ASSESSMENT OF NOISE POLLUTION LEVEL: THE CASE OF ADAMA TOWN

Onesimus Bekuma Amenu

A thesis submitted to the department of Architecture
School of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for the Degree of Master's in urban planning and design

Office of Graduate Studies
Adama Science and Technology University

May, 2024
Adama, Ethiopia

ASSESSMENT OF NOISE POLLUTION LEVEL: THE CASE OF ADAMA TOWN

Onesimus Bekuma Amenu

Advisor: Prof. Ambuj Kumar

A thesis submitted to the department of Architecture
School of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for the Degree of Master’s in urban planning and design

Office of Graduate Studies
Adama Science and Technology University

May, 2024
Adama, Ethiopia

Declaration

I hereby declare that this Master Thesis entitled "Assessment of Noise Pollution Level: The Case of Adama Town" is my own work. That is, it has not been submitted for the award of any academic degree, diploma, or certificate in any other university. All sources of materials that are used for this thesis have been accordingly acknowledged through citation.

Onesimus Bekuma

Name of student	Signature	Date

Recommendation

I, the Advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "Assessment of Noise Pollution Level: The Case of Adama Town," prepared under my guidance by Onesimus Bekuma Amenu submitted in partial fulfilment of the requirements for the degree of Masters of Science in Urban Planning and Design. Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

Prof. Ambuj Kumar		
Major Advisor	Signature	Date

Approval Board of Examiners

I, the advisor of the thesis entitled "Assessment of Noise Pollution Level: The Case of Adama Town," and developed by Onesimus Bekuma Amenu hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis. Prof. Ambuj Kumar.

Prof. Ambuj Kumar		
Major Advisor/Supervisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis by Onesimus Bekuma Amenu have read and evaluated the thesis entitled "Assessment of Noise Pollution Level: The Case of Adama Town," and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfilment of the requirement of the degree of Master of Science in Urban Planning and Design.

Chairperson	Signature	Date
Reviewer 1	Signature	Date
Reviewer 2	Signature	Date

Finally, approval and acceptance of the thesis proposal is contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

Department Head	Signature	Date
School Dean	Signature	Date
Office of Postgraduate Studies, Dean	Signature	Date

ACKNOWLEDGMENT

Above all, I thank my almighty God for always being there with me and guiding me all the time during my academic study and at the time of research.

Next, I would like to extend my gratitude to my advisor Prof. Ambuj Kumar for his moral support, academic consultation, suggestions, and unlimited feedback. It is also my pleasure to acknowledge Dr. Belay Zeleke (Ph.D.), besides my advisor, for his passion and dedication during the course work, and Dr. Sitotaw Haile (Ph.D) for inspiring me to do this research starting from seminar I.

I would also like to thank the administrative bodies of Adama General Hospital, Adama Highschool, Adama Referral Hospital, Goro Highschool, ODA Special Boarding School, Rift Valley University, Sister Aklesia Memorial Hospital and St. Mary School for their willingness and provision of necessary documents.

Finally, I would like to express my deepest appreciation to my family for their continuous support during my study time and research period.

TABLE OF CONTENTS

CHAPTER **PAGES**

LIST OF TABLES

TABLE **PAGES**

LIST OF FIGURES

Abbreviations and Acronyms

CANH	Commercial activities near the hospital
CANS	Commercial activities near the school
dB	Decibels
dB (A)	A weighted decibels
GPS	Global Positioning System
Hz	Hertz
Km	Kilo meter
Km/h	Kilo meter per hour
L_{10}	A-weighted sound level exceeded for 10% of the time, during period of measurement
L_{50}	A-weighted sound level exceeded for 50% of the time, during period of measurement
L_{90}	A-weighted sound level exceeded for 90% of the time, during period of measurement
Leq	Continuous Equivalent Noise Level in dB(A)
L_{NP}	Noise pollution level
NC	Noise climate
NWH	Noise within the hospital
NWS	Noise within the school
ODA	Oromia Development Association
SLM	Sound Level Meter
SPL	Sound Pressure Level
St.	Saint
TNI	Traffic Noise Index
UNCED	United Nations Conference for Environment
USGS	United States Geological Survey
WHO	World Health Organization

ABSTRACT

One of the main sources of pollution in cities is noise. Nowadays, noise pollution is acknowledged on a global scale as a serious issue that degrades urban regions' quality of life. The study of Evaluation of Level of Noise Pollution was conducted in selected silent zones (healthcare facilities and educational facilities) of Adama town. In Adama, healthcare and educational institutions are located around major traffic routes, commercial areas, and industrial sites, with poor environmental protection protocols and no legislation. This research aimed to identify and evaluate the level of noise pollution in silent zones in Adama town, Ethiopia and recommending proper mitigation measures to be taken by comparing the research findings with WHO guidelines. The research type is mixed research and was conducted using deductive approach. Purposive sampling was used to select the study areas based on their location and their distance from noisy areas. Eight study areas were selected and they were Adama General Hospital, Adama Highschool, Adama Referral Hospital, Goro Highschool, ODA Special Boarding School, Rift Valley University, Sister Aklesia Memorial Hospital and St. Mary School. This study used 372 questionnaire surveys using simple random sampling method to obtain information related to the impact of the noise to the users. Different criteria such us noise level, distance, impact, temporal variability and accessibility to measurement were employed to identify the noise sources. Noise level of the study areas was measured using Sound Level Meter. The measured noise parameters were L_{10}, L_{50}, L_{90} and Equivalent Noise Level (Leq) while the calculated noise parameters were Noise Pollution Level (L_{NP}), Noise Climate and Leq. All collected data were compared and analysed with generally accepted international guideline of WHO. In most of the study areas, the common noise sources were transportation (traffic noise), noise within the study areas and noise from commercial activities around the study areas. The regression analysis shows that these noise sources predict 61% of the noise level in the study areas. The average Equivalent Noise Levels of Adama General Hospital, Adama Referral Hospital, Sister Aklesia Memorial Hospital, Adama Highschool, Goro Highschool, ODA Special Boarding School, Rift Valley University and St. Mary School were 53.43 dB(A), 59.18 dB(A), 54.58 dB(A), 47.93 dB(A), 50.24 dB(A), 46.1 dB(A), 51.8 dB(A) and 52.73 dB(A) respectively. Leq was used to compare with the permissible limit suggested by WHO and the result showed that every study area's Leq was higher than the permissible limit. Generally, it is recommended that, further standards, rules and regulations have to be formulated and enforced by Adama Land Administration and different international design guidelines should be adopted and employed in our context. Further analyses should also be conducted in this thematic area.

Keywords: *Noise Pollution, Noise pollution Level, Silent zones, Adama*

CHAPTER ONE

1. INTRODUCTION

1.1. BACKGROUND OF THE STUDY

Environment refers to the surrounds in which a person or community lives and includes both the physical and cultural settings. In a broad sense, environment refers to all that a living organism is exposed to. Particularly the conditions of people's lives or the society in which they live. It consists of the collection of social, cultural, and ecological values that exist in a certain location and time and have an impact on current and future generations (Hammer et.al, 2014). It encompasses not only the physical environment in which life arises but also the relations between living things, inanimate items, water, soil, and air, as well as intangibles like culture. Environmental pollution is the introduction of contaminants into the natural environment that cause adverse change. Pollution can take the form of chemical substances or energy, such as noise, heat or light (Olayinka, 2012).

One of the main sources of pollution in cities is noise. Noise was designated as a contaminant by the World Health Organization (WHO) in 1972. Due to the detrimental impacts of noise pollution on human health, the Global Soundscape Project, founded by Murray Schafer in Canada, emphasized the necessity of enhancing urban soundscape quality during the same decade. One of the main contributors to the decline in the quality of the environment and living in a city is noise pollution, which has gone past the limits of industrial areas and into areas used for recreation, rest, and work. Yet how it perceives things depends on how things in space and time interact with people, places, and activities (Jariwala et.al, 2017).

Nowadays, noise pollution is acknowledged on a global scale as a serious issue that degrades urban regions' quality of life (Woolner & Hall, 2010). Many studies have been conducted to evaluate the noise pollution in numerous places across the world, including several in Africa (Zannin et.al, 2013). As indicated by the numerous anti-noise legislation, regulations, and noise policies, actions to control noise consequences have been of immediate concern for communities in developed nations (Alam, 2011).

Even some countries like Egypt, imposed limitations to enhance the environment. This restriction includes (i) ban on horns; (ii) ban on horns and trucks; and (iii) ban on horns, trucks and noisy buses (Sakr et.al, 2020). Unfortunately, such action is still scarce in poorer nations, particularly in Africa.

Ethiopia is one of the emerging nations whose urban environments have changed significantly over the past ten years as a result of industrialization, urbanization, the extension of the road system, and the rise in the number of motor vehicles. These modifications have undoubtedly brought about an increase in noise levels that negatively affect the locals. Ethiopia is one of the developing nations with the most extensive environmental policies, with the general objective of the policy being to enhance and improve people's health and quality of life (Doda, 2017). Controlling noise pollution is one of the goals of Environmental Pollution Control Proclamation 300/2002. Although there are policies and laws addressing noise pollution, they have never been successfully implemented due to a lack of programs, and as a result, this nation has not yet completely acknowledged noise pollution as a danger factor for human health. The absence of baseline data on the level of noise in urban quiet regions as well as its impact on human health may be the cause of this (Goshu et.al, 2017).

The increasing number of complaints from the city's noise-impacted populations proves that environmental noise pollution in Addis Ababa has undergone substantial changes at various points in time. The report presented by Mahlet G. for the Forum for Environment confirmed that Addis Ababa exceeded the WHO threshold for noise pollution (1999). According to a study carried out in Dire Dawa City, the average noise level measured at commercial, residential, and mixed locations exceeded the WHO-acceptable limit. In the Ethiopian metropolitan areas under study, the pattern is essentially the same. In order to take prompt action against noise pollution and to provide a baseline for future research, regional analysis of this issue is crucial. This study is, thus, aimed at assessing the noise pollution level from various sources in Adama town.

1.2. STATEMENT OF THE PROBLEM

Adama being a busy commercial, industrial and transport center in the rift valley, is mostly prone to noise pollution. In urban areas, the noise pollution problem is primarily caused by road traffic. Due to the constant use of loudspeakers set to a very high pitch for an extended period of time, the noise problem is also made worse at locations where public festivals and religious worship or functions are held. Operating commercial and industrial facilities that are either close to silent zones are other significant sources of noise pollution in cities.

Even if our country lacks technology-based materials to reduce noise pollution, the responsible authority side appears to be quite reluctant to put the enacted rule and regulation into effect (WHO, 2001). As we can see from Adama's current situation, the most noise-sensitive institutions, such as schools, hospitals and residential neighborhoods, are dispersed across the city's main thoroughfares, shopping malls, business districts, and building sites. The silent zones under study are surrounded by various sources of noise pollution that were constructed using common non-soundproof materials that cannot shield the community from the disturbance caused by noise pollution.

Additionally, as previously stated, laws and regulations were established at the national level to control environmental pollution in general and noise pollution in particular. However, due to a lack of implementation and follow-up, most of Adama's hospitals and educational institutions are suffering from noise pollution from loud speakers used by religious institutions, the live musical beat of nightclubs, bars, and restaurants, shouting at midnight, and street noises. This research study concentrates mostly on assessing the level of environmental noise pollution from various sources. Then, in order to evaluate the levels of noise pollution and legal issues for noise pollution in the necessary government institutions in Adama that are accountable for monitoring and controlling these dangerous problems, the researcher used the WHO guidelines for community noise pollution in the healthcare facilities, and schools.

Since there is a lack of awareness regarding the adverse impact of noise pollution there are very few researches conducted. (Zerihun S. et.al, 2017) have researched on the people’s perception on major noise source and its impacts on health at Dire Dawa City. (Goshu B et.al, 2017) have researched the general urban noise in Dire Dawa City.

(Doda D., 2017) studied noise pollution in Addis Ababa (Bole Michael Community Area). (Bogale G.G., et.al, 2022) have researched the spatial distribution of health-risky road traffic noise pollution in Dessie City. There are also a few more researches conducted in some other parts of the country. However, even though Adama is a busy transportation corridor, researches regarding noise pollution are yet to be conducted in the area. Furthermore, in Ethiopia, there are no researches conducted in a context of urban planning and design. In most of the researches there are limited noise parameters used to analyse the noise pollution of a certain area. Often used noise parameters are: Lmax, Lmin, and Leq.

1.3. OBJECTIVES OF THE STUDY

1.3.1. General Objective

The general objective of this study is to analyze and assess the level of noise pollution in silent zones in Adama town, Ethiopia.

1.4.2. Specific Objectives

1. To identify the noise sources around the study areas.
2. To evaluate the noise pollution level in the study areas.
3. To compare the measured noise level values in the study areas with WHO's standard permissible noise limit.

1.4. RESEARCH QUESTIONS

1. What are the noise sources that contribute to the noise pollution around the designated silent zones?
2. What is the extent of noise pollution level at different urban locations under silent zones?
3. Which areas of the city are more exposed to noise pollution than the WHO-recommended standard acceptable limit?

1.5. SIGNIFICANCE OF THE STUDY

This research provides valuable information on the sources and levels of noise pollution, as well as potential solutions to reduce it. The findings from this research can help inform policy decisions and regulations that can be implemented to reduce noise pollution in different locations of Adama Town. It can inspire municipal administration stakeholders to raise public awareness, particularly by collaborating with school communities, and to cooperate with the city council to reduce noise pollution and conduct noise mapping.

Additionally, this research can help identify areas where additional resources may be needed to address noise pollution issues. By understanding the current state of noise pollution in these selected areas, the government can take steps to ensure that citizens are not exposed to excessive levels of noise.

Future scholars that wish to undertake a deeper and more extensive investigation on the chosen topic might use the findings of this study as a standard. Also, it might point up significant knowledge gaps and serve as a resource for upcoming work.

Additionally, first to benefit from the problem's final resolution by the relevant authorities is the community affected by it. This research helps to inform the public about the dangers of excessive noise exposure and how it can affect their health and wellbeing. Ultimately, this research helps to create a healthier and more peaceful environment for all residents of Adama Town.

1.6. SCOPE OF THE STUDY

1.6.1. Thematic Scope

This study's scope is restricted to evaluating the level of noise coming from different sources in and around the selected areas of healthcare facilities and schools in Adama town. Since this study attempts to conduct a thorough direct examination using data collection tools, its conclusions are more factual and reliable. The noise parameters used in this research are L10, L50, L90, Equivalent Noise Level (Leq), Noise Climate (NC) and Noise Pollution Level (LNP). Data collected in general were from physical measurement, field observations and questionnaire survey.

1.6.2. Spatial Scope

This paper includes three healthcare facilities and five school (educational facilities) located in different areas of Adama town that are selected purposively.

1.6.3. Temporal Scope

The physical measurements for the noise data monitoring was carried out in the wintertime under favourable weather circumstances, when there are no signs of precipitation and the wind speed is less than 5 m/s. Local meteorological information was taken into account, including vertical temperature profiles, precipitation, humidity, and wind speed.

1.7. OPERATIONAL DEFINITIONS

Silent zone: Silent zone is an area that does not comprise, less than 100 metres around hospitals, educational institutions and courts.

Noise parameters: Noise parameters are specific measurements or metrics used to describe and quantify various characteristics of noise. These characteristics aid in comprehending the type, degree, and effects of noise in various contexts.

1.8. ORGANIZATION OF THE DOCUMENT

The thesis is divided into five chapters, each of which thoroughly and methodically analyzes the study's data and content. The thesis's foundational chapter is further illustrated in the following ways.

Chapter One: Introduction to the study introduces the thesis by lighting the main topic of the study, research problems, objectives, questions, significance, scope, operational definitions and organization.

Chapter Two: Literature review is a chapter that discusses key definitions of Noise pollution, characteristics of noise, noise sources, impacts of noise pollution, noise management and mitigation systems and legal frameworks. It also includes both empirical and theoretical frameworks about noise pollution.

Chapter Three: Research Methodology is a chapter that discusses the methodology of the research. The chapter explains the methods used for the study and the process of data collection and analysis in detail.

Chapter Four: Result and Discussion is a chapter that discusses the results of qualitative and quantitative data findings. The quantitative data are gotten from physical measurements. The qualitative data are analyzed based on a questionnaire survey, field observation notes, and printed documents.

Chapter Five: Conclusion and recommendation is the concluding part of the research. The chapter made a conclusion based on the findings from the measurements and the comparison with the standard, the study concludes the results and discussion as well as it stated recommendations.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. DEFINITION OF NOISE POLLITION

Depending on the source of the sound and how it affects the listener, noise can have many different definitions. According to Christopher, noise is "sound that the recipient does not want to hear". Because noise is defined as unwanted sound, it can be thought of as the wrong sound at the wrong time and place (Doda, 2017). Many definitions of noise have been offered, and each one is dependent on the knowledge and understanding of the individual. Even a sound measurement cannot definitively define what constitutes noise because noise is a subjective phenomenon. In this study, noise is defined as sound that is unwanted by humans. A recipient of sound has the right to determine whether or not the sound qualifies as noise. Noise affects each person differently. It relies on a number of variables, including the person's age, sex, and mood. This means that the only way to determine whether a sound is "noise" or "non-noise" is to provide a range of guidelines. (WHO, 2018)

In the context of acoustic pollution, noise is referred to as "refuse," therefore governments typically try to eliminate particular sources of sound that impede the productive activities of the city under the guise of auditory health and urban planning (Keerthana, 2013).

According to environmental noise exposure standards and legislation, residential and educational institutions should not have exposure levels above 55 dB(A) between 7:00 am and 11:00 pm and 45 dB(A) between 11:00 pm and 7:00 am. (FTA, 2018). In some regions, especially in major urban centers, these regulations are frequently not followed, putting people at risk for noise discomfort. Much technological progress has been made in the last four decades to lessen the noise effects of transportation sources like aircraft, trains, and roads. However, because of rising traffic levels (by all modes) during longer hours of the day and evening, many of the advantages of these efforts have been lost. A bigger fraction of the population has also been exposed to higher noise levels as a result of increases in urban population. According to the World Health Organization, noise poses a serious hazard to people's health (da Paiva et.al, 2015). In an urban setting, environmental noise is unavoidable. Noise is becoming a bigger issue despite efforts to limit exposure, mainly because of ongoing urbanization and increased mobility (Eriksson, 2012).

Road, train, and airline traffic are the main sources of environmental noise, but other sources include noise from nearby homes, building sites, and industrial facilities. Individuals' health and well-being are impacted by the lack of peaceful and healing spaces in society. An excessive amount of noise exposure may have negative effects on health, including annoyance, sleep problems, decreased communication, cognitive repercussions, and physiological stress reactions. There is evidence that traffic noise has a long-term impact on the cardiovascular system, although there are still many problems with risk assessment (Eriksson, 2012).

Cities in developing countries have seen a continuous decline in the urban environmental quality due to population growth, infrastructure expansion, and automobile use. As a result, the population growth has caused traffic noise levels to continuously increase, which has decreased the quality of life in cities. For urban planners and environmental engineers, reducing road traffic noise in cities is a major task (Thompson et.al, 2022). Hence, noise should be taken into account while designing and building new transportation systems as well as when making modifications to already existing ones (Ayyub, 2012). Local government officials and environmentalists also understand the significance of tracking changes in noise pollution when creating mitigation strategies. The sympathetic and endocrine stress response with consequent acute alterations in vascular tension are assumed to be the molecular mechanism connecting noise to hypertension. According to the theory, prolonged exposure to noise may cause permanent circulatory alterations like arteriosclerosis and raise cardiovascular risk factors like hypertension (WHO, 2022).

2.2. CHARACTERISTICS OF NOISE

Examining how much noise people are exposed to and how it affects them is important because sound is an environmental component. The level of exposure is determined by the following factors:

- the emission of sound
- how the sound is received by the human body and
- the environment in which the sound is being emitted and heard.

The auditory and non-auditory impacts of noise exposure include what is heard or felt. A listener can perceive a sound wave as a physical disruption of molecules within a medium, such as air, water, or solid. A vibrating item, known as a sound source, produces sound waves (Mahmoud et.al, 2019).

These various waves combine and travel in a variety of direct and indirect directions before reaching the listener. The listener's inner ear contains organs that vibrate in response to these molecular disturbances, converting the vibrations into changing electrical potentials that are sensed by the brain – allowing the phenomenon of hearing to occur. The physical qualities of sounds can be described by quantitative values. Noise is generally characterized by its frequency, amplitude, and duration (FTA, 2018).

- **Frequency**: Noise is typically measured in hertz (Hz), which is the number of cycles per second. Low-frequency noise has a frequency below 500 Hz, while high-frequency noise has a frequency above 2000 Hz.
- **Amplitude**: The amplitude of noise is measured in decibels (dB). Low-amplitude noise has an amplitude below 40 dB, while high-amplitude noise has an amplitude above 80 dB.
- **Duration**: Noise can be either short or long in duration. Short-duration noise lasts for less than one second, while long-duration noise lasts for more than one second.

Noise can also be classified as either continuous or intermittent. Continuous noise is constant and does not vary over time, while intermittent noise varies over time and may include periods of silence between bursts of sound (Fiedler & Zannin, 2015).

2.3. SOURCES OF NOISE POLLUTION

2.3.1. Industries

The majority of industries employ enormous machines that can make a lot of noise. The most prominent examples include pneumatic devices, high-speed rotating or stamping processes, machinery or machine tools, and duct, fan, and blower systems. Moreover, a number of pieces of machinery, including grinding mills, exhaust fans, compressors, and generators, contribute to the production of significant noise. To lessen the impact of noise, employees in these factories and industries wear earplugs (WHO, 2018).

2.3.2. Transportation

The sound of a revving engine is one of the most iconic noises associated with transportation. It is a deep, throaty roar that can be heard from miles away and is often associated with speed and power. It is the sound of a car, truck, or motorcycle accelerating quickly and powerfully.

The excessive noise causes regular people to lose their capacity to hear clearly. For a very long time, the public has complained about aircraft noises as being annoying. Again, a number of variables, including the number of aircraft, flight routes, takeoff, approach, and landing techniques, affect how much noise contributes to the overall level. For instance, a plane's impact on the surrounding area can be reduced by as much as 9 dB when flying at an altitude of roughly 1000 m as opposed to 500 m. (A) (Yang et.al, 2020).

Road cars produce most of their noise from the engine and through frictional contact with the ground and air. At speeds more than 60 km/h, engine noise typically outweighs road-contact noise. Railway noise varies based on the type of engine, wagons, rails, and their foundations, as well as the roughness of the wheels and rails, but train speed has the biggest impact on it. Wheel squeal, which is a very loud high-frequency sound, can be produced at very high levels by small radius curves in the track, like those that may be present for urban trains. Running engines, loudspeakers, and whistles in stations can produce noise, as can shunting activities in marshaling yards (Morillas et.al, 2021). The proportion of high-frequency sound energy increases at speeds over 250 km/h, and the sound can be heard as being comparable to that of an overflying jet aircraft. Significant noise is produced by aircraft activities near both commercial and military airports. It is well known that takeoffs from aircraft generate loud noise, including rattling and shaking. Long low-altitude flight lanes where the landings occur are very noisy. For safety purposes, the noise is generated by the landing gear, automatic power control, and when reverse thrust is employed. Larger, heavier aircraft generally make more noise than smaller, lighter planes. The turbulence produced by the jet exhaust mixing with the surrounding air served as the primary mechanism for noise creation in the early turbojet powered aircraft. When compared to regular airports, noise from military airfields may be particularly problematic (Moroe & Mabaso, 2022; WHO, 2018).

2.3.3. Construction and Building Activities

Construction of new buildings and excavation activities can generate a lot of noise. Cranes, cement mixers, welding, hammering, boring, and other work operations all produce a range of noises. Building operations are occasionally carried out without taking into account the environmental noise implications, and construction equipment is frequently improperly maintained and quiet. When performed during sensitive hours of the day, city services like trash removal and street cleaning can also cause significant disruption. Heat pumps, plumbing systems, ventilation and air conditioning plants, and elevators, for instance, can disrupt the internal auditory environment and annoy neighbors (WHO, 2022).

2.3.4. Social Events

Noise pollution produced by speakers in different social events like marriage, parties, pub, disc, or place of worship can have a significant impact on the community. In religious institutions, loud music and chanting can disrupt the peace of the neighborhood, making it difficult for people to concentrate or relax. In night clubs, loud music and bass can cause physical discomfort to those nearby, as well as interfere with sleep patterns (Ma et.al, 2018).

