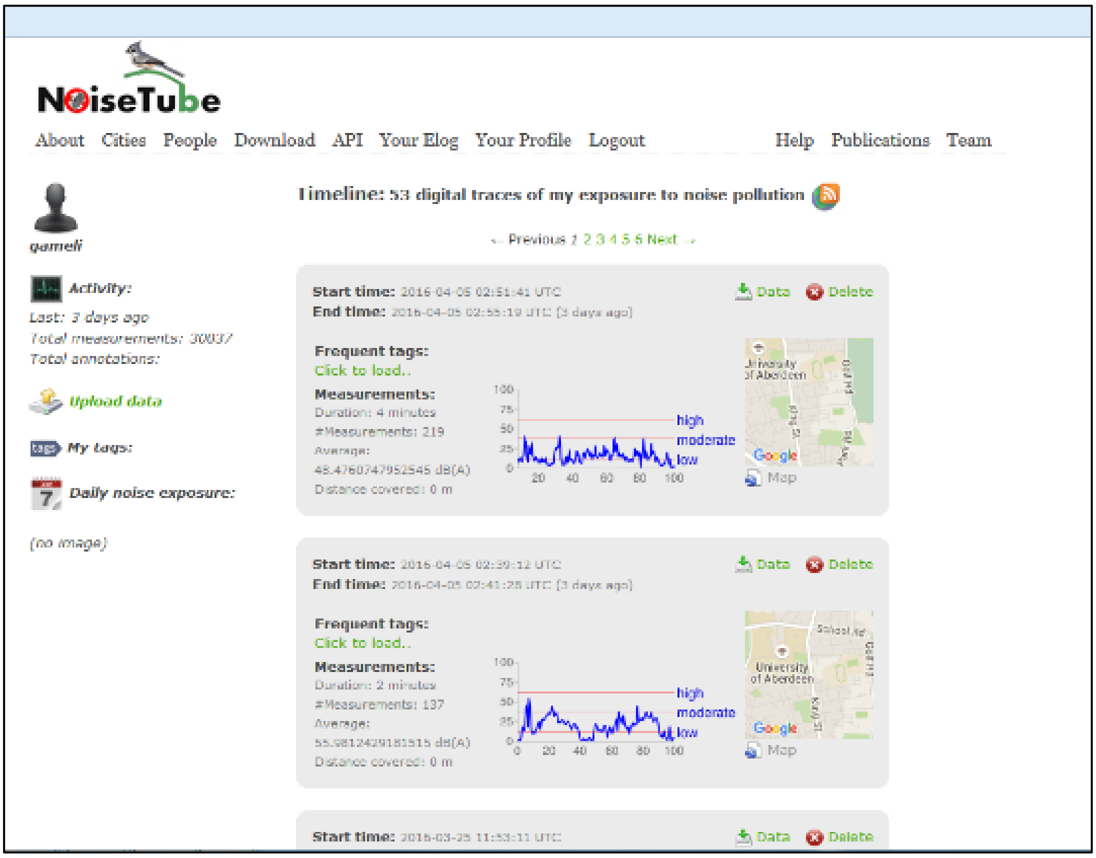

Figure 9: Data ready for download

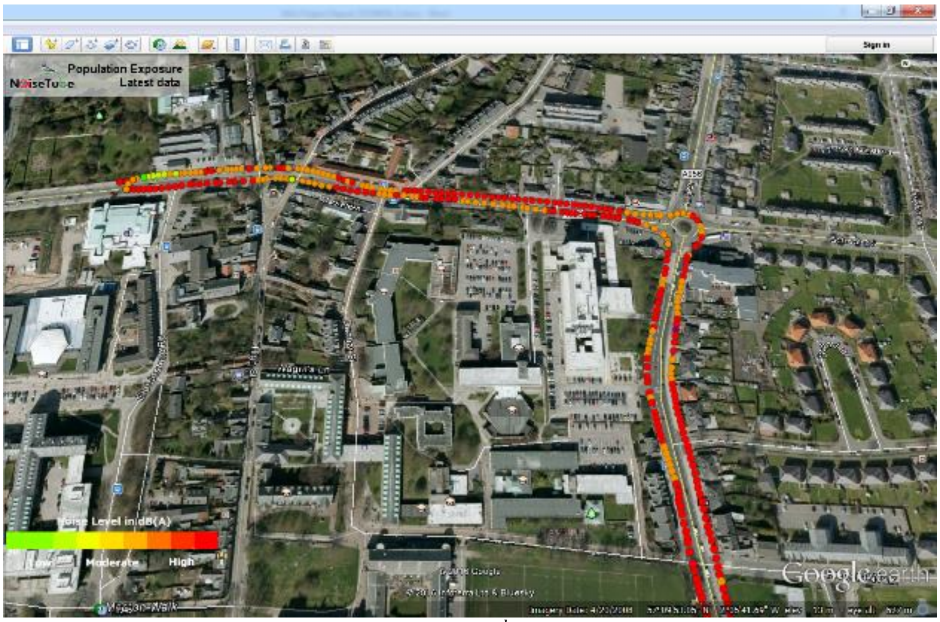

Figure 10: Downloaded data for Friday 4th March 2016

3.3 VALIDATION OF THE FIELD DATA

3.3.3 Taking out the Bicycle Noise

The noise generated by the bicycle was obtained and subtracted from the field data. This was done by tracking noise with the smart phone within a serene environment. The average readings for walking and riding the bicycle were noted and a difference of **3 dB (A)** was realised between the two instances. In order to edit the field data, the kml file was opened using MS Excel and the difference was subtracted from the 25 sets of field values.

3.3.4 Regression Analysis

Owing to the fact that, the smart phone is not a standard sound level meter, the processed data obtained was taken through another validation process. First of all, the sound level meter was calibrated with the calibrator. After that, the calibrated sound level meter and the smart phone were used to measure a pink noise that was produced from a computer at eight different levels of loudness. The exercise was conducted in a quiet room in order to eliminate or minimize external interference. Table 1 shows the results obtained from the measurements.

Table 1: Results from pink noise measurement

Sound Level Meter [dB(A)]	**Samsung Galaxy Core Prime [dB(A)]**
54	48
59	54
69	66
74	70
78	78
85	78
87	80
93	86

Using the measured values in table 1 above, a regression analysis was done between the phone's values and the sound level meter's values. As shown in figure 11, the Regress module in Idrisi TerrSet was used to perform the analysis. The equation obtained for the regression line is:

Y= 3.037969 + 1.029922X

Where **X** represents the sound level meter readings and **Y** represents the phone readings. A strong correlation between the phone and the sound meter was realised; it is evident in the correlation coefficient of **0.990114.** According to Eastman (2015), the relationship is stronger when the points are closer to the trend line. This is represented numerically by the correlation coefficient ("r").

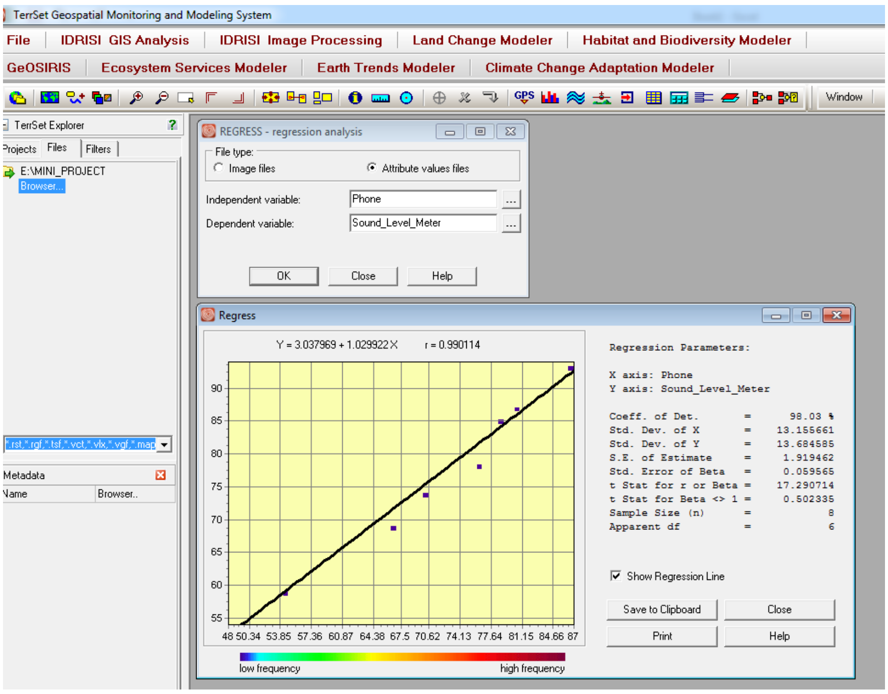

Figure 11: Regression Analysis

3.3.5 Checking of Positional Accuracy

The field observations were plotted on the base map and it was realised that the accuracy radius is rarely larger than 20m; except for a few outliers, all the points fell within the street corridor. It was also observed that, the accuracy associated with open spaces were better than areas with high rising structures. The level of positional accuracy was therefore deemed acceptable for this type of project.

3.4 **DATA POST-PROCESSING**

3.4.1 Spatial Analysis: Point Statistics

Using the ArcToolbox, the Point Statistics tool was used to generate the mean values of neighbouring points within a default cell size of 2.7m. Figure 12 shows the parameters that were specified for the analysis.

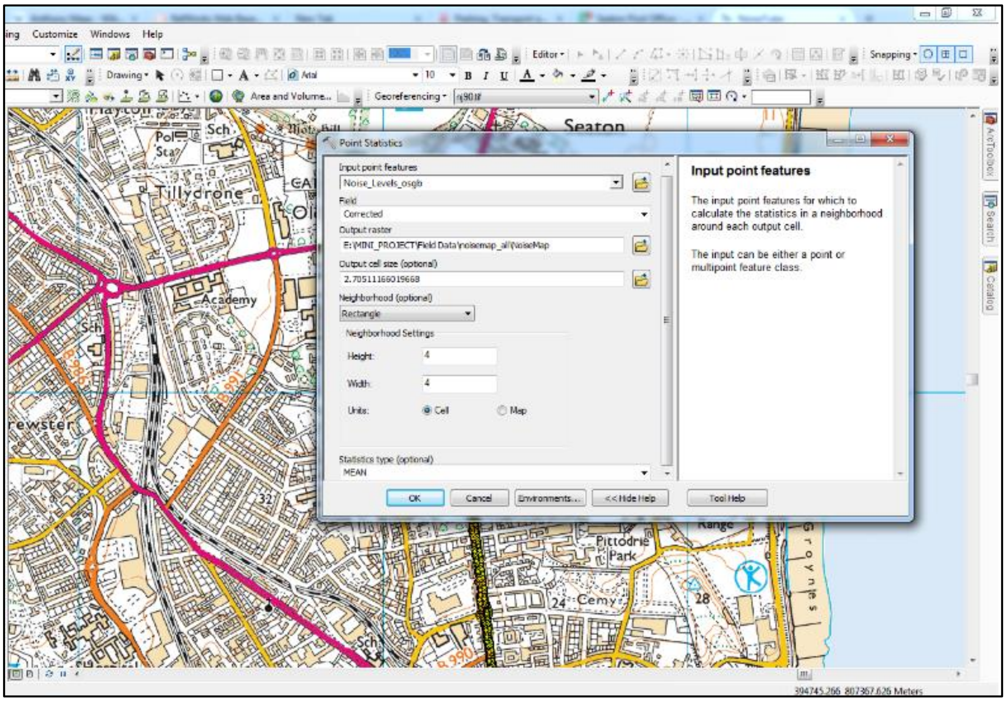

Figure 12: Point Statistics on Measurements

After the analysis, the noise map was generated and it was reclassified into four classes; 52.5-60, 60-70, 70-80 and 80-82. Figure 13 below illustrate the classes obtained.