The most common type of noise pollution produced by speakers in religious institutions and night clubs is low-frequency sound. Low-frequency sound is often referred to as “bass” and is characterized by its deep, rumbling sound. This type of noise has been linked to an increased risk of hearing loss, as well as other health problems such as headaches, fatigue, irritability, and difficulty concentrating. Additionally, low-frequency sound has been found to travel farther than higher frequencies, meaning that it can affect people who are not even in the immediate vicinity of the source (Hunashal & Patil, 2012)..

In addition to physical health effects, noise pollution from speakers in religious institutions and night clubs can also have psychological effects on those living nearby. The constant disruption of peace and quiet can lead to feelings of stress and anxiety for those living close by. Furthermore, it can also lead to decreased property values due to the negative perception associated with living near a noisy area (Hunashal & Patil, 2012).

2.3.5. Noise from Leisure Activities

There is an increase in the usage of motorized devices for leisure activities. Motor racing, off-road vehicles, motorboats, water skiing, snowmobiles, and other activities, for instance, greatly add to the loud noises in formerly tranquil locations. Shooting activities not only have a high risk for upsetting the local population, but they can also be harmful to the participants' hearing. Even playing tennis, ringing church bells, and other religious activities might cause concerns about loudness. There are some indoor concerts that can have incredibly loud sound pressure levels. The accompanying noise issues outside are brought on by people entering and exiting. Intense noise can also be produced by pyrotechnics, festivals, and outdoor concerts (Chowdhury et.al, 2010).

Road traffic noise concerns are frequently made worse by the broader issue of access to events and places for recreational activities. Intense sound produced by music on headphones can also cause severe hearing impairment (WHO, 2018).

2.4. IMPACT OF NOISE POLLUTION

The delicate hair cells in the inner ear that aid in hearing can be harmed by two different types of sounds. The first category includes unexpected, extremely loud noises like fireworks, explosions, and gunshots. The second are the loud noises heard at occasions like loud music concerts. This type of hearing loss is irreversible regardless of the reason. The body has been seen to undergo noticeable alterations in response to sudden and unexpected sounds, including elevated blood pressure, elevated heart rate, and contractions of the muscles. In addition, saliva and gastric juice flow cease, as do stomach contractions and digestion. (WHO, 2022)

Repeated exposure to unexpected noise should, obviously, be kept to a minimal because the changes are so noticeable. Fortunately, these alterations disappear once a person becomes used to the loudness (Abbaspour et.al, 2015). In the context of noise pollution, the sensory hearing loss is one of the more significant types of hearing loss. The most typical type of hearing loss linked to noise is sensory hearing loss, which is brought on by injury to the inner ear (cochlea). This kind of hearing loss impacts speech comprehension and hearing clarity in addition to lowering sound levels or the capacity to hear faint sounds. Thousands of microscopic hair cells in the cochlea send sound impulses to the auditory nerve.

Long-term exposure to loud noises can flatten or deform hair cells, or even cause them to fuse together, which reduces their ability to transmit sound. Although sensory hearing loss is typically irreversible, further loss can be stopped by wearing safety gear. The severity of a hearing loss is referred to as its degree. The most common classifications are the following five broad ones. The figures reflect the thresholds of the patient, or the softest intensity that is recognized in sound:

- Normal range or no instrument = 0 dB to 20 dB
- Mild loss = 20 dB to 40 dB
- Moderate loss = 40 dB to 60 dB
- Severe loss = 60 dB to 90 dB
- Profound loss = 90 dB or more

Some of the negative effects of noise on health might not be as obvious and audible. If anecdotal comments are considered as the standard, sleep difficulties are likely the most common cause of noise irritation. (WHO, 2022)

The World Health Organization has recommended a night time average level of 35-40 dB for undisturbed sleep. According to the World Health Organization, health risks associated with noise pollution include:

- interferences with social behavior (aggressiveness, protest and helplessness);
- interference with speech communication;
- affects performance at work/school;
- pain and hearing fatigue;
- hearing impairment including tinnitus;
- annoyance;
- interferences with social behavior (aggressiveness, protest and helplessness);
- interference with speech communication;
- sleep disturbance and all its consequences on a long and short-term basis;
- cardiovascular effects;
- hormonal responses (stress hormones) and their possible consequences on human metabolism (nutrition) and immune system.

2.5. WHO GUIDELINE FOR NOISE POLLUTION

In order to guarantee that patients receive healing environments and that healthcare providers have a comfortable place to work, the World Health Organization (WHO) has established guidelines regarding noise pollution levels in hospitals. The average sound pressure level in general wards and patient rooms should not be higher than 35 dB(A). Similarly, in intensive care units (ICUs), the average sound level should not be higher than 35 dB(A), and during surgery, the sound level should not be higher than 30 dB(A).

The World Health Organization (WHO) also provides guidelines for noise pollution levels in schools to ensure a conducive learning environment for students and a healthy workplace for teachers. The guidelines are: for outdoors, the noise level should not exceed an average of 55 dB(A) daytime and 45 dB(A) during night. The noise level in classrooms should not exceed an average of 35 dB(A) during teaching activities.

2.6. LEGAL FRAMEWORKS OF ENVIRONMENTAL ISSUES IN ETHIOPIA

Ethiopia has endorsed a legislation to control noise pollution. Noise has been classified as a hazardous waste that should be controlled by Ethiopian Environmental Pollution Control Proclamation No.300/2002, which went into effect on December 3, 2002 and consists of 22 articles separated into six parts.

Noise is specified as one of the harmful pollutants that are prohibited in Article 5 of the proclamation. The article outlines procedures for the collection, transportation, and treatment of municipal garbage, including recycling. Based on scientific and environmental principles, the Environmental Protection Authority must create "practicable" environmental regulations. The discharge or effluent waste water and sewerage, air pollution, subsoil, noise, and waste management are all covered by these regulations (FDRE, 2002).

Additionally, according to the Federal Democratic Republic of Ethiopia's 2005 Criminal Code provision, Article 815, Sub articles 1 and 2, Anyone who obstructs another person's work, rest, or tranquility, including through fights and wrangling, yells, songs, vociferations, or uproars, signals, calls, or the ringing of bells, or by abusing loud instruments, apparatus, machines, or other loudproducing items, will be punished financially.

According to article 2, the court may impose a fine and an arrest sentence of up to one month if the noise or disturbance is willfully made near hospitals, schools, or other comparable institutions, occurs at night as determined by police regulations or by tradition, or is made with malicious intent (FDRE, 2005).

2.7. EMPIRICAL LITERATURE REVIEW

Table 2.1: *Summary of reviewed literatures*

<table>
<tr><th></th><th>Topic</th><th>Author(s)</th><th>Year</th><th>Summary</th></tr>
<tr><td>1</td><td>Noise pollution and annoyance</td><td>Karina Mary da Paiva Vianna
Maria Regina Alves Cardoso
Rui Manuel Calejo Rodrigues</td><td>2015</td><td rowspan="3">Researches on how noise pollution affects human health has shown that it has negative consequences, particularly in vulnerable locations like homes, schools, and hospitals. According to these research, exposure to high noise levels can have a variety of negative health effects, including nerve damage, headaches, anxiety, sleep difficulties, and hearing impairment. The results highlight how critical it is to implement noise reduction plans, improve urban planning, and launch awareness programs in order to protect the health of those who are impacted by urban noise.</td></tr>
<tr><td>2</td><td>Noise pollution and human cognition</td><td>Rhiannon Thompson
Rachel B. Smith
Yasmin Bou Karim
Chen Shen
Kayleigh Drummond
Chloe Teng
Mireille B. Toledano</td><td>2022</td></tr>
<tr><td>3</td><td>A multilevel analysis of perceived noise pollution, geographic contexts and mental health in Beijing</td><td>Jing Ma
Chunjiang Li
Mei-Po Kwan
Yanwei Chai</td><td>2018</td></tr>
<tr><td>4</td><td>An Assessment of Noise Pollution in Addis Ababa: The Case of Bole Michael Community Area</td><td>Dana Doda</td><td>2017</td><td rowspan="4">Multiple studies conducted across various urban areas globally (such as Beijing, Addis Ababa, Dhaka, Dire Dawa, Tirupur, Kolhapur) have delved into the prevalent issue of urban noise pollution. Using sound level meters, these studies assessed noise levels in different zones like residential, commercial, industrial, and silence zones. In all cases, the studies revealed elevated noise levels, particularly near areas of high traffic. These exceeded permissible limits, emphasizing the critical need for effective noise control measures and awareness campaigns to address the adverse impacts on public health and wellbeing in urban environments.</td></tr>
<tr><td>5</td><td>Assessment of noise pollution in Dhaka city</td><td>S.C. Chowdhury
M.M. Razzaque
M.M. Helali
Hans Boden</td><td>2010</td></tr>
<tr><td>6</td><td>Urban Noise: A Case Study in Dire-Dawa City, Ethiopia</td><td>Belay Sitotaw Goshu
Hailemariam Mamo
Solomon Zerihun</td><td>2017</td></tr>
<tr><td>7</td><td>an Analysis of Noise Pollution in Tirupur City</td><td>G. Keerthana</td><td>2013</td></tr>
</table>

8	Assessment of Noise Pollution Indices in the City of Kolhapur, India	Rajiv B. Hunashal Yogesh B. Patil	2012	
9	Evaluation of urban traffic noise pollution based on noise maps	Weijun Yang Jinying He Canming He Ming Cai	2020	Diverse cities' traffic noise pollution levels have been studied, with differing degrees of success. According to a research done in South Africa and Beijing, noise levels during peak traffic hours were higher than advised, which could have an adverse effect on locals' health. Likewise, studies carried out in Kolhapur, Tirupur and Dhaka demonstrated the detrimental effects of traffic noise on the quality of sleep and cognitive function. On the other hand, a research conducted in certain cities found that noise levels were comparatively lower as a result of efficient urban planning and the application of noise control techniques. These results highlight the necessity of all-encompassing approaches to reduce traffic noise pollution and safeguard urban populations' health.
10	Quantifying traffic noise pollution levels: a cross-sectional survey in South Africa	Nomfundo Moroe Paballo Mabaso	2022	
11	Variability of traffic noise pollution levels as a function of city size variables	Juan Miguel Barrigon Morillas Guillermo Rey Gozalo David Montes-Gonzalez Rosendo Vilchez-Gomez Valentin Gomez Escobar	2021	
12	Road traffic air and noise pollution exposure assessment – A review of tools and techniques	Jibran Khan Matthias Ketzel Konstantinos Kakosimos Mette Sorensen Steen Solvang Jensen	2018	
13	Spatial distribution of health-risky road traffic noise pollution in Dessie City, North East Ethiopia	Getahun Gebre Bogale Tadesse Sisay Asnakew Molla Mekonen Muluken Tessema Aemiro	2022	
14	Evaluation of noise pollution in urban traffic hubs—Noise maps and measurements	Paulo Eduardo Kirrian Fiedler Paulo Henrique Trombetta Zannin	2015	
15	Assessment of Noise Pollution and Architectural Solutions for The Colleges and Universities	Riyadh Muteib Mahmoud Abbas Hadi Abbas Rashed Hamed Yaseen	2019	These studies stressed the significance of measuring and keeping an eye on noise levels in particular urban areas at different times of the day (and night). In order to comprehend the extent and intensity of noise pollution, these research used sound level meters to collect continuous readings at various places. The main cause of noise pollution has been traffic, which has led to noise levels that are higher than
16	Hierarchal assessment of noise pollution in urban areas – A case study	Majid Abbaspour Elham Karimi Parvin Nassiri Mohammad Reza Monazzam	2015	

		Lobat Taghavi		allowed. The studies suggested possible ways to lessen noise exposure in urban environments and emphasized the importance of routine noise monitoring.
17	Monitoring Rail Traffic Using Wsn	Ayyub Zinvand Iorestani	2012	
		Seyes Ali Mousavi		
		Raja Ebadaty		
18	Residential Traffic Noise Exposure Assessment – Application and validation of Environmental Noise Directive maps	Charlotta Eriksson	2012	
		Mats E Nilsson		
		Dag Stenkvist		
		Tom Bellander		
		Goran Pershagen		
19	Noise pollution and its effects on medical care workers and patients in hospitals	DF Juang	2010	Researches on the negative impacts of noise pollution on human health have shown that it is particularly harmful in vulnerable settings like homes, schools, and hospitals. These researches found that exposure to high noise levels can have a variety of detrimental effects on health, including headaches, anxiety, sleep difficulties, hearing impairment, and nerve damage. The results highlight the critical need for improved urban planning, noise reduction measures, and awareness campaigns to protect the health of those impacted by noise pollution in urban environments.
		CH Lee		
		T Yang		
		MC Chang		
20	Traffic-Related Air Pollution, Noise at School, and Behavioral Problems in Barcelona Schoolchildren: A Cross-Sectional Study	Joan Forns	2016	
		Payam Dadvand		
		Maria Foraster		
		Mar Alvarez-pedrerol		
		Ioar Rivas		
		Monica Lopez-vincente		
		Elisabet Suades-Gonzalez		
21	The United Nations conference on environment and development (UNCED)	SP Johnson	2001	Manuals, Laws and Regulations on noise pollution management
22	Transit Noise and vibration impact assessment manual	Antoinette Quagliata	2018	
		Meghan Ahearn		
		Eric Boeker		

(Source: Author, 2024)

2.8. RESEARCH GAP

Since there is a lack of awareness regarding the adverse impact of noise pollution there are very few researches conducted. Zerihun S., Mamo H., Sitotaw B. & Mengistu E. (2017) have researched on the people's perception on major noise source and its impacts on health at Dire Dawa City. Goshu B., Mamo H., & Zerihun S. (2017) have researched the general urban noise in Dire Dawa City. Doda D. (2017) studied noise pollution in Addis Ababa (Bole Michael Community Area). Bogale G.G., Sisay T., Mekonen A.M., & Aemiro M.T. (2022) have researched the spatial distribution of health-risky road traffic noise pollution in Dessie City.

There are also a few more researches conducted in some other parts of the country. However, even though Adama is a busy transportation corridor, researches regarding noise pollution are yet to be conducted in the area. Furthermore, in Ethiopia, there are no researches conducted in a context of urban planning and design. In most of the researches there are limited noise parameters used to analyse the noise pollution of a certain area. Often used noise parameters are: Lmax, Lmin, and Leq.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. DESCRIPTION OF THE STUDY AREAS

Adama (Oromo: Adaamaa or Hadaamaa), is a city in the central Oromia Region of Ethiopia. Located in the East Shewa Zone 99 km (62 mi) southeast of the capital, Addis Ababa, the city sits between the base of an escarpment to the west, and the Great Rift Valley to the east. The latitude of Adama, Oromia, Ethiopia is 8.514477, and the longitude is 39.269257. Adama, Oromia, Ethiopia is located at Ethiopia country in the Cities place category with the GPS coordinates of 8° 30' 52.1172" N and 39° 16' 9.3252" E (Wikipedia, 2023).

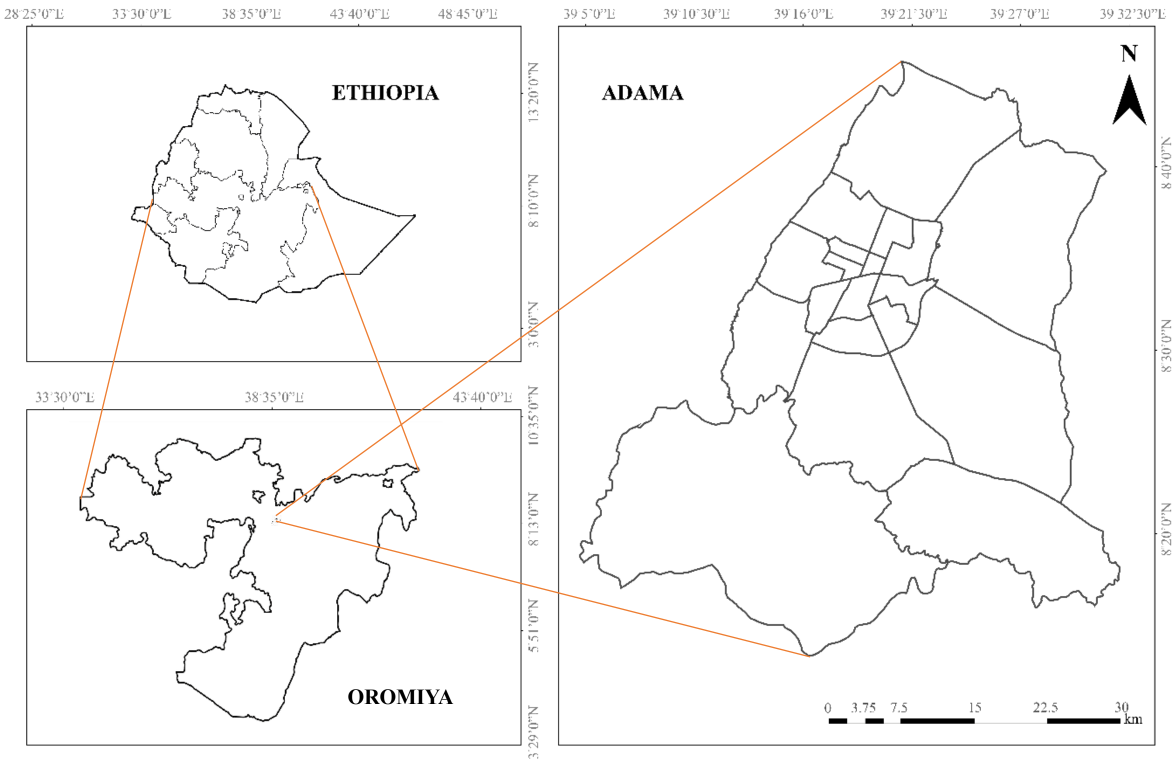

***Figure 3.1**: Location map*

Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), this city has a total population of 220,212, an increase of 72.25% over the population recorded in the 1994 census, of whom 108,872 are men and 111,340 women. With an area of 29.86 square kilometers, Adama has a population density of 7,374.82; all are urban inhabitants. A total of 60,174 households were counted in this city, which results in an average of 3.66 persons to a household, and 59,431 housing units (Wikipedia, 2023).

3.2. SAMPLING AND SAMPLING TECHNIQUES

In this research, three healthcare facilities and five schools were included. These areas are Adama General Hospital, Adama Referral Hospital, Adama Secondary School, Goro Highschool, ODA Special Boarding School, Rift Valley University, St. Mary School and Sister Aklesia Memorial Hospital. Study areas were selected on the basis of location and their distance from noisy areas. For this noise pollution identification and assessment study, the selected areas were selected purposively (based on intent), because in these study areas noise pollutions are expected to be high.

3.2.1. Description of Selected Areas

Three healthcare facilities and five educational facilities were studied in this research. The location of these study areas is put in the table and figure below.

Figure 3.2: *Location of the study areas*

Table 3.1: *Location description of the study areas*

Study areas		GPS location	
		Latitude	**Longitude**
A	Adama General Hospital	8° 33' 38.32" N	39° 16' 57.89" E
B	Adama Highschool	8° 31' 20.47" N	39° 15' 01.48" E
C	Adama Referral Hospital	8° 32' 55.71" N	39° 16' 33.16" E
D	Goro Highschool	8° 33' 24.14" N	39° 15' 41.49" E
E	ODA Special Boarding School	8° 31' 20.47" N	39° 15' 01.48" E
F	Rift Valley University	8° 32' 17.01" N	39° 15' 52.91" E
G	St. May School	8° 32' 35.64" N	39° 16' 30.22" E
H	Sister Aklesia Memorial Hospital	8° 32' 35.92" N	39° 16' 08.65" E

3.2.2. Respondents Sample size

The population size consisted of everyone who was in the compound of the study area. For the schools the population size includes students, teachers and other workers in the school where as the population size in the healthcare facilities includes number of patients that can use the facility per day and the workers of thee facility.

To determine the sample size Cochran's formula was used. This formula helps us find the sample size of a finite population.

$$n = \frac{n_0}{1+\frac{n_0}{N}} \quad \text{...}(1)$$

Where, $n_0 = \frac{z^2 p(1-p)}{e^2}$ ....(2)

Where, N is the population size, z is the standard normal variate based on the confidence coefficient, p is the estimate for P, and e is a specified margin of error.

Table 3.2: *Sample Size*

Nọ	Study areas	Population Nọ	Sample size from each study area	Sample size (in %)
1	Adama General Hospital	350	12	3.18
2	Adama Referral Hospital	700	24	6.36
3	Sister Aklesia Memorial Hospital	100	3	0.91
4	Adama Highschool	2872	97	26.11
5	Goro Highschool	3378	114	30.71
6	ODA Special Boarding School	548	19	4.98
7	Rift Valley University	2583	87	23.48
8	St. Mary School	470	16	4.27
Total		**11001**	**372**	**100**

(Source: Author, 2024)

3.3. METHODOLOGY FLOW CHART

The figure below (figure 3.3) shows the procedures followed in carrying out this research. The research problems were identified by observing the real-world issues and reviewing different kinds of literatures. To solve the problems, research objectives and questions were defined. The scope of the study was also defined. Then, the necessary data were collected during the fieldwork and prepared to make it suitable for the analysis. Finally, analysis at different levels were carried out, and based on the analysis result conclusion and recommendations were drawn.

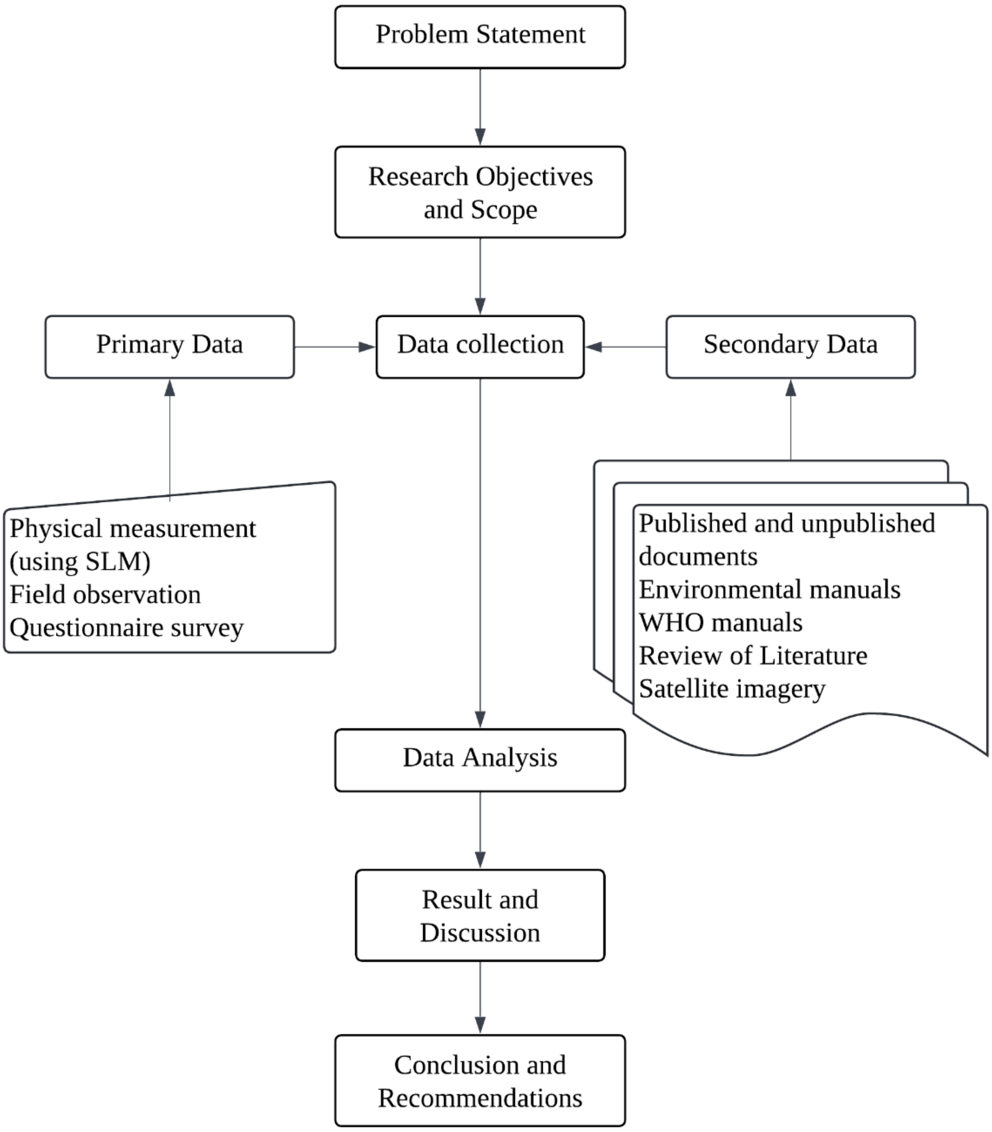

Figure 3.3: *Methodology flow chart*

(Source: Author, 2024)

3.4. RESEARCH DESIGN

Explanatory research design was employed to conduct this research. This study's experimental methodology used both qualitative and quantitative data from physical measurements made in a few of Adama Town's selected areas. Primary sources were used to gather the necessary data for this study, which was then used as an input for methods of statistical and inferential analysis. It was thought that using an experimental design gives the researcher more confidence and result in accurate and reliable results.