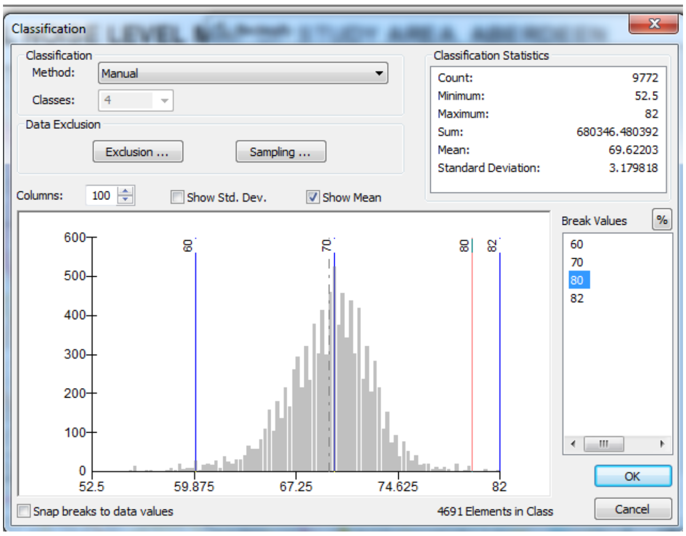

Figure 13: Reclassification

4.0 CHAPTER 4: RESULTS AND DISCUSSION

4.1 VISUALISING NOISE MAP IN GOOGLE EARTH

The initial set of results were obtained immediately after the field data was uploaded and processed by the NoiseTube Server. Even though these initial results have not yet been subjected to any adjustment, the relative noise levels are clearly portrayed. Figures 14 and 15 show sample noise maps of the study area in Google Earth. Figure 14 shows the results of the measurement on Sunday morning while figure 15 shows the results measurement done on Friday evening.

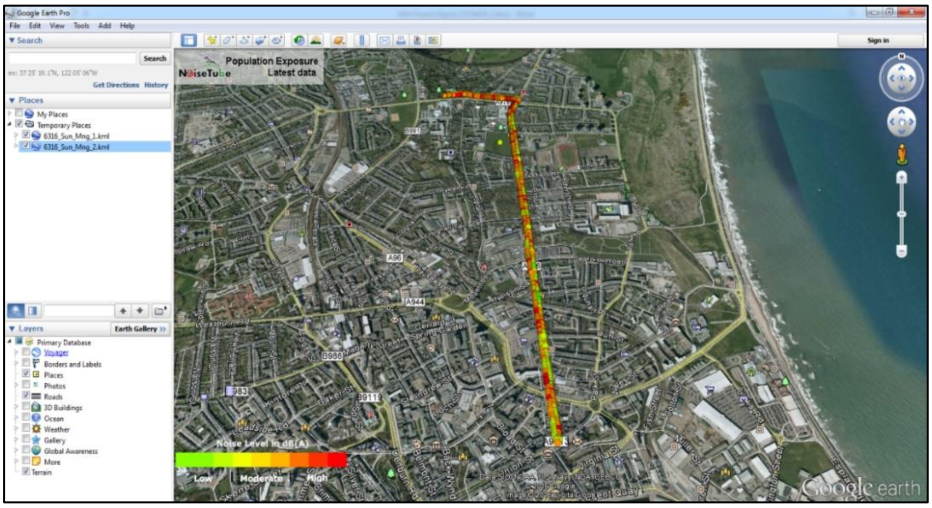

Figure 14: Noise map_Sunday morning (6-3-2016)

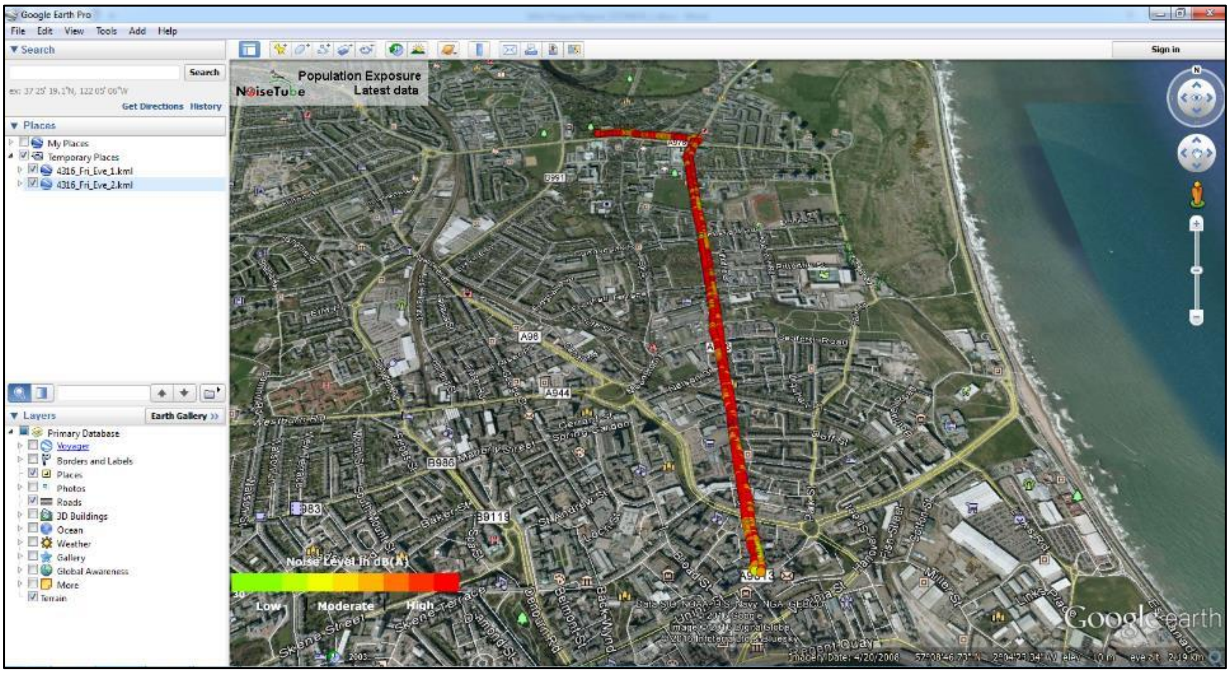

Figure 15: Noise map_Friday evening (4-3-2016)

Comparing the two maps, it was observed that the noise level is lesser on Sunday morning as compared to Friday evening. On the other hand, the noise levels look similar at the southern tip of the study area (around Castle gate, Aberdeen). Specific noise levels values can be attained using the identify tool in Google Earth. Again, comparing the noise maps of other days and different times of the day, a trend can easily be seen for planning purposes. In a nutshell, the noise maps present a wide range of flexibility that can aid city authorities in carrying out well informed decisions.

4.2 VISUALISING NOISE MAP IN ARCGIS

After performing the spatial analysis on the combined data in ArcGIS, a noise map was produced (raster format). See figure 16 for the noise map of the study area.