3.5. IDENTIFYING THE NOISE SOURCES AROUND THE DESIGNATED SILENT ZONES IN ADAMA TOWN

3.5.1. Method of Data Collection and Analysis

The process of identifying the sources of noise pollution in the designated areas was systematically conducted, employing a set of stringent criteria. These criteria include: noise level, distance from the study area, impact, temporal variability and availability for measurement.

3.5.1.1. Noise level

The noise level of the potential sources of noise pollution was measured using Sound Level Meter (SLM). This instrument measures the sound pressure level in dB (A) i.e., decibels in A weighted scale. A microphone, an electrical circuit with an attenuator, amplifier, weighing networks or filters, and a display unit make up the essential components of a sound level meter. The sound level meter can measure the sound frequency from 300 Hz to 8 kHz and from 30 dB to 130 dB in A weighted scale at four ranges. i.e., 30 to 80 dB(A) for low; 50 to 100 dB(A) for medium; 80 to 130 dB(A) for slightly high and 30 to 130 dB(A) automatic measurement range. The signal is passed through a weighing network which provides a conversion and gives the sound pressure level in dB (A). When measuring long term noise exposure, the noise level is not always steady and may vary considerably, in an irregular way to over the measurement period. This uncertainty can be solved by measuring the continuous equivalent level, which is defined as, the constant sound pressure level which would have produced the same total energy as the actual level over the given time Leq dB (A).

Figure 3.4*: Sound Level Meter*

Data collection time for potential noise sources around educational facilities was during school from 9AM to 4PM on different days of the week at different hours of the day by following the standard guidelines of ISO1996/1:2003: Morning (9AM - 12AM) and afternoon (1PM - 4PM). For healthcare facilities data collection time was in the morning (8AM – 11AM), afternoon (1PM – 4PM) and evening (7PM – 10PM). But, exact time for data collection in some cases depended on the activities held on there.

The data collected was analyzed using different noise parameters. First, statistical percentile levels L_{10}, L_{50}, and L_{90} for every hour were computed using Microsoft Excel. When these parameters are used for the evaluation of different noise pollution indices, such as Noise Climate (NC), Equivalent Noise Level (Leq), Traffic Noise Index (TNI), and Noise Pollution Level, they help to estimate a statistical measure indicating how frequently a particular sound level is exceeded in a unit dB (A), every hour.

3.5.1.2. Distance from The Study Areas

The distance of the potential sources of noise pollution around the study areas was mapped using EZ map website. The noise decreases as the distance increases and this sound level to distance relationship was analyzed using sound attenuation formula. Sound attenuation describes how the SPL changes with increasing distance from the sound source. For example, you can imagine two houses standing close to a highway. If we measured the distance from each of the buildings to the road and the SPL of one of them, we would be able to calculate the sound level in the other house.

$$SPL_2 = SPL_1 - 20 \log \left(\frac{R_2}{R_1}\right) \quad \text{……………………………………………………………………….(3)}$$

3.5.1.3. Impact

To identify the impact of the noise sources in the study area a questionnaire was used. 372 questionnaires were printed and deployed by using 2 data collectors. In this process, students, patients, workers in the school and workers in the health care centers were respondents for the questionnaires because they are direct and have day-to-day relations with the study areas and are highly exposed and facing problems because of the noise generated from these noise sources. Simple random sampling technique was adopted for the questionnaire survey to take samples from respondents in the study areas. The questionnaire was prepared in the English language and then translated into the local language (Afan Oromo and Amharic).

3.5.1.4. Temporal Variability

Temporal variability is a factor that is used to identify whether the potential noise source has a constant noise over the measurement time or varies over time. For this analysis field observation and questionnaires were the sources of data.

3.5.2. Criteria Eligibility Analysis

Table 3.3: *Criteria Eligibility analysis scores*

Criteria	Score				
	1.00	**0.75**	**0.50**	**0.25**	**0.00**
Noise level	Over 85 dB	60 – 85 dB	40 – 60 dB	35 – 40 dB	< 35 dB
Distance	0m – 2m	2m - 6m	6m - 56m	56m - 100m	Over 100m
Impact	Extreme	High	Moderate	Low	No impact
Temporal variability	80% - 100%	60% - 80%	40% - 60%	20% - 40%	0% - 20%
Accessibility for measurement	80% - 100%	60% - 80%	40% - 60%	20% - 40%	0% - 20%

(Source: Author, 2024)

For the noise level, the score was 1 when the noise level exceeded 85 dB(A) which according to WHO's guideline is labeled as an extreme noise and the score was 0 if the noise level less than 35 dB(A) which is an ideal noise level for sleeping, classrooms and hospitals. 0.5 score was given for a noise level between 40 dB(A) and 60 dB(A) which is a range of a moderate noise level. For the distance, 0m – 2m is a distance by which there is no significant change of noise level thus the score was 1. 0.5 score was given for the distances between 6m to 56m.

This was based on the assumption that if the noise level of a certain source is 75 dB(A) at its source, the noise level decreases to 60 dB(A) within the distance of 6m and it decreases to 40 dB(A) within the distance of 56m and this gives us the moderate noise level. The same noise level decreases to 35 dB(A) in a 100m distance which makes its score 0.

Score for the impact was given based on the answer by the respondents. The impacts were categorized under extreme, high, moderate, low and no impact. The score also decreases respectively.

The score was given 1 for the potential noise sources which generate noise 80% - 100% of the measurement time. For those which generated noise less than 20% of the measured time the score was given 0.

Similarly, for the noise sources that were available 80% - 100% of the measurement time the score was given 1 and for those that were available only less than 20% of the measurement time the score was given 0.

The criteria selected to identify the potential noise sources have their own weight based on their significance. The numerical value for the criteria weight was computed using the method of Analytic Hierarchy Process (AHP).

The analytic hierarchy process (AHP) is one of the most popular and widely employed multicriteria methods. In this technique, the processes of rating alternatives and aggregating to find the most relevant alternatives are integrated. The technique is employed for ranking a set of alternatives or for the selection of the best in a set of alternatives. The ranking/selection is done with respect to an overall goal, which is broken down into a set of criteria.

Analytic Hierarchy Process (AHP), developed by Saaty (1980), uses pairwise comparison questions to elicit a matrix of judgments of the relative preference between each pair of alternatives with respect to each attribute, and a matrix of judgments of the relative importance of each pair of attributes. The prioritization of the criteria was based on the researcher’s reasoning. The noise level is the most direct and measurable aspect of noise pollution. It provides a quantitative assessment of the intensity of noise, which is crucial in understanding the severity of the pollution and its potential effects on the environment and human health. High noise levels can indicate sources that are particularly problematic and require immediate attention for mitigation.

Distance or spatial distribution refers to the arrangement of noise sources in relation to the study area. Understanding spatial distribution helps in identifying the sources of noise and determining how they contribute to overall noise pollution levels. For example, sources located closer to sensitive receptors may have a higher impact and require targeted mitigation measures. The impact of noise pollution includes both the perception of the respondents and the health effects of the noise sources. Health impacts may include hearing loss, sleep disturbances, and stress. Identifying the impact of noise pollution is essential for prioritizing mitigation efforts and implementing measures to protect the environment and public health.

Temporal variability has less weight compared to the above criteria because it's not a direct aspect of noise pollution. Accessibility for measurement is the least weighted criteria as it is not a major factor and all of the places were available for measurement.

Table 3.4: *Pair-wise comparison of the criteria*

PAIR-WISE COMPARISON					
Criteria	Noise level	Distance	Impact	Temporal variability	Accessibility for measurement
Noise level	1	3	3	5	7
Distance	1/3	1	1	3	5
Impact	1/3	1	1	3	5
Temporal variability	1/5	1/3	1/3	1	3
Accessibility for measurement	1/7	1/5	1/5	1/3	1
SUM	**2.01**	**5.53**	**5.53**	**12.33**	**21**

(Source: Author, 2024)

In this matrix, a value of 1 indicates equal importance, 3 indicates moderate importance, 5 indicates strong importance, and 7 indicates extreme importance. The reciprocal values were used to maintain consistency (e.g., noise level was thrice as important as distance, then distance was one-third as important as noise level).

Table 3.5: *Normalized pair-wise comparison of the criteria*

NORMALIZED PAIR-WISE COMPARISON						
Criteria	Noise level	Distance	Impact	Temporal variability	Accessibility for measurement	**Criteria weight**
Noise level	0.50	0.54	0.54	0.41	0.33	**0.46**
Distance	0.17	0.18	0.18	0.24	0.24	**0.20**
Impact	0.17	0.18	0.18	0.24	0.24	**0.20**
Temporal variability	0.10	0.06	0.06	0.08	0.14	**0.09**
Accessibility for measurement	0.07	0.04	0.04	0.03	0.05	**0.04**

(Source: Author, 2024)

The final criteria weight obtained from the normalized pair-wise comparison was then multiplied with the score given for each potential noise sources to have their exact score out of 1. Potential noise sources which scored more than 0.59 were the considered as noise sources.

3.5.3. Perception Data Analysis

After the data collection, the variables were coded on SPSS and Microsoft Excel and a reliability test was made to check the consistency of the data. To understand the relation between the variables, it used linear regression analysis.

By displaying variables side by side, the relationship was shown by doing correlation, and finally linear multiple regression was made to investigate which independent variable was affecting dependent variables more.

3.6. EVALUATING THE NOISE POLLUTION LEVEL IN SELECTED SILENT ZONES OF ADAMA TOWN

3.6.1. Method of Data Collection and Analysis

Measuring the physical data was done using Sound Level Meter (SLM). Data collection time for educational facilities was during school from 9AM to 4PM on different days of the week from at different hours of the day by following the standard guidelines of ISO1996/1:2003: Morning (9AM - 12AM) and afternoon (1PM - 4PM). For healthcare facilities data collection time was in the morning (8AM – 11AM), afternoon (1PM – 4PM) and evening (7PM – 10PM). But, exact time for data collection in some cases depended on the activities held on there.

The sampling process was based on 15-min measurements at each chosen site, and the noise level was recorded every minute. Furthermore, this is the standard sample and measuring technique used by other workers (Hunashal et al, 2012; Fiedler et al, 2015; Goshu et al, 2017; Baloye et al, 2015).

Establishing useful statistical noise measures that capture the variability and describe the size of the noise issue was essential for this investigation. First, statistical percentile levels L_{10}, L_{50}, and L_{90} for every hour was computed using Microsoft Excel. When these parameters are used for the evaluation of different noise pollution indices, such as Noise Climate (NC), Equivalent Noise Level (Leq), Traffic Noise Index (TNI), and Noise Pollution Level, they help to estimate a statistical measure indicating how frequently a particular sound level is exceeded in a unit dB(A) (A), every hour.

Where, NC measures the range over which the sound levels are fluctuating in an interval of time, L_{10} is noise level exceeding for 10 percent of total time of measurement which provides a good measure of peak sound level caused by intruding or intermittent noise, L_{50} is the level of sound exceeding for 50 percent of total time of measurement; it represents the median sound level, L_{90} is the level of sound exceeding for 90 percent of total time of measurement that provides a good measure of the ambient baseline noise of measurement site known as Background or Residual noise level, L_{eq} is the equivalent continuous noise level in dB(A).

The parameter, noise pollution level (L_{NP}), is used to express varying level of noise as suggested by Rao (1991). L_{NP} is expressed in the units of dB(A).

Analyzing the data is considered to get significant differences in noise level measurements taken at various times. Also, it is utilized to analyze the data and determine which urban areas are more prone to nuisance. Also, using MS-Excel, the data at various times from each zone and certain area locations under each zone was evaluated. The analysis was then performed to compare and evaluate if there was a statistically significant variation in the levels of noise pollution across particular sites.

3.6.2. Noise Descriptors and Measurements

Most noise standards take into account a number of additional exposure factors, such as the time of day, tone/impulse components, type of area in which the noise occurs, etc. They are typically specific for sources (such as vehicles, aircraft, machinery, factories, loudspeakers, etc.) and environments (such as homes, workplaces, etc.). As a result, there is a wide range of descriptions for acoustical noise (Tempest, 1985).

Many descriptors, including L_{10}-L_{90}, have been put out in an effort to quantify the discomfort brought on by fluctuating noise (Crocker, 1997). There are sporadic references to the noise pollution level L_{NP} (Robinson, 1969) and the traffic noise index TNI (Griffiths, Langdon, 1968). All of these indicators provide information on the magnitude of variations from the background noise norm.

3.6.2.1. Noise Descriptors

a. A-Weighting

The A-scale approximates the frequency response of the average young ear when listening to most ordinary everyday sounds.

When people make relative judgments of the loudness or annoyance of a sound, their judgments correlate well with the A-scale sound levels of those sounds. Weighting networks adjust the response of the instrument to fall within the limits specified. Weighting networks modify the frequency response of the instrument so that its indications simulate the ears sensitivity.

b. dB(A)

Some low-pitched and high-pitched sounds are not perceived by the human ear equally. It is mathematically possible to transform the way sounds are measured to reflect how the average human hears them. A-weighted decibels (dB) are the adjusted measurements (A).

Normal conversation sounds between 55 and 65 dB(A) at a distance of 6 feet (A). dB(A) is a measure of sound pressure in decibels indicated by measuring equipment using A-scale frequency weighting (Chhatwal, 1989). dB(A) and dB(C) are the units of sound intensity exactly like the decibel except that before the measurement is made sounds of high and low frequencies that are heard poorly or not at all by the human ear have been filtered out. The letter A and C refer to two filtering methods. The A weighting network filters out very low frequencies very severely B moderately and C hardly filters out any.

c. Leq

It is the equivalent continuous noise level measured over a certain time period in dB(A). It is continuously measured at a particular point (Chhatwal, 1989). It is the average rate of energy absorption by the human ear for the time frame in question.

The equivalent acoustic level (Leq) is the sound level of a stable noise that, over a certain time period, has the same amount of energy as a variable noise. It represents the mean acoustic energy experienced over the observation time.

$$L_{eq} = L_{50} + \left[\frac{(L_{10} - L_{90})^2}{60}\right] \quad (4)$$

d. Ln

The parameter Ln shows how often a certain sound level is surpassed when measurements are conducted over time (Deshpande, 2005). The noise level was surpassed by 75 dB(A) for 30% of the measured time if $L_{30} = 75$ dB(A). L_{10} is the level that is 10% of the time exceeded. L_{50} denotes a level that is exceeded 50% of the time, whereas L_{90} denotes a level that is exceeded 90% of the time.

e. Noise Pollution Level (L_{NP})

$$L_{NP} = L_{eq} + K\boldsymbol{\sigma} \quad (5)$$

Where, **K** = 2.56 is a constant and **σ** is the standard deviation of the sound level during the same period.

The following alternative equation can also be used for equation (5).

$$L_{NP} = L_{eq} + a(L_{10} - L_{90}) \quad (6)$$

The constant ***a*** in equation (6) is considered to be equal to one.

The above equation can also be written as:

$$L_{NP} = L_{50} + \left[\frac{(L_{10} - L_{90})^2}{60}\right] + (L_{10} - L_{90}) \quad (7)$$

Where, L_{10}, L_{50}, and L_{90}, respectively, denote the levels that the record of a noise level in a particular interval exceeds 10%, 50%, and 90% of the time. L_{NP} is also measured in dB(A) units (A). It accounts for changes in the sound signal and thus provides a more accurate indication of environmental noise pollution for the disruption of the human system's physiological and psychological functions (Parbat, 2007).

f. Noise climate (NC)

Noise climate (NC) is the range over which the sound levels are fluctuating in an interval of time and is given by the relation:

$$NC = (L_{10} - L_{90}) \qquad (8)$$

3.7. COMPARING THE MEASURED NOISE LEVEL VALUES WITH WHO'S STANDARD PERMISSIBLE NOISE LIMIT

Data sources used to compare the measured noise values with WHO's standard permissible noise limit were various secondary data such as WHO guidelines, literature reviews and other printed or unprinted documents as well as the quantitative data measured from direct physical measurement.

All collected data was compared and analyzed with generally accepted international guidelines and standards which are the WHO's guideline for noise pollution.

The comparison was based on:

- Noise parameters such as equivalent continuous sound pressure (Leq), noise pollution level (L_{NP}) and noise climate (NC),
- Noise sources such as traffic noise, noise from industries, noise from construction sites and noise from leisure activities.

3.8. ETHICAL CONSIDERATION

Before beginning data collection, different participants were provided a consent letter to conduct the research. The study's purpose was thoroughly stated to the participants, together with how the data obtained from them was employed in this study. The knowledge gathered from the participants was only used for this specific research, and therefore the study kept the confidentiality of all individuals who participated in the study.

3.9. SUMMARY OF METHODS

Table 3.6: *Summary of methods*

Specific objectives	Data used	Source of data	Collection method	Instrument used	Analysis software
To identify the noise sources around the designated silent zones in Adama town.	Physical measurement of the noise levels Responses of the users of the study areas based on the prepared questionnaire Secondary data	Potential noise sources Sampled residents EZ map website	Observation Physical measurement Questionnaire survey Googling	SLM A4 papers Notebook Computer	SPSS Microsoft Word 2021 Microsoft Excel 2021
To evaluate the noise pollution level in silent zones in Adama town.	Physical measurement of the noise levels	Study areas	Physical measurement	SLM A4 papers	
To compare the measured noise level values of the study areas with WHO's standard permissible noise limit	Physical measurement of the noise levels WHO's standard guideline 2022	Study areas World Health Organization website	Physical measurement Googling	SLM Computer	

(Source: Author, 2024)

CHAPTER FOUR

4. RESULT AND DISCUSSION

This chapter is organized as per the specific objectives of the research and it shows the results of the physical measurements conducted in the study areas.

4.3. IDENTIFICATION OF NOISE SOURCES

Several criteria were considered to identify the noise sources in and/or around each study area. These criteria are: noise level, spatial distribution (distance from the study area), impact, temporal variability and accessibility for measurement.

4.3.1. Noise Level

A sound level meter placed between 1.2 and 1.5 meters above the ground was used to measure the noise level produced by each source, guaranteeing an accurate depiction of the noise perceived at human ear level. In order to account for variations in noise levels caused by variables like traffic patterns, multiple readings were taken over time. The noise parameter used to determine the noise level was the equivalent noise level (Leq) and the measurement was taken hourly.

4.3.2. Spatial Distribution (Distance)

Spatial distribution, which refers to the location and distance of noise sources from the study area, was determined through field surveys and the use of EZ map website. Field surveys involved physically mapping out the locations of noise sources relative to the study area, while EZ map was used to analyze spatial data and create visual representations of noise sources and their proximity to the study area.

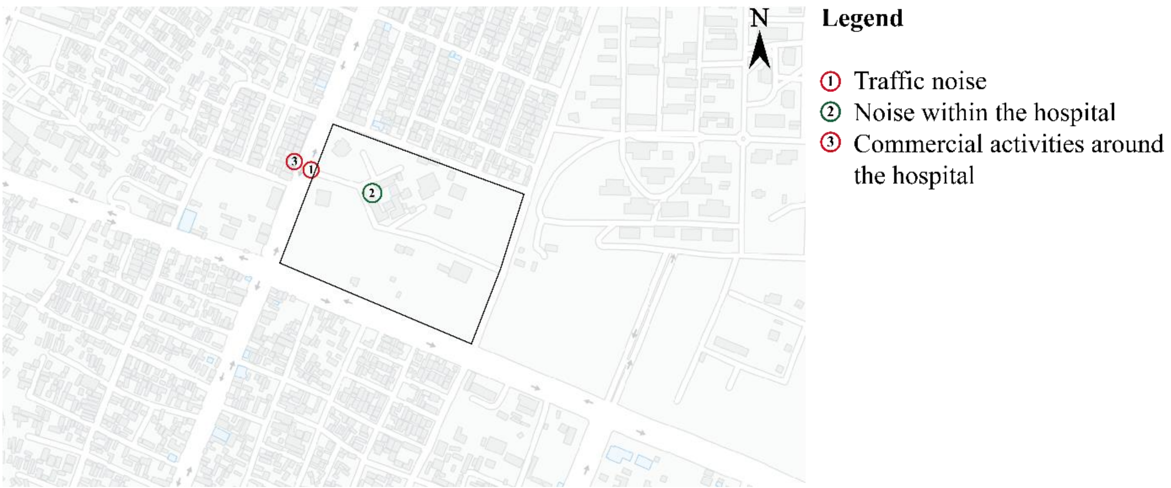

Figure 4.1: *Noise sources spatial distribution around Adama General Hospital*

(Source: EZ map, 2024)

Table 4.1: *Noise sources and their distance from Adama General Hospital*

Noise source	Distance (m)
Traffic noise	79.55
NWH	2
CANH	113.05

The nearest traffic noise from Adama General Hospital 79.55m and the nearest commercial activity that generates noise was 113.05m away from the hospital.

Figure 4.2: *Noise sources spatial distribution around Adama Referral Hospital*

(Source: EZ map, 2024)

Table 4.2: *Noise sources and their distance from Adama Referral Hospital*

Noise source	Distance (m)
Traffic noise	39.3
NWH	2
CANH	51.04
Eyesus Church	144.96

The nearest traffic noise from Adama Referral Hospital 39.3m and the nearest commercial activity that generates noise was 51.04m away from the hospital. Eyesus Church which was found to the south-western direction of the hospital was 144.96m away from the hospital.

Figure 4.3: *Noise sources spatial distribution around Sister Aklesia Memorial Hospital*

(Source: EZ map, 2024)

Table 4.3: *Noise sources and their distance from Sister Aklesia Memorial Hospital*

Noise source	Distance (m)
Traffic noise	19.29
NWH	2
CANH	48.98

The nearest traffic noise from Sister Aklesia Memorial Hospital 19.29m and the nearest commercial activity that generates noise was 48.98m away from the hospital.

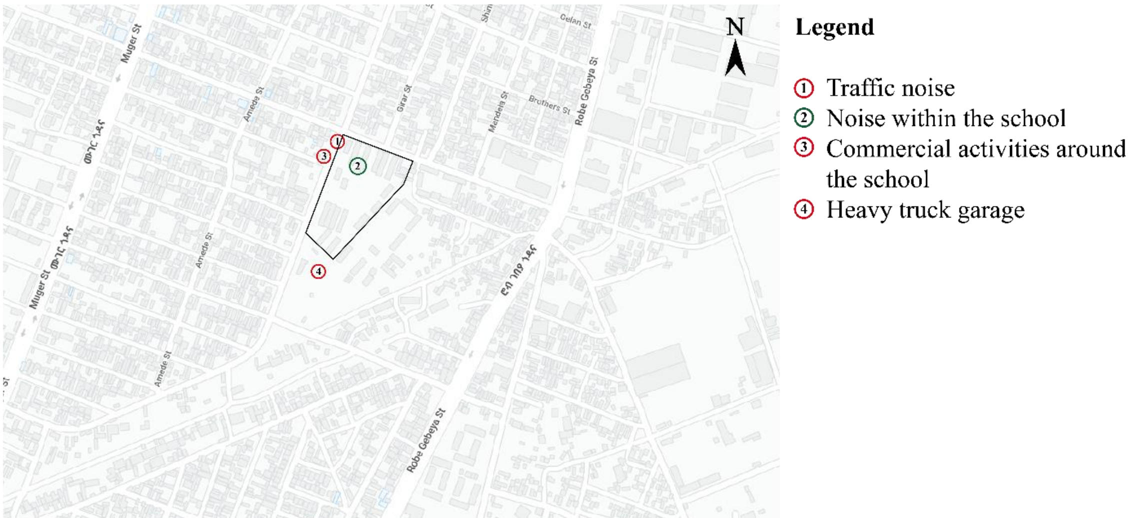

Figure 4.4: *Noise sources spatial distribution around Adama Highschool*

(Source: EZ map, 2024)

Table 4.4: Noise sources and their distance from Adama Highschool

Noise source	Distance (m)
Traffic noise	40.88
NWH	2
CANH	51.8
Heavy truck garage	70.75

The nearest traffic noise from Adama Highschool 40.88m and the nearest commercial activity that generates noise was 51.8m away from the classrooms. Heavy truck garage which is found to the southern direction of the school was 70.75m away from the classrooms.