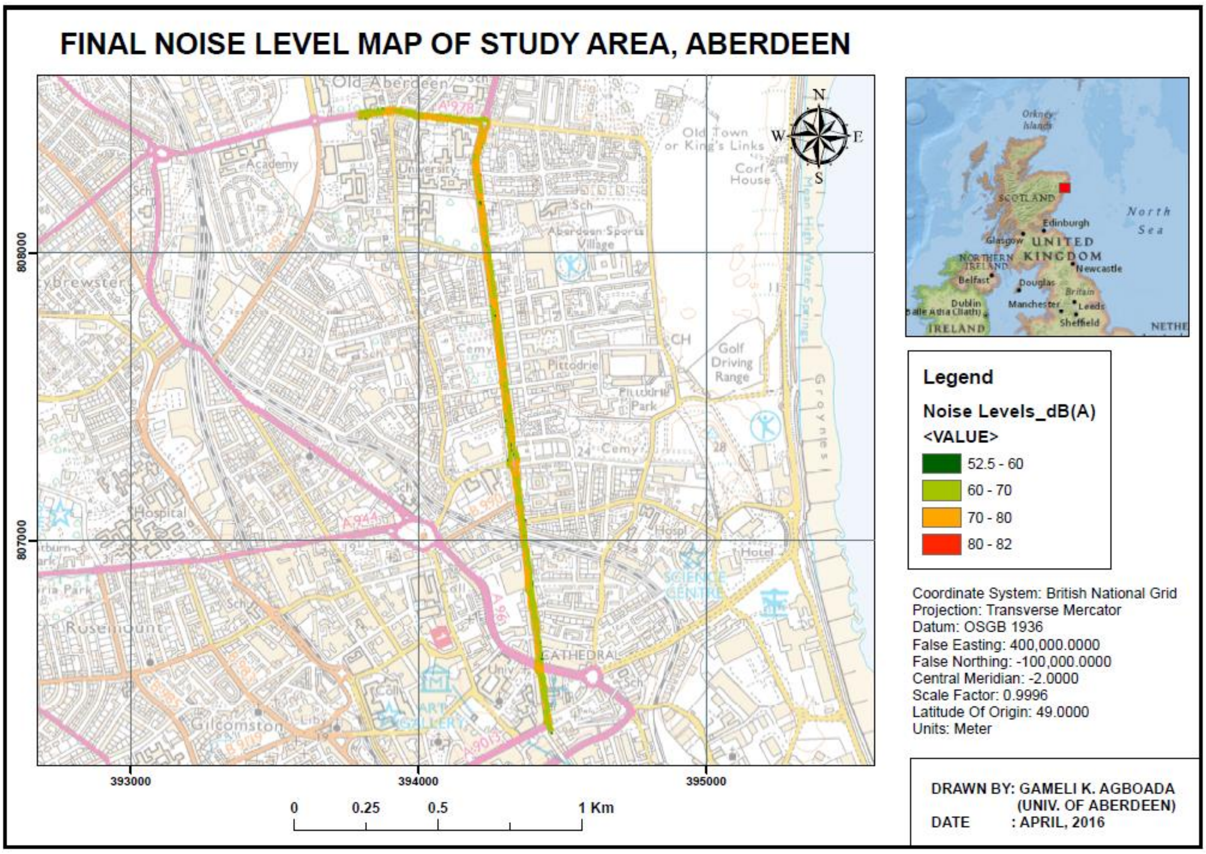

Figure 16: Final noise map of the study area

It was observed that, the predominant noise level values across the study area is between 60 dB (A) to 80 dB (A). Another observation is that, it is relatively less noisy between the southern end of the study area to the first junction northwards. However, the junction itself is quite noisy (See to figure 17). Again, it was observed that, moving 700m from the junction northwards, the western part of the street is generally noisier that the eastern part of it (See figure 18).

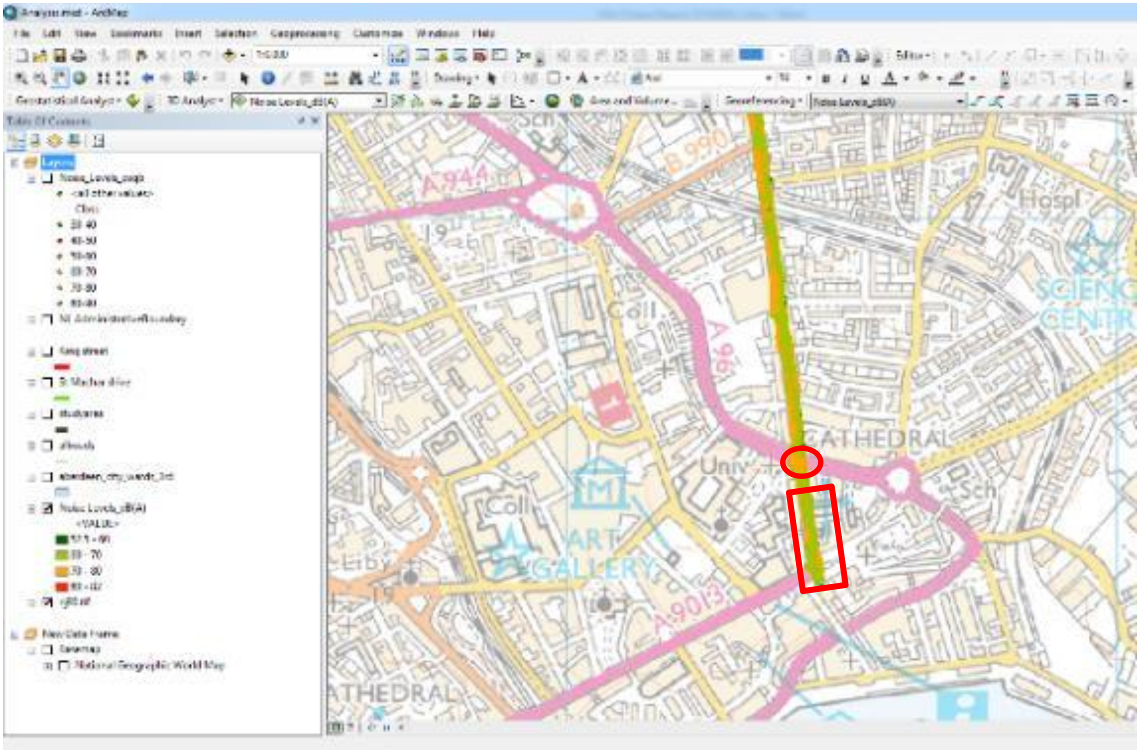

Figure 17: Comparison between the southern end and the junction

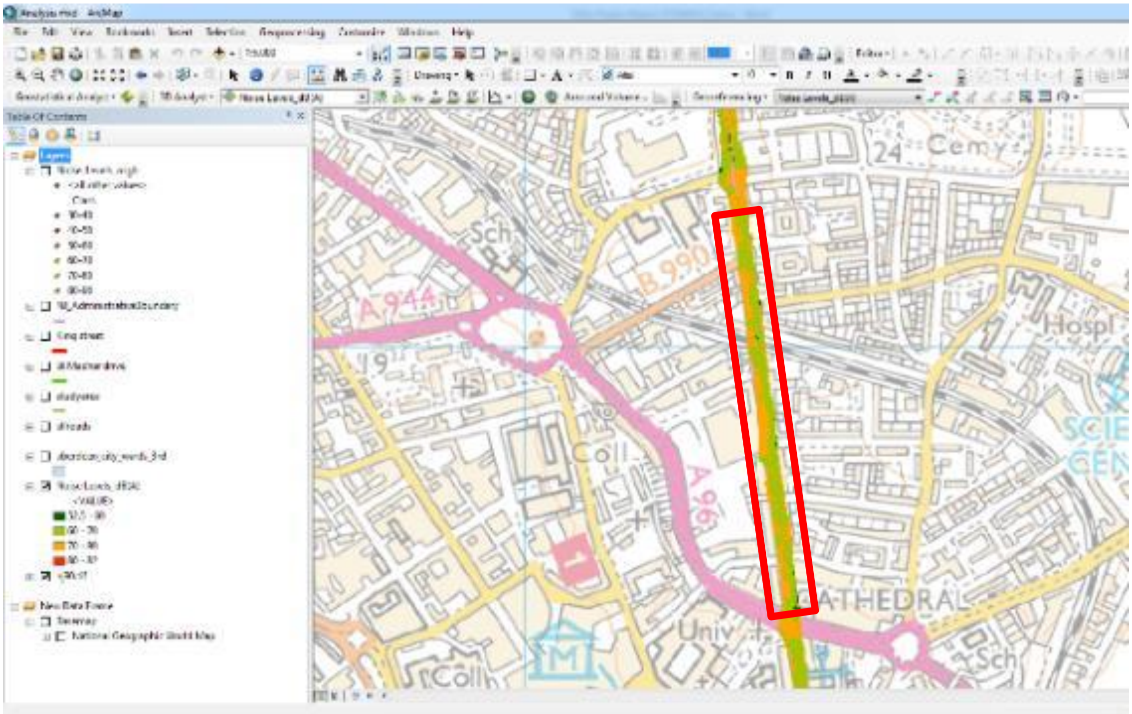

Figure 18: Comparison between western and eastern side of street

5.0 CHAPTER 5: CONCLUSION

The project aimed at using smart phone as a sound-measuring device to collect, analyse and share local knowledge about the level of noise exposure within a chosen study area in order to support the making of informed planning decisions. Eventually, a noise map was produced for the study area and the results were discussed.

It is therefore recommended that, the project is replicated on a larger scale. Considering the entire city as a study area is recommended as it will provide a good database for good decision making; it will aid in planning toward noise pollution control and hence saving lives and the environment.

6.0 REFERENCES

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BIOGRAPHICAL NOTES

A Geomatic Engineer with over 15 years of experience in the geospatial and oil & gas industry. Has a sound technical background in surveying & mapping, geospatial technology and construction management. Obtained MSc. in GIS and BSc. in Geodetic Engineering from the University of Aberdeen and KNUST respectively. Holds certificates in Mini-MBA, Project Mgt., Sustainable Mgt., ISO 45001, UAV Piloting & Data Processing, Site Mgt. Safety, Construction Quality Mgt., BOSIET, Basic Plant Operation etc. Having worked earlier with a the Ghana National Petroleum Corporation, he was part of the 9-member team of experts who established Ghana's premier natural gas processing company (Ghana National Gas Limited Company). He is a professional member of the Licensed Surveyor's Association of Ghana, Ghana Institution of Surveyors, Ghana Geospatial Society, and Ghana Institution of Engineering.

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