Figure 4.5: *Noise sources spatial distribution around Goro Highschool*

(Source: EZ map, 2024)

Table 4.5: *Noise sources and their distance from Goro Highschool*

Noise source	Distance (m)
Traffic noise	52.87
NWH	2
CANH	74.19
Holy Trinity Church	184.1
Ayub al Ansar Mosque	92.44
Selase Gospel Light Church	118.71

The nearest traffic noise from Goro Highschool 52.87m and the nearest commercial activity that generates noise was 74.19m away from the classrooms. Holy Trinity Church which is found to the north-western direction of the school was 184.1m away from the classrooms, Ayub al Ansar Mosque which is found to the southern direction of the school was 92.44m away from the classrooms and Selase Gospel Light Church which is found to the northern direction of the school was 118.71m away from the classrooms.

Figure 4.6: *Noise sources spatial distribution around ODA Special Boarding School*

(Source: EZ map, 2024)

Table 4.6: *Noise sources and their distance from ODA Special Boarding School*

Noise source	Distance (m)
Traffic noise	44.15
NWH	2
CANH	172.21
Adama 09 Full Gospel Church	109.49

The nearest traffic noise from ODA Special Boarding School was 44.15m and the nearest commercial activity that generates noise was 172.21m away from the classrooms. Adama 09 Full Gospel Church which is found to the northern direction of the school was 109.49m away from the classrooms.

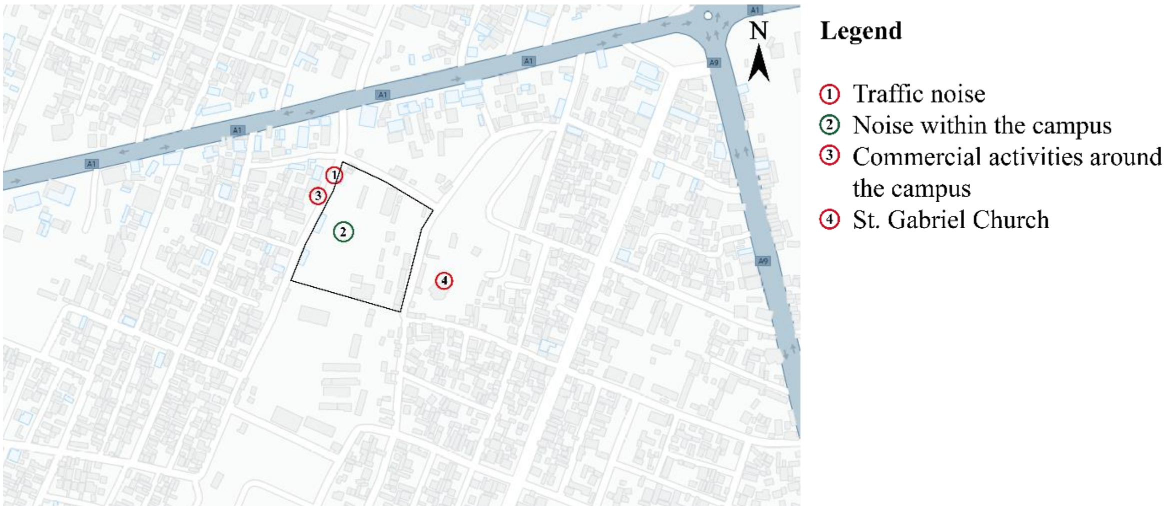

Figure 4.7: *Noise sources spatial distribution around Rift Valley University*

(Source: EZ map, 2024)

__Table 4.7:__ Noise sources and their distance from Rift Valley University

Noise source	Distance (m)
Traffic noise	45.18
NWH	2
CANH	61.78
St. Gabriel Church	85.14

The nearest traffic noise from Rift Valley University was 45.18m and the nearest commercial activity that generates noise was 61.78m away from the classrooms. St. Gabriel Church which is found to the western direction of the campus was 85.14m away from the classrooms.

***Figure 4.8:** Noise sources spatial distribution around St. Mary School*

(Source: EZ map)

__Table 4.8:__ Noise sources and their distance from St. Mary School

Noise source	Distance (m)
Traffic noise	32.18
NWH	2
CANH	58.78
St. Mary Church	69.48

The nearest traffic noise from St. Mary School was 32.18m and the nearest commercial activity that generates noise was 58.78m away from the classrooms. St. Mary Church which is found to the northern direction of the school was 69.48m away from the classrooms.

4.3.3. Impact

The survey questionnaire structured by different attributes was used to gather information related to the impact of the potential noise sources on the users of the study areas. The respondents have identified and ranked the possible noise sources around the study areas. From the survey it’s understood that the noise sources around the different study areas were common. These noise sources are:

1. Noise from traffic flow: the study areas are located near roads hence they are exposed to the noise pollution generated by the traffic flow.
2. Noise within the area: noise is generated from within the compound of the study area. As for the healthcare centres, the noise is mostly generated from the lobbies, corridors, waiting areas and reception areas. And as for the schools, the noise comes from the corridors (hallways) and playgrounds in the compound.
3. Commercial activities in and around the area: the study areas are exposed to the noise that comes from different commercial activities in and around the study areas. These activities are: shops, cafes, restaurants, game zones and etc.
4. Other noise sources: This includes mostly religious institutions and a heavy truck garage in the case of Adama Highschool.

4.2.3.1. Noise Disturbance Frequency by Respondents

Table 4.9: *Noise disturbance frequency in the schools*

	Frequency	Percent	Valid percent	Cumulative percent
Always	7	2	2	2
Sometimes	50	15	15	17
Rarely	223	67	67	84
Never	54	16	16	100
Total	333	100	100	

Table 4.9 illustrated that out of the 333 respondents from the schools, 7 (2%) of them were always disturbed, 50 (15%) of them were sometimes disturbed, 223 (67%) of them were rarely disturbed and 54 (16%) of them were never disturbed.

Table 4.10: *Noise disturbance frequency in the hospitals*

	Frequency	Percent	Valid percent	Cumulative percent
Always	2	6	6	6
Sometimes	12	31	31	37
Rarely	17	43	43	80
Never	8	20	20	100
Total	39	100	100	

Table 4.10 illustrated that out of the 39 respondents from the hospitals, 2 (6%) of them were always disturbed, 12 (31%) of them were sometimes disturbed, 17 (43%) of them were rarely disturbed and 8 (20%) of them were never disturbed.

4.2.3.2. Noise Pollution Rate by Respondents

Table 4.11: *Noise pollution rate of the schools*

	Frequency	Percent	Valid percent	Cumulative percent
Extremely high	7	2	2	2
High	67	20	20	22
Moderate	210	63	63	85
Low	50	15	15	100
Total	333	100	100	

Table 4.11 illustrated that out of the 333 respondents from the schools, 7 (2%) of them classified the noise disturbance as an extremely high, 67 (20%) classified the noise disturbance as high, 210 (63%) of them described the noise disturbance as moderate and 50 (15%) of them classified it as low.

Table 4.12: *Noise pollution rate of the hospitals*

	Frequency	Percent	Valid percent	Cumulative percent
Extremely high	2	6	6	6
High	12	28	28	34
Moderate	16	42	42	76
Low	9	24	24	100
Total	39	100	100	

Table 4.12 illustrated that out of the 39 respondents from the hospitals, 2 (6%) of them classified the noise disturbance as an extremely high, 12 (28%) classified the noise disturbance as high, 16 (42%) of them described the noise disturbance as moderate and 9 (24%) of them classified it as low.

4.2.3.3. Temporal Analysis of Frequency of Disturbance

Table 4.13: *Temporal variation of noise disturbance in the schools*

	Frequency	Percent	Valid percent	Cumulative percent
Morning	0	0	0	0
Afternoon	74	100	100	100
Evening	0	0	0	100
Total	74	100	100	

The respondents who classified the noise disturbance level as extremely high and high have further classified the time of the day when the disturbance occurs the most. Table 4.13 illustrated that the afternoon period was when the noise disturbance occurs the most around the hospitals.

Table 4.14: Temporal variation of noise disturbance in the hospitals

	Frequency	Percent	Valid percent	Cumulative percent
Morning	4	27	27	27
Afternoon	10	73	73	100
Total	14	100	100	

Table 4.14 illustrated that out of the 14 respondents 4 (27%) of them identified the morning time as a period when noise disturbance occurs the most around the hospitals and 10 (73%) of them identified the afternoon time as a period when noise disturbance occurs the most around the hospitals.

4.2.3.4. Effect of The Noise Generated

Table 4.15: Effect of the noise generated in the schools

		Frequency	Percent	Valid percent	Cumulative percent
The noise pollution around the school affects the teaching learning process.	Yes	74	22	22	22
	No	259	78	78	100
	Total	333	100	100	

Table 4.15 illustrated that out of the respondents 74 (22%) of them said that the noise pollution has an impact on the teaching learning process of the schools. 259 (78%) of them said that the noise doesn't have an effect on the teaching learning process.

Table 4.16: Effect of the noise generated in the hospitals

		Frequency	Percent	Valid percent	Cumulative percent
The noise pollution around the hospital affects the service given there.	Yes	13	34	34	34
	No	26	66	66	100
	Total	39	100	100	

Table 4.16 illustrated that out of the respondents 13 (34%) of them said that the noise pollution has an impact on the service given by the healthcare centers. 26 (66%) of them said that the noise doesn't have an effect on the teaching learning process.

Table 4.17: Effect of the noise generated in the schools

	Frequency	Percent	Valid percent	Cumulative percent
It has an adverse impact	8	9	9	9
It is manageable	66	91	91	100
Total	94	100	100	

Table 4.17 illustrated that out of the 74 respondents who said that the noise disturbance around the schools have an impact on the teaching learning process, 8 (9%) of them said that it has an adverse impact while 66 (91%) of them said that the noise disturbance is manageable.

Table 4.18: *Effect of the noise generated in the hospitals*

	Frequency	Percent	Valid percent	Cumulative percent
It has an adverse impact	3	18	18	18
It is manageable	10	82	82	100
Total	13	100	100	

Table 4.18 illustrated that out of the 13 respondents who said that the noise disturbance around the schools have an impact on the service given by the healthcare centers, 3 (18%) of them said that it has an adverse impact while 10 (82%) of them said that the noise disturbance is manageable.

4.2.3.5. Noise Level Difference Between Different Areas

Table 4.19: *Noise level difference between different areas in the schools*

		Frequency	Percent	Valid percent	Cumulative percent
There is a noise level difference between different areas of the school	Yes	313	94	94	94
	No	20	6	6	100
	Total	333	100	100	

Table 4.19 illustrated that 313 (94%) of the respondents have said that there was a difference in noise levels between different areas in the schools. The noise level tends to increase in areas like corridors (hallways), cafes inside the compound and playgrounds. 20 (6%) said that there was no noise level difference between different areas.

Table 4.20: *Noise level difference between different areas in the hospitals*

		Frequency	Percent	Valid percent	Cumulative percent
There is a noise level difference between different areas of the hospital	Yes	36	93	93	93
	No	3	7	7	100
	Total	39	100	100	

Table 4.20 illustrated that 36 (93%) of the respondents have said that there was a difference in noise levels between different areas in the healthcare centers. The noise level tends to increase in areas like corridors, waiting rooms, cafes inside the compound and reception areas. 3 (7%) said that there was no noise level difference between different areas.

4.2.3.6. Noise Sources Rank Analysis

Table 4.21: *Average rank of noise sources around Adama General Hospital*

	N	Mean	Std. Deviation	Maximum	Minimum
Traffic noise	12	1.25	0.452	1	2
Noise within the area	12	1.75	0.452	1	2
Commercial activities in and around the area	12	3.00	0.000	3	3

The average rank of the traffic noise around Adama General Hospital was 1.25 which indicates that most of the respondents have ranked it higher the lowest rank being 2. The standard deviation for the traffic flow was 0.452 which indicates that there is an average dispersion of ranks between 1 and 2 but mostly ranked as the first source of noise. The average rank of the noise within the hospital was 1.75 which indicates that most of the respondents have ranked it higher even though not as high as traffic noise. The maximum rank of noise generated within the area was 1 and the lowest rank was 2. The standard deviation for the noise generated within the hospital was 0.452 which indicates that there is an average dispersion of rank between 1 and 2 but mostly ranked as the second source of noise. Noise generated from commercial activities around the hospital was ranked third by all of the respondents.

Table 4.22: *Average rank of noise sources around Adama Referral Hospital*

	N	Mean	Std. Deviation	Maximum	Minimum
Traffic noise	24	2.04	0.859	1	3
Noise within the area	24	2.21	0.833	1	3
Commercial activities in and around the area	24	1.75	0.737	1	3
Other noise sources	24	4.00	0.000	4	4

The average rank of the traffic noise around Adama Referral Hospital was 2.04 which indicates that most of the respondents have ranked it higher the lowest rank being 3. The standard deviation for the traffic flow was 0.859 which indicates that the rank is highly dispersed from 1 to 3. The average rank of the noise within the hospital was 2.21 which indicates that most of the respondents have ranked it a bit lower than traffic noise.

The maximum rank of noise generated within the area was 1 and the lowest rank was 3. The standard deviation for the noise generated within the hospital was 0.833 which indicates that the rank is highly dispersed from 1 to 3. Noise generated from commercial activities around the hospital was ranked highest its average rank being 1.75.

The standard deviation was 0.737 which indicates that there is a fair amount of dispersion between the ranks 1 to 3. A noise that comes from the Eyesus church was ranked fourth by all of the respondents.

Table 4.23: *Average rank of noise sources around Sister Aklesia Memorial Hospital*

	N	Mean	Std. Deviation	Maximum	Minimum
Traffic noise	3	2.00	1.000	1	3
Noise within the area	3	2.67	0.577	2	3
Commercial activities in and around the area	3	1.33	0.577	1	2

The average rank of the traffic noise around Sister Aklesia Memorial Hospital was 2. The standard deviation for the traffic flow was 1 which indicates that there is a complete dispersion of ranks between 1 to 3. The average rank of the noise within the hospital was 2.67 the maximum rank being 2. The standard deviation for the noise generated within the hospital was 0.577 which indicates that there is an average dispersion of rank between 2 and 3. Noise generated from commercial activities around the hospital was ranked the highest its mean value being 1.33. The lowest rank given to it was 2 and the standard deviation of it was 0.577.

Table 4.24: *Average rank of noise sources around Adama Highschool*

	N	Mean	Std. Deviation	Maximum	Minimum
Traffic noise	97	2.34	1.135	1	4
Noise within the area	97	2.53	1.146	1	4
Commercial activities in and around the area	97	2.59	1.087	1	4
Other noise sources	97	2.55	1.109	1	4

The average rank of the traffic noise around Adama Highschool was 2.34 which indicates that most of the respondents have ranked it higher the lowest rank being 4. The standard deviation for the traffic flow was 1.135 which indicates that there is an average dispersion of ranks from the mean value. The average rank of the noise within the school was 2.53 which indicates that most of the respondents have ranked it higher even though not as high as traffic noise.

The maximum rank of noise generated within the area was 1 and the lowest rank was 4. The standard deviation for the noise generated within the school was 1.146 which indicates that there is an average dispersion of rank from the mean value.

Noise generated from commercial activities around the school has an average ranking of 2.59 the highest rank being 1 and the lowest rank being 4. The standard deviation was 1.087 which shows that there is an average dispersion of rank from the mean value. Noise that comes from the heavy truck garage has a average rank of 2.55 and the standard deviation was 1.109.

Table 4.25: *Average rank of noise sources around Goro Highschool*

	N	Mean	Std. Deviation	Maximum	Minimum
Traffic noise	114	1.70	0.752	1	3
Noise within the area	114	2.53	0.778	1	3
Commercial activities in and around the area	114	1.77	0.652	1	3
Other noise sources	114	4.00	0.000	4	4

The average rank of the traffic noise around Goro Highschool was 1.7 which indicates that most of the respondents have ranked it higher the lowest rank being 3. The standard deviation for the traffic flow was 0.752 which indicates that there is an average dispersion of ranks from the mean value. The average rank of the noise within the school was 2.53. The maximum rank of noise generated within the area was 1 and the lowest rank was 3. The standard deviation for the noise generated within the school was 0.778 which indicates that there is an average dispersion of rank from the mean value.

Noise generated from commercial activities around the school has an average ranking of 1.77 which indicates that most of the respondents have ranked it higher even though not as high as traffic noise the highest rank being 1 and the lowest rank being 3. The standard deviation was 0.652 which shows that there is an average dispersion of rank from the mean value. Noise that comes from different religious institutions like Holy Trinity Church, Ayub al Ansar Mosque and Selase Gospel Light Church have been ranked fourth by every respondent.

Table 4.26: *Average rank of noise sources around ODA Special Boarding School*

	N	Mean	Std. Deviation	Minimum	Maximum
Traffic noise	19	1.42	0.507	1	2
Noise within the area	19	1.55	0.911	1	3
Commercial activities in and around the area	19	1.89	0.809	1	3
Other noise sources	19	4.00	0.000	4	4

The average rank of the traffic noise around ODA Special Boarding School was 1.42 which indicates that most of the respondents have ranked it higher the lowest rank being 2. The standard deviation for the traffic flow was 0.507 which indicates that there is a lower dispersion of ranks from the mean value.

The average rank of the noise within the compound was 1.55 which indicates that most of the respondents have ranked it higher even though not as high as traffic noise. The maximum rank of noise generated within the area was 1 and the lowest rank was 3. The standard deviation for the noise generated within the compound was 0.911 which indicates that there is an average dispersion of rank from the mean value.

Noise generated from commercial activities around the school has an average ranking of 1.89 the highest rank being 1 and the lowest rank being 3. The standard deviation was 0.809 which shows that there is an average dispersion of rank from the mean value. Noise that comes from Adama 09 Full Gospel Church was ranked fourth by every respondent.

Table 4.27: *Average rank of noise sources around Rift Valley University*

	N	Mean	Std. Deviation	Maximum	Minimum
Traffic noise	87	1.69	0.670	1	3
Noise within the area	87	2.31	0.826	1	3
Commercial activities in and around the area	87	2.00	0.835	1	3
Other noise sources	87	4.00	0.000	4	4

The average rank of the traffic noise around Rift Valley University was 1.69 which indicates that most of the respondents have ranked it higher the lowest rank being 3. The standard deviation for the traffic flow was 0.67 which indicates that there is an average dispersion of ranks from the mean value. The average rank of the noise within the compound was 2.31. The maximum rank of noise generated within the area was 1 and the lowest rank was 3. The standard deviation for the noise generated within the compound was 0.826 which indicates that there is an average dispersion of rank from the mean value.

Noise generated from commercial activities around the campus has an average ranking of 2 which indicates that most of the respondents have ranked it higher even though not as high as traffic noise the highest rank being 1 and the lowest rank being 3. The standard deviation was 0.835 which shows that there is an average dispersion of rank from the mean value. Noise that comes from St. Gabriel was ranked fourth by every respondent.

Table 4.28: *Average rank of noise sources around St. Mary School*

	N	Mean	Std. Deviation	Maximum	Minimum
Traffic noise	16	1.38	0.500	1	2
Noise within the area	16	1.94	0.854	1	3
Commercial activities in and around the area	16	2.69	0.479	2	3
Other noise sources	16	4.00	0.000	4	4

The average rank of the traffic noise around St. Mary School was 1.38 which indicates that most of the respondents have ranked it higher the lowest rank being 2. The standard deviation for the traffic flow was 0.5 which indicates that there is a lower dispersion of ranks from the mean value. The average rank of the noise within the school was 1.94 which indicates that most of the respondents have ranked it higher even though not as high as traffic noise. The maximum rank of noise generated within the area was 1 and the lowest rank was 3. The standard deviation for the noise generated within the school was 0.854 which indicates that there is an average dispersion of rank from the mean value.

Noise generated from commercial activities around the school has an average ranking of 2.69 the highest rank being 2 and the lowest rank being 3. The standard deviation was 0.479 which shows that there is a lower dispersion of rank from the mean value. Noise that comes from St. Mary Church was ranked fourth by every respondent.

Table 4.29: *Average rank of noise sources around the study areas*

	N	Mean	Std. Deviation	Maximum	Minimum
Traffic noise	372	1.85	0.894	1	4
Noise within the area	372	2.38	0.922	1	4
Commercial activities in and around the area	372	2.12	0.909	1	4
Other noise sources	372	3.62	0.852	1	4

Generally, most of the respondents across the study areas have put traffic noise as the primary noise source with an average ranking of 1.85 and standard deviation of 0.894, its highest ranking being first and its lowest ranking being fourth.

Noise that come from different commercial activities in and around the study areas has been put second with an average ranking of 2.12 and standard deviation of 0.909, its highest ranking being first and its lowest ranking being fourth. Noise that was generated within the study areas has been put third with an average ranking of 2.38 and standard deviation of 0.922, its highest ranking being first and its lowest ranking fourth. Other noise sources were ranked fourth by the respondents with an average ranking of 3.62 and standard deviation of 0.852. Based on the above analysis the impact parameter was classified as high, moderate, low and no impact and its value was given to every potential noise source.

4.2.4. Temporal Variability

Temporal variability analysis was made by mere observation when measuring the noise levels of the study areas. In all the study areas traffic noise, noise within the study areas and the noise disturbance that come from different commercial activities have a 100% temporal variable which means there was a noise from these areas every time the measurement was taken.

Eyesus Church around Adama Referral Hospital had a temporal variability of 0% because there was no noise coming from it every time the measurement was taken. A heavy truck garage near the Adama Highschool had a 9% temporal variability which means out of the 6 hours measurement, noise was coming from it for 32 minutes. Religious institutions around Goro Highschool have temporal variability of 0%. Adama 09 Full Gospel Church around ODA special boarding school has a temporal variability of 0%. St. Gabriel Church around Rift Valley University and St. Mary Church around St. Mary School both have a temporal variability of 0%.

4.2.5. Accessibility for Measurement

Every potential noise source was accessible 100% of the time for the researcher and there were no difficulties during the measurement.

4.2.6. Criteria Value Analysis for The Noise Sources

Table 4.30: *Criteria values for the noise sources around Adama General Hospital*

ADAMA GENERAL HOSPITAL					
	Noise level	Distance	Impact	Temporal variability	Accessibility for measurement
Traffic noise	69.34	19.29	Moderate	100%	100%
NWH	53.80	2.00	Low	100%	100%
CANH	69.81	48.98	High	100%	100%
ADAMA REFERRAL HOSPITAL					
Traffic noise	72.33	39.30	Moderate	100%	100%
NWH	68.28	2.00	Moderate	100%	100%
CANH	68.90	51.04	High	100%	100%
Eyesus Church	>85	144.96	Low	0%	100%
SISTER AKLESIA MEMORIAL HOSPITAL					
Traffic noise	69.34	19.29	Moderate	100%	100%
NWH	53.80	2.00	Low	100%	100%
CANH	69.81	48.98	High	100%	100%
ADAMA HIGHSCHOOL					
Traffic noise	66.38	40.88	Moderate	100%	100%
NWS	61.25	2.00	Moderate	100%	100%
CANS	63.08	51.80	Moderate	100%	100%
Heavy truck garage	91.66	70.75	Moderate	9%	100%
GORO HIGHSCHOOL					
Traffic noise	69.90	52.87	High	100%	100%
NWS	62.77	2.00	Moderate	100%	100%
CANS	72.22	74.19	High	100%	100%
Holy Trinity Church	>85	184.10	No impact	0%	100%
Ayub al Ansar Mosque	>85	92.44	No impact	0%	100%
Selase Gospel Light Church	>85	118.71	No impact	0%	100%
ODA SPECIAL BOARDING SCHOOL					
Traffic noise	67.28	44.15	Moderate	100%	100%
NWS	59.26	2.00	Moderate	100%	100%
CANS	62.20	172.21	Low	100%	100%
Adama 09 Full Gospel Church	>85	109.49	No impact	0%	100%
RIFT VALLEY UNIVERSITY					
Traffic noise	74.80	45.18	High	100%	100%
NWS	68.08	2.00	Moderate	100%	100%
CANS	73.42	61.78	High	100%	100%
St. Gabriel Church	>85	85.14	No impact	0%	100%
ST. MARY SCHOOL					

Traffic noise	71.46	32.98	High	100.00%	100.00%
NWS	59.48	2.00	Moderate	100.00%	100.00%
CANS	61.64	58.78	No impact	100.00%	100.00%
St. Mary Church	>85	69.48	No impact	0.00%	100.00%

4.2.7. Criteria Score for The Noise Sources

Table 4.31*: Criteria Score for the noise sources*

ADAMA GENERAL HOSPITAL					
	Noise level	Distance	Impact	Temporal variability	Accessibility for measurement
Traffic noise	0.75	0.25	0.50	1.00	1.00
NWH	0.75	0.75	0.50	1.00	1.00
CANH	0.75	0.00	0.25	1.00	1.00
ADAMA REFERRAL HOSPITAL					
Traffic noise	0.75	0.50	0.50	1.00	1.00
NWH	0.75	0.75	0.50	1.00	1.00
CANH	0.75	0.50	0.75	1.00	1.00
Eyesus Church	1.00	0.00	0.25	0.00	1.00
SISTER AKLESIA MEMORIAL HOSPITAL					
Traffic noise	0.75	0.50	0.50	1.00	1.00
NWH	0.50	0.50	0.25	1.00	1.00
CANH	0.75	0.50	0.75	1.00	1.00
ADAMA HIGHSCHOOL					
Traffic noise	0.75	0.50	0.50	1.00	1.00
NWS	0.75	0.75	0.50	1.00	1.00
CANS	0.75	0.50	0.50	1.00	1.00
Heavy truck garage	0.75	0.25	0.50	0.00	1.00
GORO HIGHSCHOOL					
Traffic noise	0.75	0.50	0.75	1.00	1.00
NWS	0.75	0.75	0.50	1.00	1.00
CANS	0.75	0.25	0.75	1.00	1.00
Holy Trinity Church	1.00	0.00	0.00	0.00	1.00
Ayub al Ansar Mosque	1.00	0.25	0.00	0.00	1.00
Selase Gospel Light Church	1.00	0.00	0.00	0.00	1.00
ODA SPECIAL BOARDING SCHOOL					
Traffic noise	0.75	0.50	0.50	1.00	1.00
NWS	0.50	0.75	0.50	1.00	1.00
CANS	0.75	0.00	0.25	1.00	1.00
Adama 09 Full Gospel Church	1.00	0.00	0.00	0.00	1.00
RIFT VALLEY UNIVERSITY					
Traffic noise	0.75	0.50	0.75	1.00	1.00

NWS	0.75	0.75	0.50	1.00	1.00
CANS	0.75	0.25	0.75	1.00	1.00
St. Gabriel Church	1.00	0.25	0.00	0.00	1.00
ST. MARY SCHOOL					
Traffic noise	0.75	0.50	0.75	1.00	1.00
NWS	0.50	0.75	0.50	1.00	1.00
CANS	0.75	0.25	0.00	1.00	1.00
St. Mary Church	1.00	0.25	0.00	0.00	1.00

(Source: Author, 2024)

The score for each criterion was given for every potential noise source based on their values. For the noise level, the score was 1 when the noise level exceeded 85 dB(A) which according to WHO's guideline is labeled as an extreme noise and the score was 0 if the noise level less than 35 dB(A) which is an ideal noise level for sleeping, classrooms and hospitals. 0.5 score was given for a noise level between 40 dB(A) and 60 dB(A) which is a range of a moderate noise level.

For the distance, 0m – 2m is a distance by which there is no significant change of noise level thus the score was 1. 0.5 score was given for the distances between 6m to 56m. This was based on the assumption that if the noise level of a certain source is 75 dB(A) at its source, the noise level decreases to 60 dB(A) within the distance of 6m and it decreases to 40 dB(A) within the distance of 56m and this gives us the moderate noise level. The same noise level decreases to 35 dB(A) in a 100m distance which makes its score 0.

Score for the impact was given based on the answer by the respondents. The impacts were categorized under extreme, high, moderate, low and no impact. The score also decreases respectively.

The score was given 1 for the potential noise sources which generate noise 80% - 100% of the measurement time. For those which generated noise less than 20% of the measured time the score was given 0. Similarly, for the noise sources that were available 80% - 100% of the measurement time the score was given 1 and for those that were available only less than 20% of the measurement time the score was given 0.

4.2.8. Cumulative Score of The Noise Sources

Table 4.32: *Cumulative score the noise sources*

ADAMA GENERAL HOSPITAL						
	Noise level	Distance	Impact	Temporal variability	Accessibility for measurement	**Score**
Traffic noise	0.345	0.05	0.10	0.09	0.04	**0.625**
NWH	0.345	0.15	0.10	0.09	0.04	**0.73**
CANH	0.345	0.00	0.05	0.09	0.04	0.53
ADAMA REFERRAL HOSPITAL						**Score**
Traffic noise	0.345	0.10	0.10	0.09	0.04	**0.68**
NWH	0.345	0.15	0.10	0.09	0.04	**0.73**
CANH	0.345	0.10	0.15	0.09	0.04	**0.73**
Eyesus Church	0.46	0.00	0.05	0.00	0.04	0.55
SISTER AKLESIA MEMORIAL HOSPITAL`						**Score**
Traffic noise	0.345	0.10	0.10	0.09	0.04	**0.68**
NWH	0.23	0.10	0.05	0.09	0.04	0.51
CANH	0.345	0.10	0.15	0.09	0.04	**0.73**
ADAMA HIGHSCHOOL						**Score**
Traffic noise	0.345	0.10	0.10	0.09	0.04	**0.68**
NWS	0.345	0.15	0.10	0.09	0.04	**0.73**
CANS	0.345	0.10	0.10	0.09	0.04	**0.68**
Heavy truck garage	0.345	0.05	0.10	0.00	0.04	0.54
GORO HIGHSCHOOL						**Score**
Traffic noise	0.345	0.10	0.15	0.09	0.04	**0.73**
NWS	0.345	0.15	0.10	0.09	0.04	**0.73**
CANS	0.345	0.05	0.15	0.09	0.04	**0.68**
Holy Trinity Church	0.46	0.00	0.00	0.00	0.04	0.50
Ayub al Ansar Mosque	0.46	0.05	0.00	0.00	0.04	0.55
Selase Gospel Light Church	0.46	0.00	0.00	0.00	0.04	0.50
ODA SPECIAL BOARDING SCHOOL						**Score**
Traffic noise	0.345	0.10	0.10	0.09	0.04	**0.68**
NWS	0.23	0.15	0.10	0.09	0.04	**0.61**
CANS	0.345	0.00	0.05	0.09	0.04	0.53
Adama 09 Full Gospel Church	0.46	0.00	0.00	0.00	0.04	0.50
RIFT VALLEY UNIVERSITY						**Score**
Traffic noise	0.345	0.10	0.15	0.09	0.04	**0.73**
NWS	0.345	0.15	0.10	0.09	0.04	**0.73**
CANS	0.345	0.05	0.15	0.09	0.04	**0.68**
St. Gabriel Church	0.46	0.05	0.00	0.00	0.04	0.55

ST. MARY SCHOOL						**Score**

Traffic noise	0.345	0.10	0.15	0.09	0.04	**0.73**
NWS	0.23	0.15	0.10	0.09	0.04	**0.61**
CANS	0.345	0.05	0.00	0.09	0.04	0.53
St. Mary Church	0.46	0.05	0.00	0.00	0.04	0.55

(Source: Author, 2024)

Cumulative score for every potential noise source was obtained by multiplying each value with their calculated weight and then adding the values of the criteria together. The average score obtained was 0.59. Potential noise sources which scored more than the average score were categorized as noise sources while the others were not classified as noise sources for that specific study area.

4.2.9. Linear Multiple Regression for Impact

The result for the criteria impact (dependent variable) is illustrated below. The analysis was to test if the independent variables noise level and spatial distribution (distance) account for the variance in impact.

Table 4.33: *Regression predicting impact*

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.557[a]	.310	.262	.22888
a. Predictors: (Constant), Distance, Noise level				

(Source: Author, 2024)

In the table above, the R square of the model summary is the measure of the amount of variance in the dependent variable that is caused by the independent variables when taken as a group. R^2=0.262; taken as a set, the predictors (independent variables) noise level and distance are responsible for 26% of the variance in impact.

Table 4.34: *Beta coefficient for impact*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.958	.300		3.193	.003
	Noise level	.006	.005	.252	1.301	.204
	Distance	-.002	.001	-.367	-1.900	.007
a. Dependent Variable: Impact						

(Source: Author, 2024)

The coefficient in table 4.34 indicates, the effect of each of the predictors individually and checks where the given predictor was significant on its own. Seeing at the p-values of the predictors, noise level (B=0.006; p=0.204) and distance (B=-0.002; p=0.067) tested each at Alpha = 0.05. The negative beta value for all variables indicates that when distance increases the impact of the noise decreases. Distance from the study areas emerge as significant predictor for the impact but the change in noise level was not significant.

4.2.10. Noise Level of The Noise Sources

Table 4.35: *Leq value of noise sources in and around Adama General Hospital*

	8:00 am - 9:00 am	9:00 am - 10:00 am	10:00 am - 11:00 am	1:00 pm - 2:00 pm	2:00 pm - 3:00 pm	3:00 pm - 4:00 pm	7:00 pm - 8:00 pm	8:00 pm - 9:00 pm	9:00 pm - 10:00 pm
Adama General Hospital (Jan. 11)	57.7	61.2	59	59.1	61.4	56.4	47	45.5	33.7
Traffic noise (Jan. 12)	69.6	71.2	72.6	68.8	78.7	77.3	76.4	65.5	61.9
Noise within the hospital (Jan. 13)	64.3	65	66.7	64.3	68.5	66.4	64.5	63.1	59.8

(Source: Author, 2024)

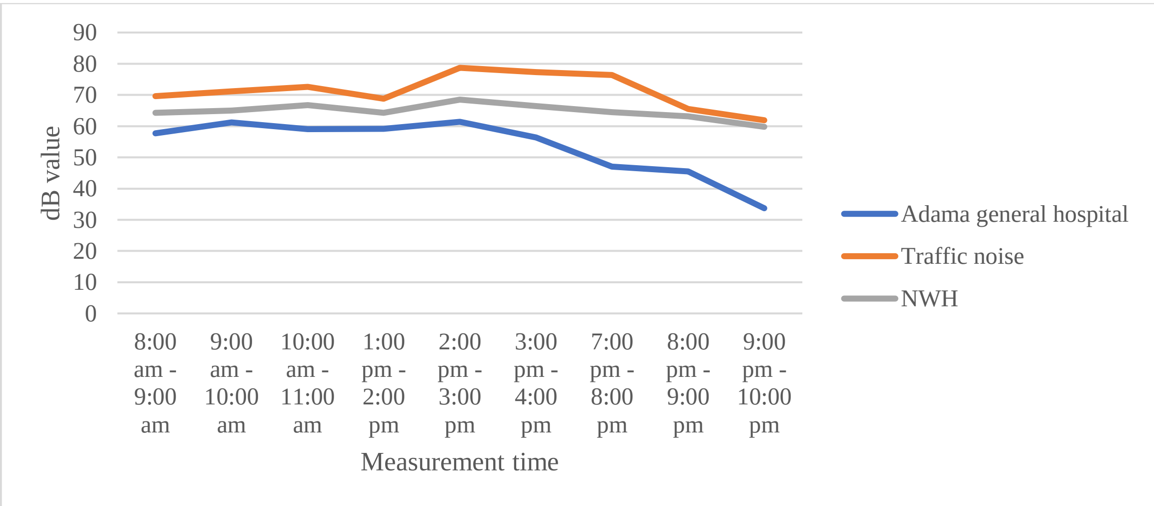

Figure 4.9: *Graphical representation of Leq value of noise sources in and around Adama General Hospital*

Table 4.35 and figure 4.9 indicate that higher noise is generated from the vehicular traffic flow around the hospital. The equivalent noise level (Leq) generated by the traffic flow ranges from 61.9 dB(A) to 78.7 dB(A). The peak of the Leq occurred from 2:00 pm – 3:00 pm.

The other noise source was the noise within the hospital which was produced by the people inside the hospital. Mainly the noise was formed in reception area and lobby of the hospital. The Leq of the noise within the hospital ranges from 59.8 dB(A) to 68.5 dB(A) the peak being occurred from 2:00 pm to 3:00 pm.

Table 4.36: *Average noise level of the noise sources around Adama General Hospital*

	N	Minimum	Maximum	Mean	Std. Deviation
Traffic noise	9	61.9	78.7	71.333	5.5857
Noise within the hospital	9	59.8	68.5	64.733	2.4581

(Source: Author, 2024)

The table above illustrates that the average equivalent noise level produced by traffic noise was 71.3 dB(A) with a standard deviation of 5.59. The average equivalent noise level within the hospital was 64.7 dB(A) with a standard deviation of 2.46.

Table 4.37: *Leq value of noise sources in and around Adama Referral Hospital*

	8:00 am - 9:00 am	9:00 am - 10:00 am	10:00 am - 11:00 am	1:00 pm - 2:00 pm	2:00 pm - 3:00 pm	3:00 pm - 4:00 pm	7:00 pm - 8:00 pm	8:00 pm - 9:00 pm	9:00 pm - 10:00 pm
Adama Referral Hospital (Jan. 15)	61.9	61.2	61.4	63.7	65	64.5	55.1	55.2	44.2
Traffic noise (Jan. 16)	72.3	74.1	75.2	74.8	76.4	76.1	72	67.6	62.5
Noise within the hospital (Jan. 17)	68	68.5	68.3	69.4	70.6	68.5	66.2	67.4	67.6
Commercial activities near the hospital (Jan. 18)	60.2	62.1	74.9	73.4	74.5	74.2	72.8	66.3	61.7

(Source: Author, 2024)

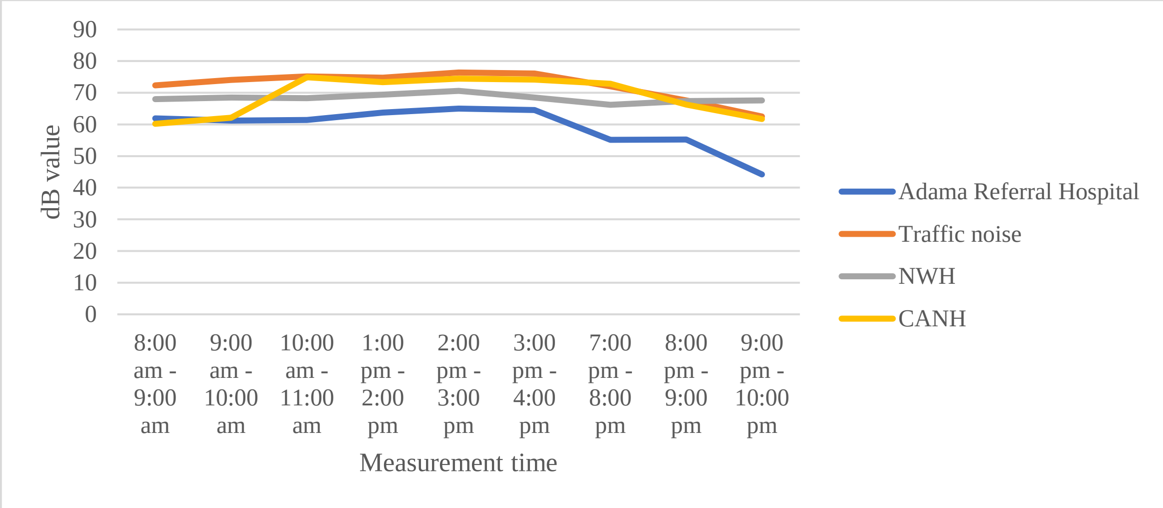

Figure 4.10: *Graphical representation of Leq value of noise sources in and around Adama Referral Hospital*

Table 4.37 and figure 4.10 indicate that higher noise was generated from the vehicular traffic flow around the hospital. The equivalent noise level (Leq) generated by the traffic flow ranges from 62.5 dB(A) to 76.4 dB(A). The peak of the Leq occurred from 2:00 pm – 3:00 pm.

The second highest noise sources around the hospital were commercial activities near the hospital. The Leq generated from these activities ranges from 60.2 dB(A) to 74.5 dB(A) and the peak Leq occurred from 2:00 pm to 3:00 pm. The other noise source was the noise within the hospital which was produced by the people inside the hospital. Mainly the noise was formed in reception area, waiting areas and the lobby of the hospital. The Leq of the noise within the hospital ranges from 66.2 dB(A) to 70.6 dB(A) the peak being occurred from 2:00 pm to 3:00 pm.

Table 4.38: *Average noise level of the noise sources around Adama Referral Hospital*

	N	Minimum	Maximum	Mean	Std. Deviation
Traffic noise	9	62.5	76.4	72.333	4.5738
Noise within the hospital	9	66.2	70.6	68.278	1.2438
Commercial activities near the hospital	9	60.2	74.9	68.900	6.2394

(Source: Author, 2024)

The table above illustrates that the average equivalent noise level produced by traffic noise was 72.3 dB(A) with a standard deviation of 4.57. The average equivalent noise level within the hospital was 68.3 dB(A) with a standard deviation of 1.24.

The average equivalent noise level generated by commercial activities around the hospital was 68.9 dB(A) with a standard deviation of 6.23.

Table 4.39: *Leq value of noise sources in and around Sister Aklesia Memorial Hospital*

	8:00 am - 9:00 am	9:00 am - 10:00 am	10:00 am - 11:00 am	1:00 pm - 2:00 pm	2:00 pm - 3:00 pm	3:00 pm - 4:00 pm	7:00 pm - 8:00 pm	8:00 pm - 9:00 pm	9:00 pm - 10:00 pm
Sister Aklesia (Jan.19)	58.8	59.4	60.7	62	62.1	62.2	49.1	45.7	31.2
Traffic noise (Jan. 20)	68.4	68.9	70.1	69.5	72.3	72.2	71.8	67.9	63
Commercial activities near the hospital (Jan. 22)	62.3	67.5	69.3	72.8	75.4	75.3	73.3	70.6	61.8

(Source: Author, 2024)

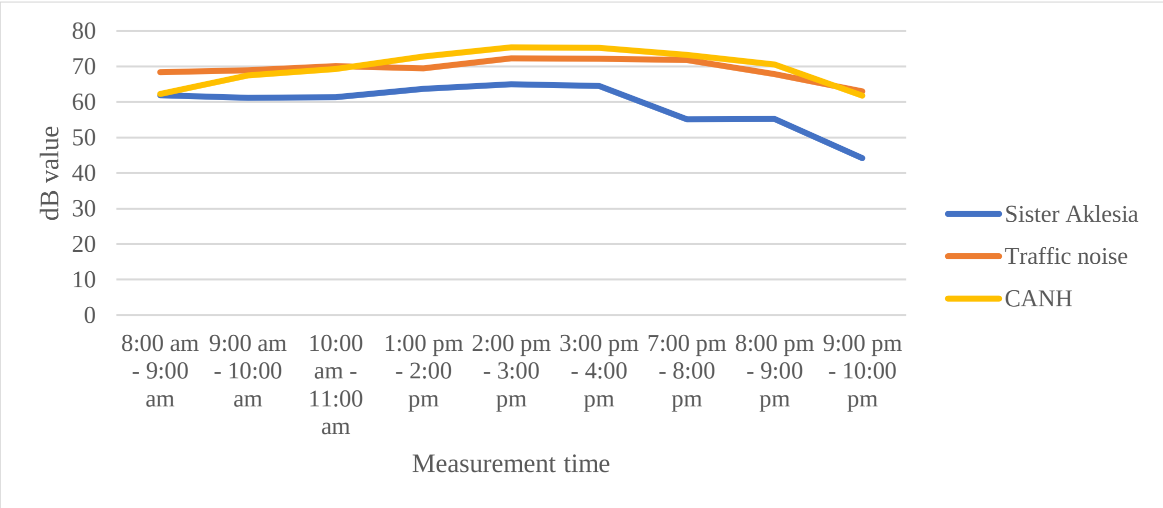

Figure 4.11: *Graphical representation of Leq value of noise sources in and around Sister Aklesia Memorial Hospital*

Table 4.39 and figure 4.11 indicate that higher noise was generated from the commercial activities around the hospital. The equivalent noise level (Leq) generated by these activities ranges from 61.8 dB(A) to 75.4 dB(A). The peak of the Leq occurred from 2:00 pm – 3:00 pm. The other noise source was the traffic flow around the hospital. The Leq of the noise from the traffic flow ranges from 63 dB(A) to 72.3 dB(A) the peak being occurred from 2:00 pm to 3:00 pm.

Table 4.40: *Average noise level of the noise sources around Sister Aklesia Memorial Hospital*

	N	Minimum	Maximum	Mean	Std. Deviation
Traffic noise	9	63.0	72.3	69.344	2.8927
Commercial activities near the hospital	9	61.8	75.4	69.811	5.1148

The table above illustrates that the average equivalent noise level produced by traffic noise was 69.3 dB(A) with a standard deviation of 2.89. The average equivalent noise level generated by commercial activities around the hospital was 69.8 dB(A) with a standard deviation of 5.11.

Table 4.41: *Leq value of noise sources in and around Adama Highschool*

	9:00 am - 10:00 am	10:00 am - 11:00 am	11:00 am - 12:00 am	1:00 pm - 2:00 pm	2:00 pm - 3:00 pm	3:00 pm - 4:00 pm
Adama Highschool (Jan. 23)	46.7	46.6	46.2	48.5	50.1	49.6
Traffic noise (Jan. 24)	65.2	65.4	64.6	65	69.4	68.7
Noise within the school	59.3	64.1	60.3	61.9	61.4	60.5
Commercial activities near the school (Jan. 25)	62.3	64.2	63.3	62.6	63	63.1

(Source: Author, 2024)

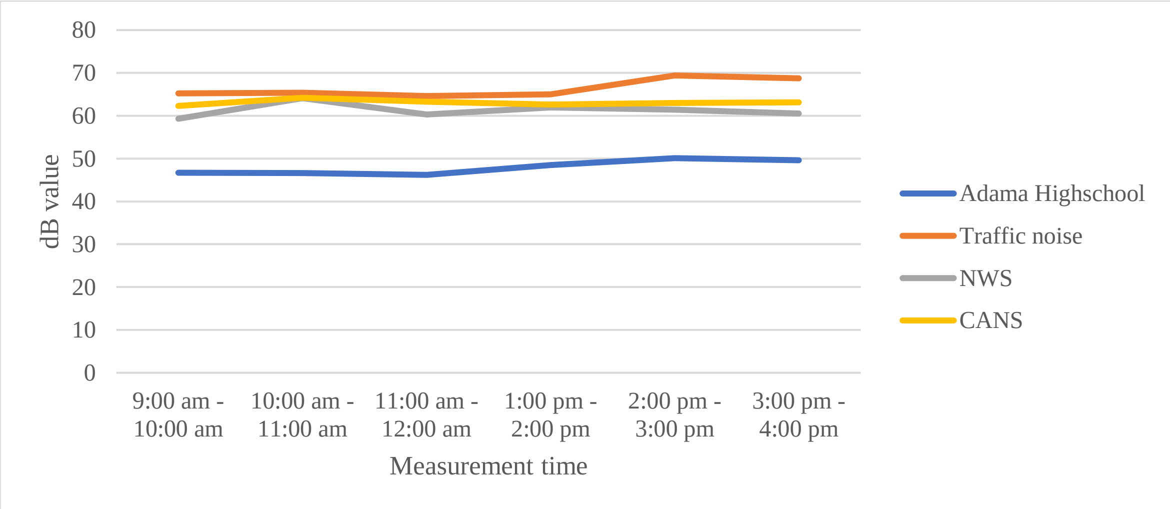

Figure 4.12: *Graphical representation of Leq value of noise sources in and around Adama Highschool*

Table 4.41 and figure 4.12 indicate that higher noise was generated from the vehicular traffic flow around the school. The equivalent noise level (Leq) generated by the traffic flow ranges from 64.6 dB(A) to 69.4 dB(A). The peak of the Leq occurred from 2:00 pm – 3:00 pm. The second highest noise sources around the school were commercial activities.

The Leq generated from these activities ranges from 62.3 dB(A) to 64.2 dB(A) and the peak Leq occurred from 10:00 am to 11:00 am. The other noise source was the noise within the school which was produced by the students inside the school. Mainly the noise was formed in the corridors and playground of the school. The Leq of the noise within the school ranges from 59.3 dB(A) to 64.1 dB(A) the peak being occurred from 10:00 am to 11:00 am.

Table 4.42: *Average noise level of the noise sources around Adama Highschool*

	N	Minimum	Maximum	Mean	Std. Deviation
Traffic noise	6	64.6	69.4	66.383	2.0942
Noise within the school	6	59.3	64.1	61.250	1.6634
Commercial activities near the school	6	62.3	64.2	63.083	0.6555

The table above illustrates that the average equivalent noise level produced by traffic noise was 66.4 dB(A) with a standard deviation of 2.09. The average equivalent noise level within the school was 61.3 dB(A) with a standard deviation of 1.66. The average equivalent noise level generated by commercial activities around the school was 63.1 dB(A) with a standard deviation of 0.66.

Table 4.43: *Leq value of noise sources in and around Goro Highschool*

	9:00 am - 10:00 am	10:00 am - 11:00 am	11:00 am - 12:00 am	1:00 pm - 2:00 pm	2:00 pm - 3:00 pm	3:00 pm - 4:00 pm
Goro Highschool (Jan.11)	45.2	54.1	49.1	51.4	50.9	50.8
Traffic noise (Jan. 12)	67.3	70.3	69.8	69.9	71.4	70.7
Noise within the school	58.8	65.5	61	62.3	64.7	64.3
Commercial activities near the school (Jan. 15)	66.3	71.8	70.5	72.6	76.1	76

(Source: Author, 2024)

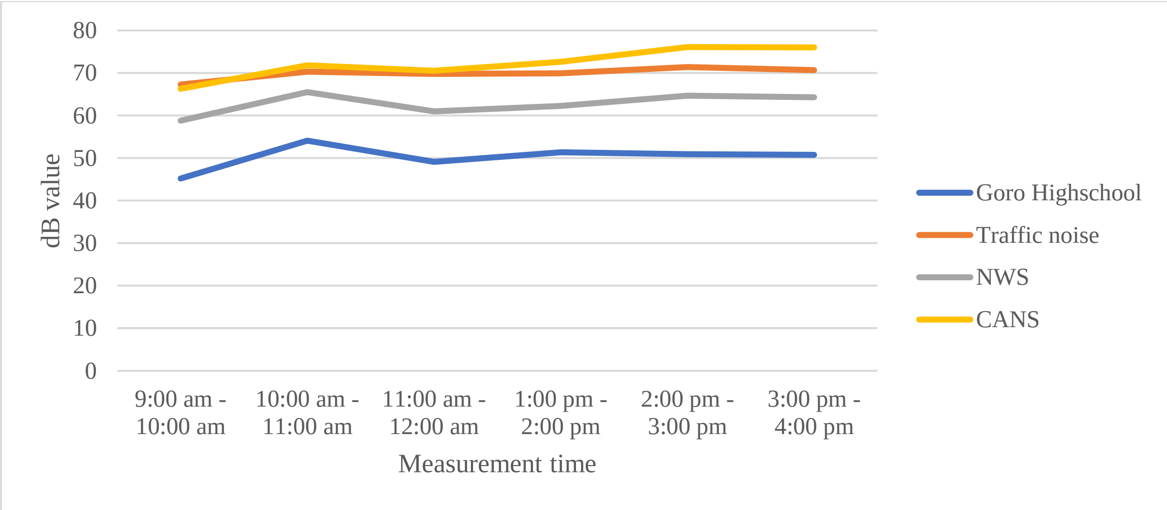

Figure 4.13: *Graphical representation of Leq value of noise sources in and around Goro Highschool*

Table 4.43 and figure 4.13 indicate that higher noise was generated from the commercial activities around the school. The equivalent noise level (Leq) generated by these activities ranges from 66.3 dB(A) to 76.1 dB(A). The peak of the Leq occurred from 2:00 pm – 3:00 pm. The second highest noise sources around the school was the vehicular traffic flow. The Leq generated from the traffic flow ranges from 67.3 dB(A) to 71.4 dB(A) and the peak Leq occurred from 2:00 pm to 3:00 pm. The other noise source was the noise within the school which was produced by the students inside the school. Mainly the noise was formed in the corridors and playground of the school. The Leq of the noise within the school ranges from 58.8 dB(A) to 65.5 dB(A) the peak being occurred from 10:00 am to 11:00 am.

Table 4.44: *Average noise level of the noise sources around Goro Highschool*

	N	Minimum	Maximum	Mean	Std. Deviation
Traffic noise	6	67.3	71.4	69.900	1.4014
Noise within the school	6	58.8	65.5	62.767	2.5547
Commercial activities near the school	6	66.3	76.1	72.217	3.6788

(Source: Author, 2024)

The table above illustrates that the average equivalent noise level produced by traffic noise was 69.9 dB(A) with a standard deviation of 1.4. The average equivalent noise level within the school was 62.8 dB(A) with a standard deviation of 2.55.

The average equivalent noise level generated by commercial activities around the school was 72.2 dB(A) with a standard deviation of 3.68.

Table 4.45: *Leq value of noise sources in and around ODA Special Boarding School*

	9:00 am - 10:00 am	10:00 am - 11:00 am	11:00 am - 12:00 am	1:00 pm - 2:00 pm	2:00 pm - 3:00 pm
ODA Special Boarding School (Jan. 17)	40.8	43.8	39	54.2	52.7
Traffic noise (Jan. 18)	66	67.3	68.7	65.5	68.9
Noise within the school (Jan. 19)	55.3	61.2	59.4	60.1	60.3

(Source: Author, 2024)

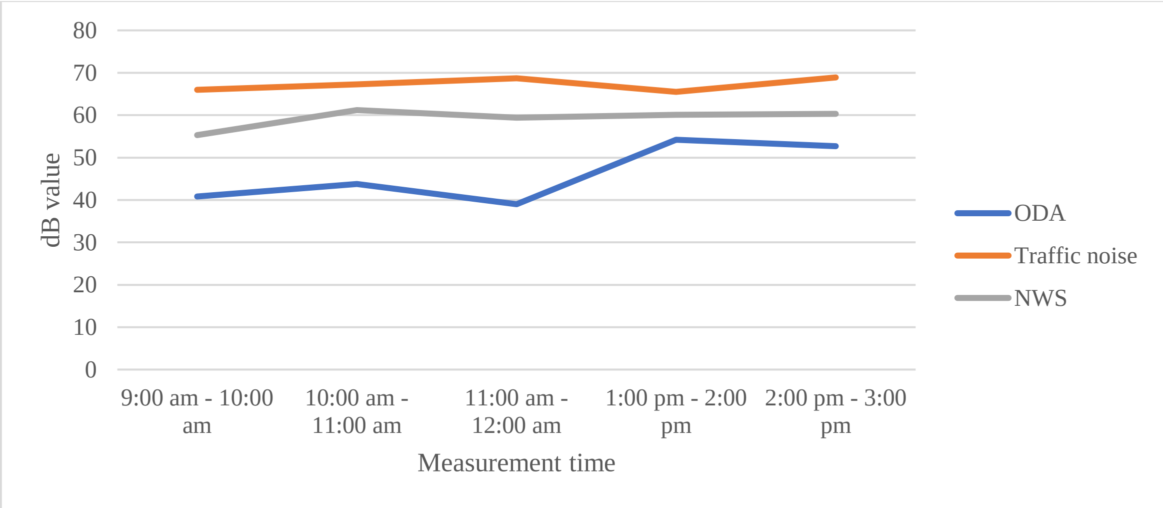

Figure 4.14: *Graphical representation of Leq value of noise sources in and around ODA Special Boarding School*

Table 4.45 and figure 4.14 indicate that higher noise was generated from the vehicular traffic flow around the school. The equivalent noise level (Leq) generated by the traffic flow ranges from 65.5 dB(A) to 68.9 dB(A). The peak of the Leq occurred from 2:00 pm – 3:00 pm.

The other noise source was the noise within the school which was produced by the people inside the school. Mainly the noise was formed in the corridors, playgrounds and dormitories of the school. The Leq of the noise within the school ranges from 55.3 dB(A) to 61.2 dB(A) the peak being occurred from 10:00 am to 11:00 am.

Table 4.46: *Average noise level of the noise sources around ODA Special Boarding School*

	N	Minimum	Maximum	Mean	Std. Deviation
Traffic noise	5	65.5	68.9	67.280	1.5369
Noise within the school	5	55.3	61.2	59.260	2.3050

(Source: Author, 2024)

The table above illustrates that the average equivalent noise level produced by traffic noise was 67.3 dB(A) with a standard deviation of 1.54. The average equivalent noise level within the school was 59.3 dB(A) with a standard deviation of 2.3.

Table 4.47*: Leq value of noise sources in and around Rift Valley University*

	9:00 am - 10:00 am	10:00 am - 11:00 am	11:00 am - 12:00 am	1:00 pm - 2:00 pm	2:00 pm - 3:00 pm	3:00 pm - 4:00 pm
Rift Valley University (Jan. 22)	44.8	50	54.2	53.7	55.5	52.7
Traffic noise (Jan. 23)	70.2	75.6	76	74.9	76.7	75.4
Noise within the school (Jan. 24)	65	68.7	67.3	69.3	69.7	68.5
Commercial activities near the school (Jan. 25)	72.6	73	73.5	72.8	74.1	74.5

(Source: Author, 2024)

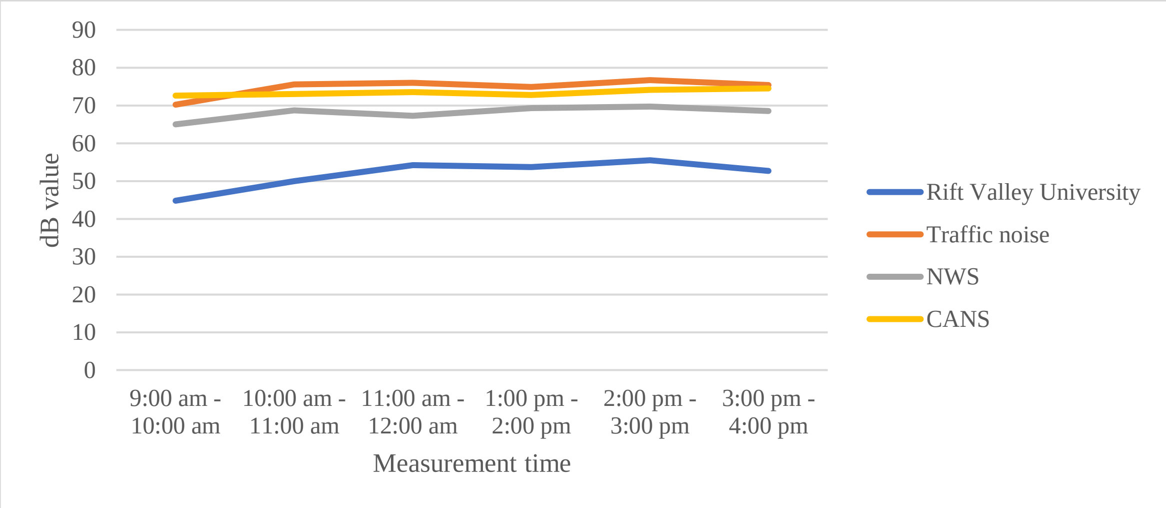

Figure 4.15: *Graphical representation of Leq value of noise sources in and around Rift Valley University*

Table 4.47 and figure 4.15 indicate that higher noise was generated from the vehicular traffic flow around the university. The equivalent noise level (Leq) generated by the traffic flow ranges from 70.2 dB(A) to 76.7 dB(A). The peak of the Leq occurred from 2:00 pm – 3:00 pm. The second highest noise sources around the university were commercial activities.

The Leq generated from these activities ranges from 72.6 dB(A) to 74.5 dB(A) and the peak Leq occurred from 3:00 pm to 4:00 pm. The other noise source was the noise within the university which was produced by the students inside the campus. Mainly the noise was formed in the corridors and open areas within the campus. The Leq of the noise within the campus ranges from 65 dB(A) to 69.7 dB(A) the peak being occurred from 2:00 pm to 3:00 pm.

***Table 4.48**: Average noise level of the noise sources around Rift Valley University*

	N	Minimum	Maximum	Mean	Std. Deviation
Traffic noise	6	70.2	76.7	74.800	2.3332
Noise within the campus	6	65.0	69.7	68.083	1.7186
Commercial activities near the campus	6	72.6	74.5	73.417	0.7574

(Source: Author, 2024)

The table above illustrates that the average equivalent noise level produced by traffic noise was 74.8 dB(A) with a standard deviation of 2.33. The average equivalent noise level within the campus was 68.1 dB(A) with a standard deviation of 1.72. The average equivalent noise level generated by commercial activities around the campus was 73.4 dB(A) with a standard deviation of 0.76.

***Table 4.49:** Leq value of noise sources in and around St. Mary School*

	9:00 Am - 10:00 Am	10:00 Am - 11:00 Am	11:00 Am - 12:00 Am	1:00 Pm - 2:00 Pm	2:00 Pm - 3:00 Pm
St. Mary School (Jan. 26)	45.5	52.4	55.4	51	49.7
Traffic Noise (Jan. 29)	70.4	71.2	72.8	69.3	73.6
Noise Within the School (Jan. 30)	55.2	63.9	58	60.2	60.1

(Source: Author, 2024)

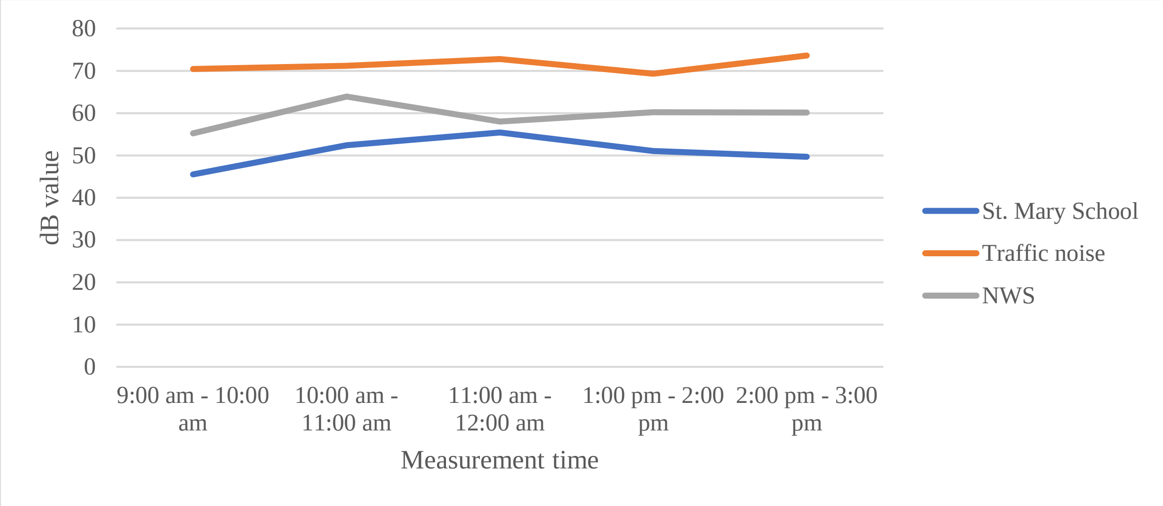

Figure 4.16: *Graphical representation of Leq value of noise sources in and around St. Mary School*

Table 4.49 and figure 4.16 indicate that higher noise was generated from the vehicular traffic flow around the school. The equivalent noise level (Leq) generated by the traffic flow ranges from 69.3 dB(A) to 73.6 dB(A). The peak of the Leq occurred from 2:00 pm – 3:00 pm. The other noise source was the noise within the school which was produced by the students inside the school. Mainly the noise was formed in the corridors and playground of the school. The Leq of the noise within the school ranges from 55.2 dB(A) to 63.9 dB(A) the peak being occurred from 10:00 am to 11:00 am.

Table 4.50: *Average noise level of the noise sources around St. Mary School*

	N	Minimum	Maximum	Mean	Std. Deviation
Traffic noise	5	69.3	73.6	71.460	1.7487
Noise within the hospital	5	55.2	63.9	59.480	3.1995

(Source: Author, 2024)

The table above illustrates that the average equivalent noise level produced by traffic noise was 71.5 dB(A) with a standard deviation of 1.75. The average equivalent noise level within the school was 59.5 dB(A) with a standard deviation of 3.2.

4.2.11. Linear Multiple Regression for The Noise Level of The Study Areas

The result for the noise levels (dependent variable) was illustrated on the table 4.51. The analysis was to test if the independent variables traffic noise, noise within the study areas and commercial activities around the study areas account for the variance in the noise level of the study areas.

Table 4.51: *Regression predicting noise level*

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.808[a]	.652	.607	3.9563
a. Predictors: (Constant), Commercial activities near the study areas, Noise within the study areas, Traffic noise				

In the table above, the R square of the model summary was the measure of the amount of variance in the dependent variable that was caused by the independent variables when taken as a group. R^2=0.607; taken as a set, the predictors (independent variables) traffic noise, noise within the study areas and noise from commercial activities around the study areas are responsible for 61% of the variance in the noise level of the study areas.

Table 4.52: *Beta coefficients of noise level*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	34.852	14.848		2.347	.008
	Traffic noise	1.085	.329	.727	3.304	.003
	Noise within the study areas	.557	.313	.317	1.780	.008
	Commercial activities near the study areas	.369	.198	.319	1.867	.015
a. Dependent Variable: Noise level of the study areas						

The coefficient in table 4.52 indicates, the effect of each of the predictors individually and checks where the given predictor was significant on its own. Seeing at the p-values of the predictors, traffic noise (B=1.085; p=0.003), noise within the study areas (B=0.557; p=0.008), and noise from commercial activities around the study areas (B=0.369; p=0.015) tested each at Alpha = 0.05. All of independent variables have a significant impact on the equivalent noise level.

Generally, the researcher aimed to investigate whether traffic noise, noise within the study areas and noise from commercial activities around the study areas has a significant impact on the equivalent noise level or not. The hypothesis was put as follows.

- H1: There is a significant impact of traffic noise on the noise level of the study areas.
- H2: There is a significant impact of noise within the study areas on the noise level of the study areas.
- H3: There is a significant impact of noise from commercial activities around the study areas on the noise level of the study areas.

Table 4.53: Regression analysis summary for noise level

Hypothesis	Regression weights	Beta coefficient	R^2	F	t-value	p-value	Hypothesis supported
H1	TN→Leq	1.085	.607	14.376	3.304	.003	Yes
H2	NWS→Leq	.557	.607	14.376	1.780	.008	Yes
H3	CANS→Leq	.369	.607	14.376	1.867	.015	Yes

(Source: Author, 2024)

4.3. NOISE POLLUTION LEVEL OF THE STUDY AREAS

4.3.1. Noise Level of Adama General Hospital

The following data is a record of ambient noise level recorded in Adama General Hospital and their calculated noise parameters.

Table 4.54: Various measured and calculated noise parameters in Adama General Hospital

Morning (January 11)	L_{10}	L_{50}	L_{90}	Leq	L_{NP}	NC
8:00 am - 8:15 am	68.1	39.9	33.6	**59.7**	94.2	34.5
8:15 am - 8:30 am	64.8	42.5	38.1	**54.4**	81.1	26.7
8:30 am - 8:45 am	67.7	36.9	32.8	**57.2**	92.1	34.9
8:45 am - 9:00 am	65.4	50.3	42.2	**59.3**	82.5	23.2
9:00 am - 9:15 am	68.9	41.6	33.7	**62.3**	97.5	35.2
9:15 am - 9:30 am	66.2	45	35.5	**60.7**	91.4	30.7
9:30 am - 9:45 am	65.9	54.4	45.3	**61.5**	82.1	20.6
9:45 am - 10:00 am	69.3	47.7	41.9	**60.2**	87.6	27.4
10:00 am - 10:15 am	65.8	44.9	37.4	**58.3**	86.7	28.4
10:15 am - 10:30 am	64.5	39.7	31.6	**57.7**	90.6	32.9
10:30 am - 10:45 am	66.6	43.3	34.7	**60.3**	92.2	31.9
10:45 am - 11:00 am	69.1	42.5	36.9	**59.8**	92	32.2
Afternoon (January 11)						
1:00 pm - 1:15 pm	67.4	42.5	36.8	**58.1**	88.7	30.6
1:15 pm - 1:30 pm	69.8	46	41.7	**59.2**	87.3	28.1
1:30 pm - 1:45 pm	63.7	49.5	40.1	**58.8**	82.4	23.6
1:45 pm - 2:00 pm	70.5	42.2	37.5	**60.3**	93.3	33
2:00 pm - 2:15 pm	71.9	46.5	42.3	**61.1**	90.7	29.6
2:15 pm - 2:30 pm	73.2	42.9	39.6	**61.7**	95.3	33.6
2:30 pm - 2:45 pm	74.3	38.5	38.2	**60.2**	96.3	36.1
2:45 pm - 3:00 pm	68.9	50.3	42	**62.4**	89.3	26.9
3:00 pm - 3:15 pm	65.2	43.4	36.4	**57.2**	86	28.8
3:15 pm - 3:30 pm	63.7	48.5	43.2	**55.5**	76	20.5
3:30 pm - 3:45 pm	68.1	44.4	40.8	**56.8**	84.1	27.3
3:45 pm - 4:00 pm	69.5	40.5	38.9	**56.1**	86.7	30.6
Evening (January 11)						

7:00 pm - 7:15 pm	62.3	33.7	32.8	**48.2**	77.7	29.5
7:15 pm - 7:30 pm	55.1	40	35.2	**46.6**	66.5	19.9
7:30 pm - 7:45 pm	54.6	37.9	32.7	**45.9**	67.8	21.9
7:45 pm - 8:00 pm	55.8	38.9	33.5	**47.2**	69.5	22.3
8:00 pm - 8:15 pm	53.4	40.2	30.9	**48.6**	71.1	22.5
8:15 pm - 8:30 pm	51.2	38.7	32.3	**44.7**	63.6	18.9
8:30 pm - 8:45 pm	52.9	36.4	30.1	**45.1**	67.9	22.8
8:45 pm - 9:00 pm	56	32.2	30.2	**43.3**	69.1	25.8
9:00 pm - 9:15 pm	51.8	36.1	31.8	**42.8**	62.8	20
9:15 pm - 9:30 pm	50.5	35.2	31.5	**32.1**	51.1	19
9:30 pm - 9:45 pm	50.7	33.1	30	**30**	50.7	20.7
9:45 pm - 10:00 pm	45.5	36.3	30	**30**	45.5	15.5

(Source: Author, 2024)

The morning session measurement shows that the L_{10} measurement ranges from 64.5 dB(A) to 69.3 dB(A), the L_{50} measurement ranges from 36.9 dB(A) to 54.4 dB(A) and the L_{90} measurement ranges from 31.6 dB(A) to 45.3 dB(A). The afternoon session measurement shows that the L_{10} measurement ranges from 63.7 dB(A) to 74.3 dB(A), the L_{50} measurement ranges from 38.5 dB(A) to 50.3 dB(A) and the L_{90} measurement ranges from 36.4 dB(A) to 43.2 dB(A).

The evening session measurement shows that the L_{10} measurement ranges from 45.5 dB(A) to 62.3 dB(A), the L_{50} measurement ranges from 32.2 dB(A) to 40.2 dB(A) and the L_{90} measurement ranges from 30 dB(A) to 35.2 dB(A).

The equivalent acoustic level (Leq) throughout the day ranges from 30 dB(A) to 62.4 dB(A) the highest being recorded from 2:45 pm to 3:00 pm. The evening measurement shows that it's quieter around 9:00 pm and afterwards and it's noisier in the afternoon. The noise pollution level (L_{NP}) throughout the day ranges from 45.5 dB(A) to 97.5 dB(A) whereas the noise climate (NC) recorded throughout the day ranges from 15.5 dB(A) to 36.1 dB(A). The record shows that there was a higher difference in L_{10} and L_{90} in the afternoon and the noise difference narrows in the evening.

4.3.2. Noise Level of Adama Referral Hospital

The following data is a record of ambient noise level recorded in Adama Referral Hospital and their calculated noise parameters.

Table 4.55: *Various measured and calculated noise parameters in Adama Referral Hospital*

Morning (January 15)	L10	L50	L90	Leq	LNP	NC

8:00 am - 8:15 am	73.6	53.8	41.8	**60.7**	92.5	31.8
8:15 am - 8:30 am	75.2	56.1	42.1	**64.4**	97.5	33.1
8:30 am - 8:45 am	76.4	60.3	49.2	**62.6**	89.8	27.2
8:45 am - 9:00 am	80.9	59.3	45.9	**59.7**	94.7	35
9:00 am - 9:15 am	82.7	52.8	40.7	**62.2**	104.2	42
9:15 am - 9:30 am	74.3	55.9	43.4	**61.8**	92.7	30.9
9:30 am - 9:45 am	81.9	57.4	44.8	**60.3**	97.4	37.1
9:45 am - 10:00 am	76.1	53.7	42.3	**62.7**	96.5	33.8
10:00 am - 10:15 am	80.3	50.2	46	**59.8**	94.1	34.3
10:15 am - 10:30 am	82.6	55.6	43.6	**60.9**	99.9	39
10:30 am - 10:45 am	78.1	52.1	44.2	**61.3**	95.2	33.9
10:45 am - 11:00 am	81.4	54	47.1	**63.6**	97.9	34.3
Afternoon (January 15)						
1:00 pm - 1:15 pm	81.8	48	43.2	**62.8**	101.4	38.6
1:15 pm - 1:30 pm	86.2	55	44.9	**63.4**	104.7	41.3
1:30 pm - 1:45 pm	80.6	52.9	45.7	**63.2**	98.1	34.9
1:45 pm - 2:00 pm	82.3	56	48.1	**65.5**	99.7	34.2
2:00 pm - 2:15 pm	87.9	51.8	42.4	**66.3**	111.8	45.5
2:15 pm - 2:30 pm	88.4	54.9	46.8	**63.7**	105.3	41.6
2:30 pm - 2:45 pm	84.6	53.7	41.3	**64.9**	108.2	43.3
2:45 pm - 3:00 pm	81.1	57.9	49	**65.1**	97.2	32.1
3:00 pm - 3:15 pm	83.1	52.3	40.6	**62.4**	104.9	42.5
3:15 pm - 3:30 pm	89.8	53.1	47.2	**63.3**	105.9	42.6
3:30 pm - 3:45 pm	91.3	57.2	49.7	**66**	107.6	41.6
3:45 pm - 4:00 pm	90.6	50.3	44.1	**66.3**	112.8	46.5
Evening (January 15)						
7:00 pm - 7:15 pm	75.1	55.2	42.7	**52.7**	85.1	32.4
7:15 pm - 7:30 pm	72.9	54	36.3	**56.3**	92.9	36.6
7:30 pm - 7:45 pm	71.2	58.7	47.8	**57.8**	81.2	23.4
7:45 pm - 8:00 pm	73.4	58.4	43.4	**53.4**	83.4	30
8:00 pm - 8:15 pm	70.8	52.4	44.2	**54.2**	80.8	26.6
8:15 pm - 8:30 pm	72.7	50.3	39.1	**59.1**	92.7	33.6
8:30 pm - 8:45 pm	71.8	53.8	35.6	**55.6**	91.8	36.2
8:45 pm - 9:00 pm	65.3	53.3	31.9	**51.9**	85.3	33.4
9:00 pm - 9:15 pm	61.8	48.7	38.1	**48.1**	71.8	23.7
9:15 pm - 9:30 pm	61.2	46.7	36.7	**46.7**	71.2	24.5
9:30 pm - 9:45 pm	60.5	35.3	30.4	**40.4**	70.5	30.1
9:45 pm - 10:00 pm	60.3	37.7	31.5	**41.5**	70.3	28.8

(Source: Author, 2024)

The morning session measurement shows that the L_{10} measurement ranges from 73.6 dB(A) to 82.7 dB(A), the L_{50} measurement ranges from 50.2 dB(A) to 60.3 dB(A) and the L_{90} measurement ranges from 40.7 dB(A) to 49.2 dB(A). The afternoon session measurement shows that the L_{10} measurement ranges from 80.6 dB(A) to 91.3 dB(A), the L_{50} measurement ranges from 48 dB(A) to 57.9 dB(A) and the L_{90} measurement ranges from 40.6 dB(A) to 49.7 dB(A). The evening session measurement shows that the L_{10} measurement ranges from 60.3 dB(A) to 75.1 dB(A), the L_{50} measurement ranges from 35.3 dB(A) to 58.7 dB(A) and the L_{90} measurement ranges from 30.4 dB(A) to 47.8 dB(A).

The equivalent acoustic level (Leq) throughout the day ranges from 40.4 dB(A) to 66.3 dB(A) the highest being recorded from 2:00 pm to 2:15 pm. The evening measurement shows that it's quieter around 9:00 pm and afterwards and it's noisier in the afternoon.

The noise pollution level (L_{NP}) throughout the day ranges from 70.3 dB(A) to 112.8 dB(A) whereas the noise climate (NC) recorded throughout the day ranges from 23.4 dB(A) to 46.5 dB(A). The record shows that there was a higher difference in L_{10} and L_{90} in the afternoon and the noise difference narrows in the morning.

4.3.3. Noise Level of Sister Aklesia Memorial Hospital

The following data is a record of ambient noise level recorded in Sister Aklesia Memorial Hospital and their calculated noise parameters.

Table 4.56: *Various measured and calculated noise parameters in Sister Aklesia Memorial Hospital*

Morning (January 19)	L10	L50	L90	Leq	LNP	NC
8:00 am - 8:15 am	70.1	51.5	50.6	**57.8**	77.3	19.5
8:15 am - 8:30 am	71.8	46	45.2	**57.8**	84.4	26.6
8:30 am - 8:45 am	80.1	51.9	46.2	**59.5**	87.7	28.2
8:45 am - 9:00 am	78.6	52.3	48.7	**60.2**	86.5	26.3
9:00 am - 9:15 am	77.3	49.7	46	**58.7**	86.3	27.6
9:15 am - 9:30 am	76.2	44.9	44.8	**61.3**	92.7	31.4
9:30 am - 9:45 am	75.1	53.1	51	**59.1**	81.1	22
9:45 am - 10:00 am	81.7	41.5	31.5	**58.4**	98.6	40.2
10:00 am - 10:15 am	72.4	49.9	46.7	**60.9**	86.6	25.7
10:15 am - 10:30 am	73.9	50	48.1	**61.1**	86.9	25.8
10:30 am - 10:45 am	79.5	54.8	48.4	**58.6**	83.3	24.7
10:45 am - 11:00 am	74.6	50	47.4	**62.3**	89.5	27.2
Afternoon (January 19)						
1:00 pm - 1:15 pm	78.2	52.7	50.5	**61.3**	89	27.7
1:15 pm - 1:30 pm	80.7	48.2	44.8	**62.4**	98.3	35.9
1:30 pm - 1:45 pm	81.8	50.9	47.7	**63.6**	97.7	34.1
1:45 pm - 2:00 pm	77.5	51.3	49.4	**60.8**	88.9	28.1
2:00 pm - 2:15 pm	82	49.6	43.7	**61.2**	99.5	38.3
2:15 pm - 2:30 pm	75.6	55.9	54.8	**63.1**	82.8	19.7
2:30 pm - 2:45 pm	79.8	53.2	51.6	**63.4**	91.6	28.2

2:45 pm - 3:00 pm	84.2	47.6	38.6	**60.9**	106.5	45.6
3:00 pm - 3:15 pm	83.4	52.7	46.4	**62.1**	99.1	37
3:15 pm - 3:30 pm	76.7	50.1	49.9	**61.7**	88.5	26.8
3:30 pm - 3:45 pm	80.1	54	49.4	**60.8**	91.5	30.7
3:45 pm - 4:00 pm	85	49.5	43.3	**64.3**	106	41.7
Evening (January 19)						
7:00 pm - 7:15 pm	69.1	35.6	31.5	**50.2**	87.8	37.6
7:15 pm - 7:30 pm	67.6	38.2	35.1	**49.5**	82	32.5
7:30 pm - 7:45 pm	68.8	31.9	30	**48.7**	87.5	38.8
7:45 pm - 8:00 pm	66.3	32.3	30.1	**47.8**	84	36.2
8:00 pm - 8:15 pm	65.2	39.7	33.2	**51.3**	83.3	32
8:15 pm - 8:30 pm	59.9	34.8	32.4	**49.1**	76.6	27.5
8:30 pm - 8:45 pm	50	33.1	31.7	**41.4**	59.7	18.3
8:45 pm - 9:00 pm	55.6	30	30	**40.9**	66.5	25.6
9:00 pm - 9:15 pm	56.9	32.7	30	**31.1**	58	26.9
9:15 pm - 9:30 pm	52.5	30.1	30	**33.6**	56.1	22.5
9:30 pm - 9:45 pm	47.7	34	30	**30.1**	47.8	17.7
9:45 pm - 10:00 pm	40.1	30	30	**30**	40.1	10.1

(Source: Author, 2024)

The morning session measurement shows that the L_{10} measurement ranges from 73.6 dB(A) to 81.7 dB(A), the L_{50} measurement ranges from 50.2 dB(A) to 54.8 dB(A) and the L_{90} measurement ranges from 40.7 dB(A) to 51 dB(A). The afternoon session measurement shows that the L_{10} measurement ranges from 80.6 dB(A) to 85 dB(A), the L_{50} measurement ranges from 48 dB(A) to 55.9 dB(A) and the L_{90} measurement ranges from 40.6 dB(A) to 54.8 dB(A). The evening session measurement shows that the L_{10} measurement ranges from 60.3 dB(A) to 69.1 dB(A), the L_{50} measurement ranges from 35.3 dB(A) to 39.7 dB(A) and the L_{90} measurement ranges from 30.4 dB(A) to 35.1 dB(A).

The equivalent acoustic level (Leq) throughout the day ranges from 30 dB(A) to 64.3 dB(A) the highest being recorded from 2:00 pm to 2:15 pm. The evening measurement shows that it's quieter around 9:00 pm and afterwards and it's noisier in the afternoon. The noise pollution level (L_{NP}) throughout the day ranges from 40.1 dB(A) to 106.5 dB(A) whereas the noise climate (NC) recorded throughout the day ranges from 10.1 dB(A) to 45.6 dB(A). The record shows that there was a higher difference in L_{10} and L_{90} in the morning and afternoon and the noise difference narrows in the evening.

4.3.4. Noise Level of Adama Highschool

The following data is a record of ambient noise level recorded in Adama Highschool and their calculated noise parameters.

Table 4.57: Various measured and calculated noise parameters in Adama Highschool

Morning (January 23)	L10	L50	L90	Leq	LNP	NC
9:00 am - 9:15 am	63.5	44.2	37.5	**45.5**	71.5	26
9:15 am - 9:30 am	64.3	46.1	36.3	**49.2**	77.2	28
9:30 am - 9:45 am	67.3	39.6	34.6	**47.4**	80.1	32.7
9:45 am - 10:00 am	70	48.9	39.4	**44.5**	75.1	30.6
10:00 am - 10:15 am	71.6	48.7	38.5	**47**	80.1	33.1
10:15 am - 10:30 am	77.4	45.4	41.7	**46.6**	82.3	35.7
10:30 am - 10:45 am	70.8	43.1	42.3	**45.1**	72.8	27.7
10:45 am - 11:00 am	67.2	44.3	39.1	**47.5**	75.6	28.1
11:00 am - 11:15 am	71.2	43	35.2	**44.6**	80.6	36
11:15 am - 11:30 am	72.7	40.5	33.8	**45.7**	84.6	38.9
11:30 am - 11:45 am	68	39.6	36.5	**46.1**	77.6	31.5
11:45 am - 12:00 pm	71.5	40.7	38.9	**48.4**	81	32.6
Afternoon (January 23)						
1:00 pm - 1:15 pm	71.7	39.3	38.6	**47.6**	80.7	33.1
1:15 pm - 1:30 pm	76.1	39.8	42.9	**48.2**	81.4	33.2
1:30 pm - 1:45 pm	71.5	40.7	39.3	**48**	80.2	32.2
1:45 pm - 2:00 pm	72.4	43.6	40.7	**50.3**	82	31.7
2:00 pm - 2:15 pm	76.9	48.5	40.1	**51.1**	87.9	36.8
2:15 pm - 2:30 pm	79.3	41.2	38.8	**48.5**	89	40.5
2:30 pm - 2:45 pm	74.6	40.4	36.4	**49.7**	87.9	38.2
2:45 pm - 3:00 pm	71.2	43.8	39.2	**50.9**	82.9	32
3:00 pm - 3:15 pm	73.1	40.2	37.6	**47.2**	82.7	35.5
3:15 pm - 3:30 pm	79.8	47.1	44.3	**48.1**	83.6	35.5
3:30 pm - 3:45 pm	81.5	43.9	40.6	**51.8**	92.7	40.9
3:45 pm - 4:00 pm	80.3	46.5	41.7	**51.3**	89.9	38.6

(Source: Author, 2024)

The morning session measurement shows that the L_{10} measurement ranges from 63.5 dB(A) to 77.4 dB(A), the L_{50} measurement ranges from 39.6 dB(A) to 48.9 dB(A) and the L_{90} measurement ranges from 33.8 dB(A) to 42.3 dB(A). The afternoon session measurement shows that the L_{10} measurement ranges from 71.2 dB(A) to 81.5 dB(A), the L_{50} measurement ranges from 39.3 dB(A) to 48.5 dB(A) and the L_{90} measurement ranges from 36.4 dB(A) to 44.3 dB(A).

The equivalent acoustic level (Leq) throughout the day ranges from 44.5 dB(A) to 51.8 dB(A) the highest being recorded from 2:00 pm to 2:15 pm. The noise pollution level (L_{NP}) throughout the day ranges from 71.5 dB(A) to 92.7 dB(A) whereas the noise climate (NC) recorded throughout the day ranges from 26 dB(A) to 40.9 dB(A). The record shows that there was a higher difference in L_{10} and L_{90} in the afternoon.

4.3.5. Noise Level of Goro Highschool

The following data is a record of ambient noise level recorded in Goro Highschool and their calculated noise parameters.

Table 4.58: *Various measured and calculated noise parameters in Goro Highschool*

Morning (January 11)	L10	L50	L90	Leq	LNP	NC
9:00 am - 9:15 am	60.6	34.5	32.7	**44.1**	72	27.9
9:15 am - 9:30 am	61.5	36.2	31.7	**42.4**	72.2	29.8
9:30 am - 9:45 am	62.2	35.3	33.1	**45.2**	74.3	29.1
9:45 am - 10:00 am	63.5	39.4	39.3	**49.2**	73.4	24.2
10:00 am - 10:15 am	65.6	46.4	42.5	**55.3**	78.4	23.1
10:15 am - 10:30 am	73.2	45.4	42.6	**55.5**	86.1	30.6
10:30 am - 10:45 am	75.4	44.9	42.3	**57.8**	90.9	33.1
10:45 am - 11:00 am	69.3	42.1	35.3	**47.6**	81.6	34
11:00 am - 11:15 am	65.7	40.7	37.6	**48**	76.1	28.1
11:15 am - 11:30 am	68.8	42.6	39.8	**51.2**	80.2	29
11:30 am - 11:45 am	71.9	41.6	31.6	**46.9**	87.2	40.3
11:45 am - 12:00 Pm	69.7	39.6	35	**50.1**	84.8	34.7
Afternoon (January 11)						
1:00 pm - 1:15 pm	73.2	42.3	39.3	**55.2**	89.1	33.9
1:15 pm - 1:30 pm	68.9	41.5	35.4	**47.9**	81.4	33.5
1:30 pm - 1:45 pm	69.5	44.9	38.5	**48.6**	79.6	31
1:45 pm - 2:00 pm	67.1	44.2	43.1	**53.8**	77.8	24
2:00 pm - 2:15 pm	71.6	40.7	33.5	**49.4**	87.5	38.1
2:15 pm - 2:30 pm	75.2	42.8	35.2	**52.7**	92.7	40
2:30 pm - 2:45 pm	78.1	44.2	31.9	**51.1**	97.3	46.2
2:45 pm - 3:00 pm	71.5	41.8	35.6	**50.3**	86.2	35.9
3:00 pm - 3:15 pm	77.3	43.7	37.7	**56.5**	96.1	39.6
3:15 pm - 3:30 pm	65.6	40.4	35.1	**45.7**	76.2	30.5
3:30 pm - 3:45 pm	72.4	44.6	41.5	**54.4**	85.3	30.9
3:45 pm - 4:00 pm	67.6	42.1	36	**46.8**	78.4	31.6

(Source: Author, 2024)

The morning session measurement shows that the L_{10} measurement ranges from 60.6 dB(A) to 75.4 dB(A), the L_{50} measurement ranges from 34.5 dB(A) to 46.4 dB(A) and the L_{90} measurement ranges from 31.6 dB(A) to 42.6 dB(A). The afternoon session measurement shows that the L_{10} measurement ranges from 65.6 dB(A) to 78.1 dB(A), the L_{50} measurement ranges from 40.4 dB(A) to 44.9 dB(A) and the L_{90} measurement ranges from 31.9 dB(A) to 43.1 dB(A).

The equivalent acoustic level (Leq) throughout the day ranges from 42.4 dB(A) to 57.8 dB(A) the highest being recorded from 10:30 am to 10:45 am. The noise pollution level (L_{NP}) throughout the day ranges from 72 dB(A) to 97.3 dB(A) whereas the noise climate (NC) recorded throughout the day ranges from 23.1 dB(A) to 46.2 dB(A). The record shows that there was a higher difference in L_{10} and L_{90} in the morning.

4.3.6. Noise Level of ODA Special Boarding School

The following data is a record of ambient noise level recorded in ODA Special Boarding School and their calculated noise parameters.

Table 4.59: *Various measured and calculated noise parameters in ODA Special Boarding School*

Morning (January 17)	L10	L50	L90	Leq	LNP	NC
9:00 am - 9:15 am	60.3	40.2	31.6	**43.9**	72.6	28.7
9:15 am - 9:30 am	63.2	39.3	32.8	**44.7**	75.1	30.4
9:30 am - 9:45 am	61.9	41.5	30.2	**38.2**	69.9	31.7
9:45 am - 10:00 am	62.6	42.2	33.5	**36.3**	65.4	29.1
10:00 am - 10:15 am	64.1	37.8	31.4	**45.6**	78.3	32.7
10:15 am - 10:30 am	66	45.6	32.9	**43.9**	77	33.1
10:30 am - 10:45 am	71.4	45.2	30.9	**42.5**	83	40.5
10:45 am - 11:00 am	66.7	46.2	34.8	**43.2**	75.1	31.9
11:00 am - 11:15 am	62.8	39.8	33.2	**44.4**	74	29.6
11:15 am - 11:30 am	63.7	33.2	32.9	**39**	69.8	30.8
11:30 am - 11:45 am	64.5	37.4	31.5	**35.5**	68.5	33
11:45 am - 12:00 Pm	66.3	35.9	30.8	**36.9**	72.4	35.5
Afternoon (January 17)						
1:00 pm - 1:15 pm	64.3	35.2	30.6	**54.1**	87.8	33.7
1:15 pm - 1:30 pm	63.1	34.1	32.8	**49.4**	79.7	30.3
1:30 pm - 1:45 pm	66.5	36.9	30.1	**59**	95.4	36.4
1:45 pm - 2:00 pm	62.8	38	31.4	**54.4**	85.8	31.4
2:00 pm - 2:15 pm	65.4	44.6	30.9	**54.4**	88.9	34.5
2:15 pm - 2:30 pm	61.7	43.6	33.2	**47.1**	75.6	28.5
2:30 pm - 2:45 pm	62.9	37	33.7	**51.2**	80.4	29.2
2:45 pm - 3:00 pm	66.2	38.7	32	**58.2**	92.4	34.2

The morning session measurement shows that the L_{10} measurement ranges from 60.7 dB(A) to 71.4 dB(A), the L_{50} measurement ranges from 33.2 dB(A) to 46.2 dB(A) and the L_{90} measurement ranges from 30.2 dB(A) to 34.8 dB(A). The afternoon session measurement shows that the L_{10} measurement ranges from 61.7 dB(A) to 66.5 dB(A), the L_{50} measurement ranges from 34.1 dB(A) to 44.6 dB(A) and the L_{90} measurement ranges from 30.1 dB(A) to 33.7 dB(A).

The equivalent acoustic level (Leq) throughout the day ranges from 35.5 dB(A) to 59 dB(A) the highest being recorded from 1:30 pm to 1:45 pm. The noise pollution level (L_{NP}) throughout the day ranges from 65.4 dB(A) to 95.4 dB(A) whereas the noise climate (NC) recorded throughout the day ranges from 28.5 dB(A) to 40.5 dB(A). The record shows that there was a higher difference in L_{10} and L_{90} in the morning.

4.3.7. Noise Level of Rift Valley University

The following data is a record of ambient noise level recorded in Rift Valley University and their calculated noise parameters.

Table 4.60: *Various measured and calculated noise parameters in Rift Valley University*

Morning (January 22)	L10	L50	L90	Leq	LNP	NC
9:00 am - 9:15 am	62.4	39.4	32.6	**41.4**	71.2	29.8
9:15 am - 9:30 am	61.5	38.6	35.5	**44.2**	70.2	26
9:30 am - 9:45 am	64.1	40.2	33	**42.5**	73.6	31.1
9:45 am - 10:00 am	62.6	43.3	41.3	**50.9**	72.2	21.3
10:00 am - 10:15 am	70.6	45.9	40.9	**51.1**	80.8	29.7
10:15 am - 10:30 am	74.7	47.2	38	**50.6**	87.3	36.7
10:30 am - 10:45 am	72.9	47.4	37.9	**48.7**	83.7	35
10:45 am - 11:00 am	68.5	42.8	38.5	**49.5**	79.5	30
11:00 am - 11:15 am	66.2	45.7	41.8	**55.6**	80	24.4
11:15 am - 11:30 am	69.3	43.3	39	**50.3**	80.6	30.3
11:30 am - 11:45 am	70.7	46.1	45.2	**55.3**	80.8	25.5
11:45 am - 12:00 Pm	73.2	49.2	45.9	**55.5**	82.8	27.3
Afternoon (January 22)						
1:00 pm - 1:15 pm	67.3	44.2	42.3	**51.2**	76.2	25
1:15 pm - 1:30 pm	68.6	50.1	48.7	**56.7**	76.6	19.9
1:30 pm - 1:45 pm	70.7	42.5	40.5	**53.8**	84	30.2
1:45 pm - 2:00 pm	72.1	45.9	41.8	**53.2**	83.5	30.3
2:00 pm - 2:15 pm	73.6	46.3	42.9	**55.3**	86	30.7
2:15 pm - 2:30 pm	76.4	40.8	36	**57.1**	97.5	40.4
2:30 pm - 2:45 pm	78.9	49.4	42.4	**56.9**	93.4	36.5
2:45 pm - 3:00 pm	75.8	41.6	33.2	**52.7**	95.3	42.6
3:00 pm - 3:15 pm	77.2	47.1	38.2	**53.3**	92.3	39
3:15 pm - 3:30 pm	73.6	43.8	37.4	**52.2**	88.4	36.2
3:30 pm - 3:45 pm	71.1	40.5	34.9	**50.5**	86.7	36.2
3:45 pm - 4:00 pm	77.2	48.2	40.8	**54.8**	91.2	36.4

(Source: Author, 2024)

The morning session measurement shows that the L_{10} measurement ranges from 61.5 dB(A) to 74.7 dB(A), the L_{50} measurement ranges from 38.6 dB(A) to 49.2 dB(A) and the L_{90} measurement ranges from 32.6 dB(A) to 45.9 dB(A). The afternoon session measurement shows that the L_{10} measurement ranges from 67.3 dB(A) to 78.9 dB(A), the L_{50} measurement ranges from 40.5 dB(A) to 50.1 dB(A) and the L_{90} measurement ranges from 33.2 dB(A) to 48.7 dB(A).

The equivalent acoustic level (Leq) throughout the day ranges from 41.4 dB(A) to 57.1 dB(A) the highest being recorded from 2:15 pm to 2:30 pm. The noise pollution level (L_{NP}) throughout the day ranges from 70.2 dB(A) to 97.5 dB(A) whereas the noise climate (NC) recorded throughout the day ranges from 19.9 dB(A) to 42.6 dB(A). The record shows that there was a higher difference in L_{10} and L_{90} in the morning.

4.3.8. Noise Level of St. Mary School

The following data is a record of ambient noise level recorded in St. Mary School and their calculated noise parameters.

Table 4.61: *Various measured and calculated noise parameters in St. Mary School*

Morning (January 26)	L10	L50	L90	Leq	LNP	NC
9:00 am - 9:15 am	64.1	42.9	39.3	**53.2**	78	24.8
9:15 am - 9:30 am	69.5	37.5	37.2	**54.9**	87.2	32.3
9:30 am - 9:45 am	62.7	46.4	39.1	**55.7**	79.3	23.6
9:45 am - 10:00 am	71.7	43.7	42.3	**58.1**	87.5	29.4
10:00 am - 10:15 am	71.4	45	40.8	**52.4**	83	30.6
10:15 am - 10:30 am	75.7	45.4	41.5	**56.8**	87.1	30.3
10:30 am - 10:45 am	77.1	43.1	32	**51.3**	96.4	45.1
10:45 am - 11:00 am	65.3	40.7	38.9	**49**	75.4	26.4
11:00 am - 11:15 am	73.5	39.9	31.8	**50.6**	92.3	41.7
11:15 am - 11:30 am	72.8	37.6	36.5	**57.2**	93.5	36.3
11:30 am - 11:45 am	74.9	42.8	42.5	**59.7**	92.1	32.4
11:45 am - 12:00 Pm	74	41.8	36.8	**54.1**	91.3	37.2
Afternoon (January 26)						
1:00 pm - 1:15 pm	65.2	40.6	37.7	**47.8**	75.3	27.5
1:15 pm - 1:30 pm	66.8	38.2	35.7	**49.3**	80.4	31.1
1:30 pm - 1:45 pm	69.3	42.2	41.9	**54.7**	82.1	27.4
1:45 pm - 2:00 pm	67.3	42.3	41.7	**52.1**	77.7	25.6
2:00 pm - 2:15 pm	70.4	39.7	32.7	**48.4**	86.1	37.7
2:15 pm - 2:30 pm	72.1	44.8	37.1	**49.5**	84.5	35
2:30 pm - 2:45 pm	75.9	43.1	32.6	**50.5**	93.8	43.3
2:45 pm - 3:00 pm	71.3	36.5	30.1	**50.3**	91.5	41.2

3:00 pm - 3:15 pm	70.6	42.7	39.9	**52.9**	83.6	30.7
3:15 pm - 3:30 pm	74.3	40.1	32.1	**51.6**	93.8	42.2

(Source: Author, 2024)

The morning session measurement shows that the L_{10} measurement ranges from 62.7 dB(A) to 77.1 dB(A), the L_{50} measurement ranges from 37.5 dB(A) to 46.4 dB(A) and the L_{90} measurement ranges from 31.8 dB(A) to 42.5 dB(A). The afternoon session measurement shows that the L_{10} measurement ranges from 65.2 dB(A) to 75.9 dB(A), the L_{50} measurement ranges from 36.5 dB(A) to 44.8 dB(A) and the L_{90} measurement ranges from 30.1 dB(A) to 41.9 dB(A).

The equivalent acoustic level (Leq) throughout the day ranges from 47.8 dB(A) to 59.7 dB(A) the highest being recorded from 11:30 am to 11:45 am. The noise pollution level (L_{NP}) throughout the day ranges from 75.3 dB(A) to 96.4 dB(A) whereas the noise climate (NC) recorded throughout the day ranges from 23.6 dB(A) to 45.1 dB(A). The record shows that there was a higher difference in L_{10} and L_{90} in the afternoon.

4.3.9. Correlation of Measured Leq And Calculated Leq

The table below shows the correlation of measured equivalent noise level which is obtained from the physical measurement on the field and calculated equivalent noise level which was obtained by calculation using equation (4).

Table 4.62: *Correlation between measured Leq and calculated Leq*

		Leq measured	Leq calculated
Leq measured	Pearson Correlation	1	.967**
	Sig. (2-tailed)		.000
	N	222	222
Leq calculated	Pearson Correlation	.967**	1
	Sig. (2-tailed)	.000	
	N	222	222
**. Correlation is significant at the 0.01 level (2-tailed).			

(Source: Author, 2024)

The Pearson's *r* value of the correlation of measured Leq and calculated Leq was 0.967 which indicates that the values obtained has a very strong positive relationship and the relationship is significant.

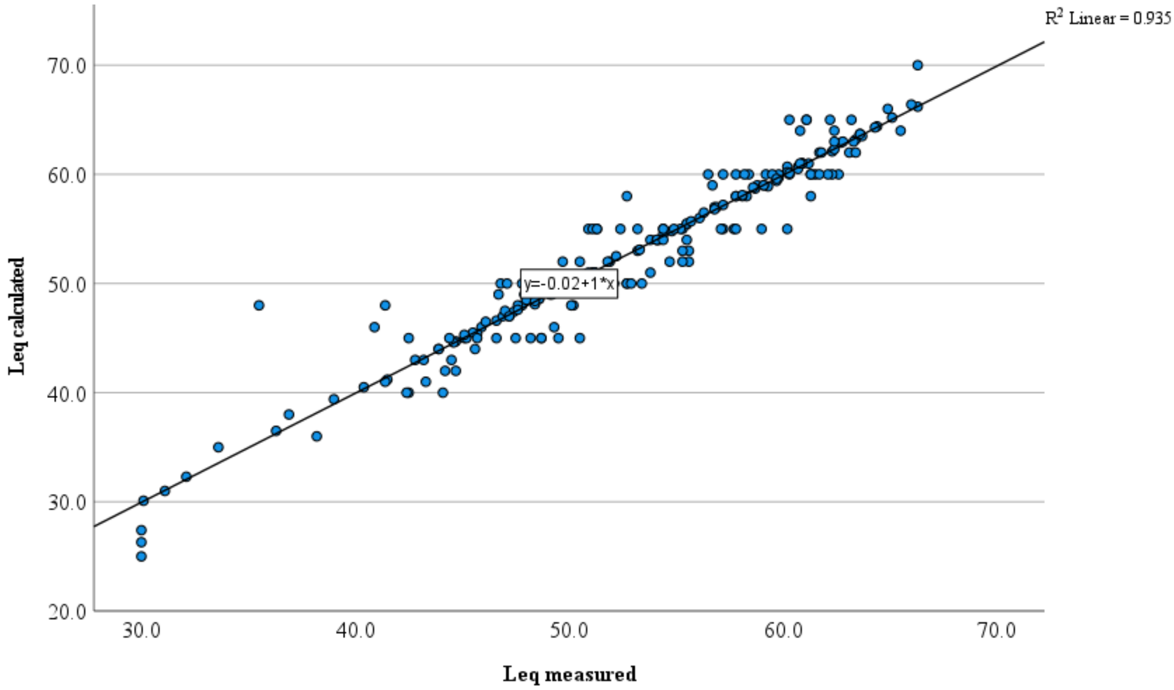

Figure 4.17: *Scatter plot of calculated Leq by measured Leq*

4.3.10. Noise Parameters Analysis

Table 4.63, figure 4.18 and figure 4.19 illustrate that in the Adama General Hospital, the average L_{10} was 63.01 dB(A) with a standard deviation of 7.67, the average L_{50} was 41.74 dB(A) with a standard deviation of 5.26, the average L_{90} was 36.17 dB(A) with a standard deviation of 4.42. The average equivalent noise level was 53.43 dB(A) with a standard deviation of 9.24, the average L_{NP} was 80.26 dB(A) with a standard deviation of 13.8 and the average noise climate was 26.84 dB(A) with a standard deviation of 5.58. Most frequent equivalent noise levels were between 55 dB(A) and 65 dB(A) while the noise climate has a relatively even distribution.

Table 4.63: *Average values and standard deviations of the noise parameters in Adama General Hospital*

		L_{10}	L_{50}	L_{90}	Leq	LNP	NC
N	Valid	36	36	36	36	36	36
Mean		63.01	41.74	36.17	53.43	80.26	26.84
Std. Deviation		7.67	5.26	4.42	9.24	13.80	5.58

(Source: Author, 2024)

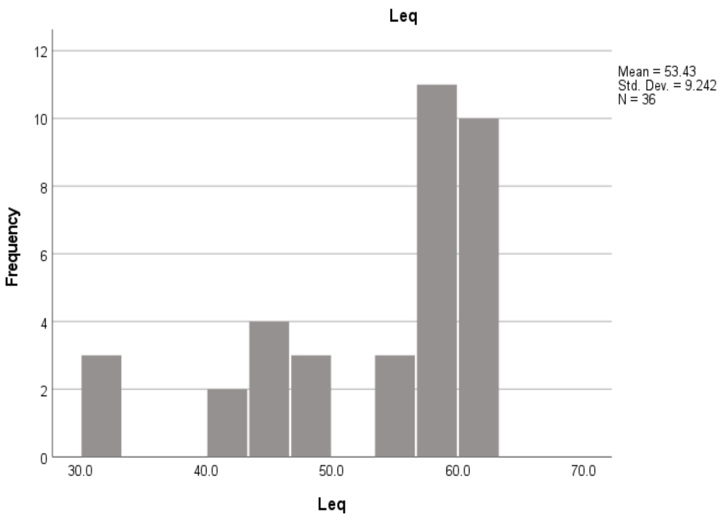

Figure 4.18: *Adama General Hospital's average equivalent noise level and its standard deviation*

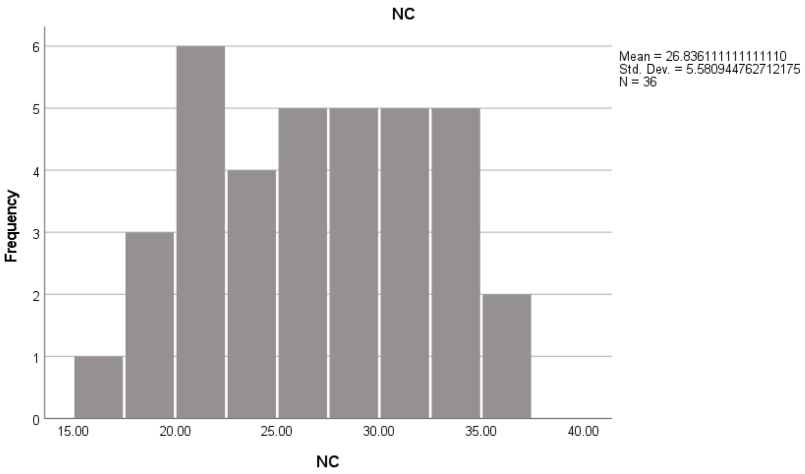

Figure 4.19: *Adama General Hospital's average Noise climate and its standard deviation*

Table 4.64, figure 4.20 and figure 4.21 illustrate that in the Adama Referral Hospital, the average L_{10} was 77.45 dB(A) with a standard deviation of 8.51, the average L_{50} was 53.02 dB(A) with a standard deviation of 5.13, the average L_{90} was 42.55 dB(A) with a standard deviation of 4.95, the average equivalent noise level was 59.18 dB(A) with a standard deviation of 6.7, the average L_{NP} was 94.08 dB(A) with a standard deviation of 11.49 and the average noise climate was 34.9 dB(A) with a standard deviation of 6.06. Most frequent equivalent noise levels were between 60 dB(A) and 67 dB(A) while the most frequent noise climate was between 30 dB(A) and 35 dB(A).

__Table 4.64:__ Average values and standard deviations of the noise parameters in Adama Referral Hospital

		L_{10}	L_{50}	L_{90}	Leq	LNP	NC
N	Valid	36	36	36	36	36	36
Mean		77.45	53.02	42.55	59.18	94.08	34.90
Std. Deviation		8.51	5.13	4.95	6.70	11.49	6.06

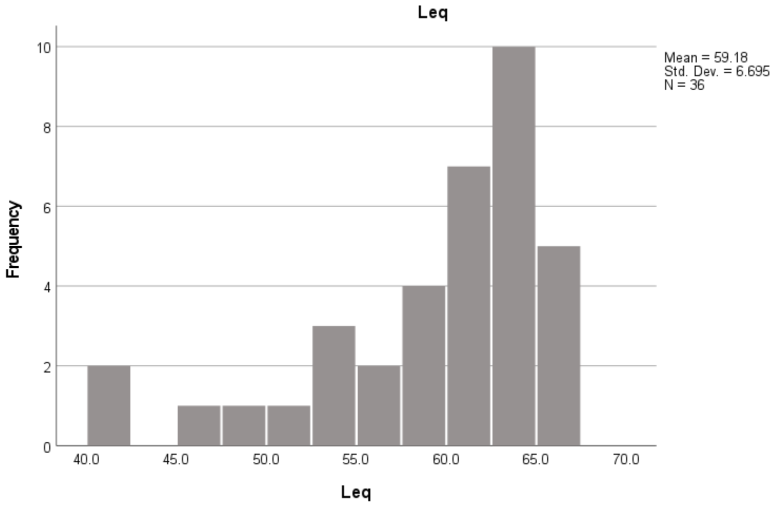

***Figure 4.20:** Adama Referral Hospital's average equivalent noise level and its standard deviation*

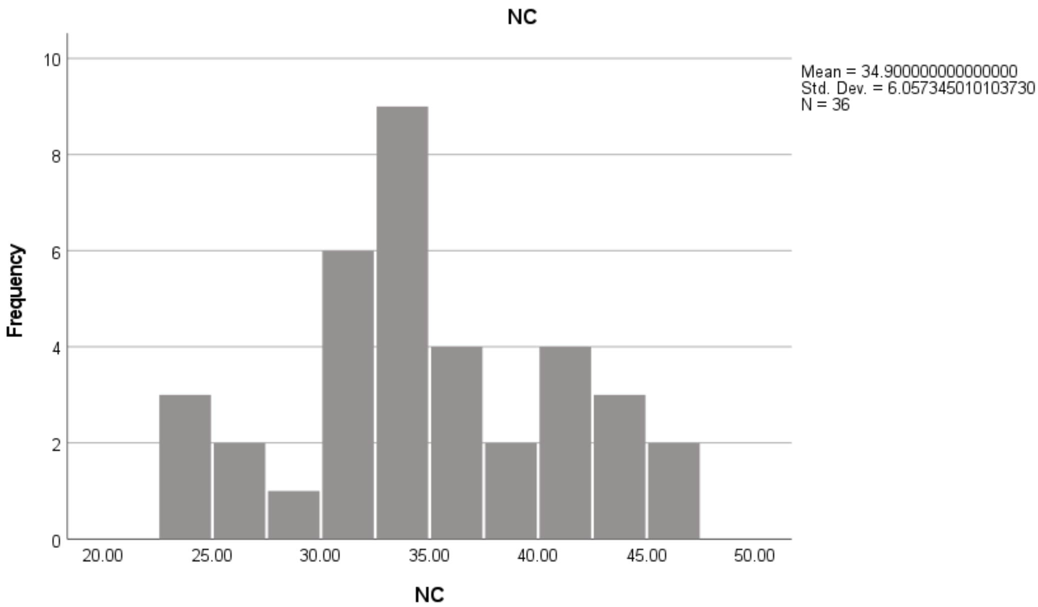

***Figure 4.21:** Adama Referral Hospital's average Noise climate and its standard deviation*

Table 4.65, figure 4.22 and figure 4.23 illustrate that in the Sister Aklesia Memorial Hospital, the average L_{10} was 71.56 dB(A) with a standard deviation of 11.34, the average L_{50} was 44.83 dB(A) with a standard deviation of 8.69, the average L_{90} was 41.63 dB(A) with a standard deviation of 8.45.

The average equivalent noise level was 54.58 dB(A) with a standard deviation of 10.36, the average L_{NP} was 83.6 dB(A) with a standard deviation of 15.23 and the average noise climate was 29.02 dB(A) with a standard deviation of 7.54. Most frequent equivalent noise levels were between 57 dB(A) and 63 dB(A) while the most frequent noise climate was between 25 dB(A) and 30 dB(A).

Table 4.65: *Average values and standard deviations of the noise parameters in Sister Aklesia Memorial Hospital*

		L_{10}	L_{50}	L_{90}	Leq	LNP	NC
N	Valid	36	36	36	36	36	36
Mean		71.56	44.83	41.63	54.58	83.60	29.02
Std. Deviation		11.34	8.69	8.45	10.36	15.23	7.54

(Source: Author, 2024)

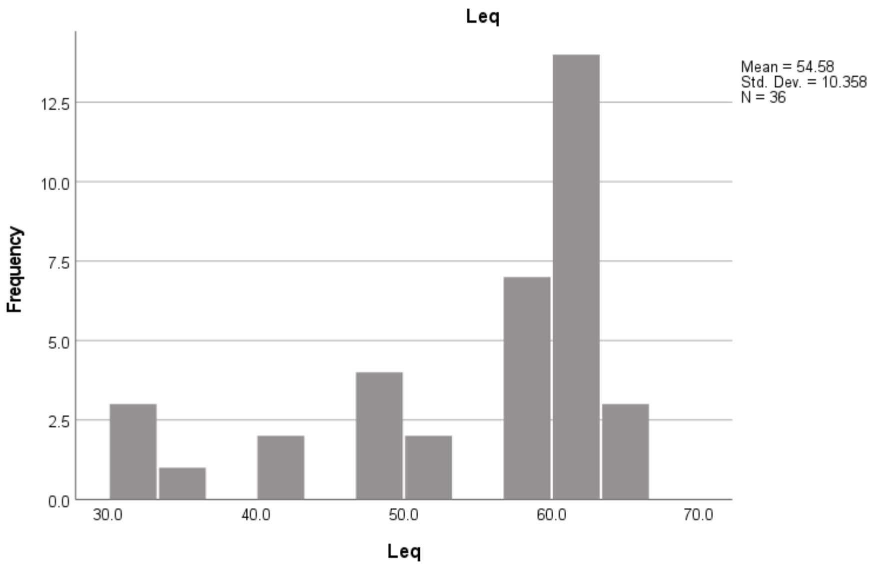

Figure 4.22: *Sister Aklesia Memorial Hospital's average equivalent noise level and its standard deviation*

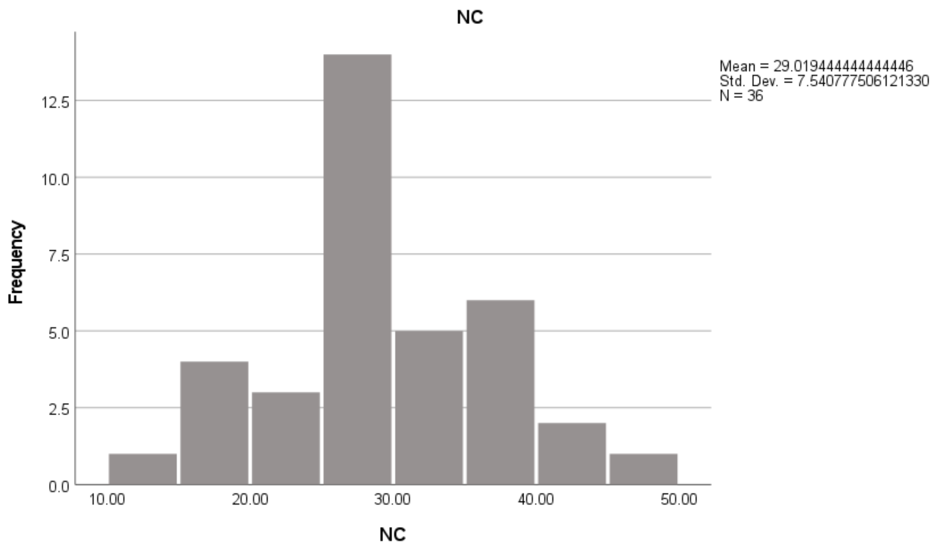

Figure 4.23: *Sister Aklesia Memorial Hospital's average Noise climate and its standard deviation*

Table 4.66, figure 4.24 and figure 4.25 illustrate that in the Adama Highschool, the average L_{10} was 72.66 dB(A) with a standard deviation of 4.85, the average L_{50} was 43.3 dB(A) with a standard deviation of 3.14, the average L_{90} was 38.92 dB(A) with a standard deviation of 2.65.

The average equivalent noise level was 47.93 dB(A) with a standard deviation of 2.14, the average L_{NP} was 81.64 dB(A) with a standard deviation of 5.29 and the average noise climate was 33.71 dB(A) with a standard deviation of 4.07. Most frequent equivalent noise levels were between 47 dB(A) and 49 dB(A) while the most frequent noise climate was around 32.5 dB(A).

Table 4.66: *Average values and standard deviations of the noise parameters in Adama Highschool*

		L_{10}	L_{50}	L_{90}	Leq	LNP	NC
N	Valid	24	24	24	24	24	24
Mean		72.66	43.30	38.92	47.93	81.64	33.71
Std. Deviation		4.85	3.14	2.65	2.14	5.29	4.07

(Source: Author, 2024)

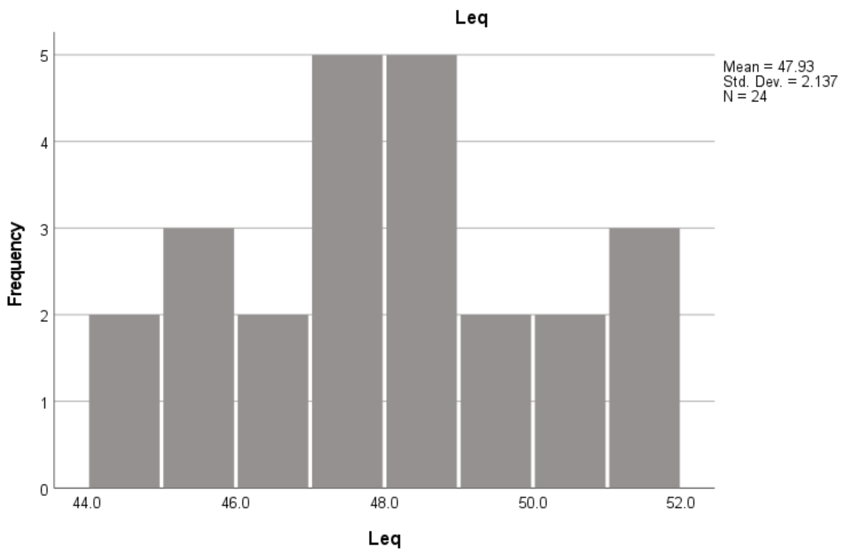

Figure 4.24: *Adama Highschool's average equivalent noise level and its standard deviation*

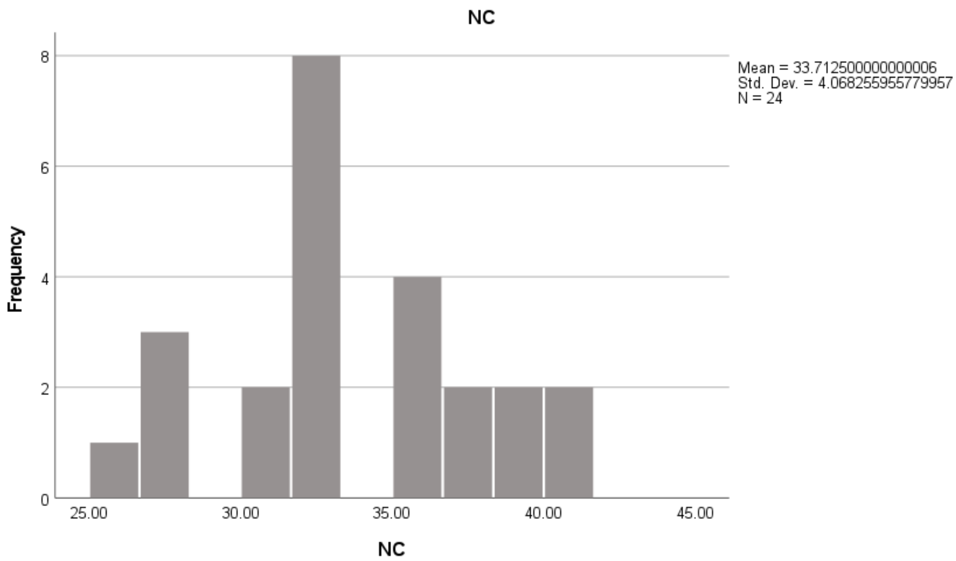

Figure 4.25: *Adama Highschool's average Noise climate and its standard deviation*

Table 4.67, figure 4.26 and figure 4.27 illustrate that in the Goro Highschool, the average L_{10} was 69.39 dB(A) with a standard deviation of 4.84, the average L_{50} was 41.75 dB(A) with a standard deviation of 3.1, the average L_{90} was 36.93 dB(A) with a standard deviation of 3.71, the average equivalent noise level was 50.24 dB(A) with a standard deviation of 4.18.

The average L_{NP} was 82.7 dB(A) with a standard deviation of 7.3 and the average noise climate was 32.46 dB(A) with a standard deviation of 5.61. Most frequent equivalent noise levels were between 45 dB(A) and 50 dB(A) while the most frequent noise climate was between 30 dB(A) and 35 dB(A).

Table 4.67: *Average values and standard deviations of the noise parameters in Goro Highschool*

		L_{10}	L_{50}	L_{90}	Leq	LNP	NC
N	Valid	24	24	24	24	24	24
Mean		69.39	41.75	36.93	50.24	82.70	32.46
Std. Deviation		4.84	3.10	3.71	4.18	7.30	5.61

(Source: Author, 2024)

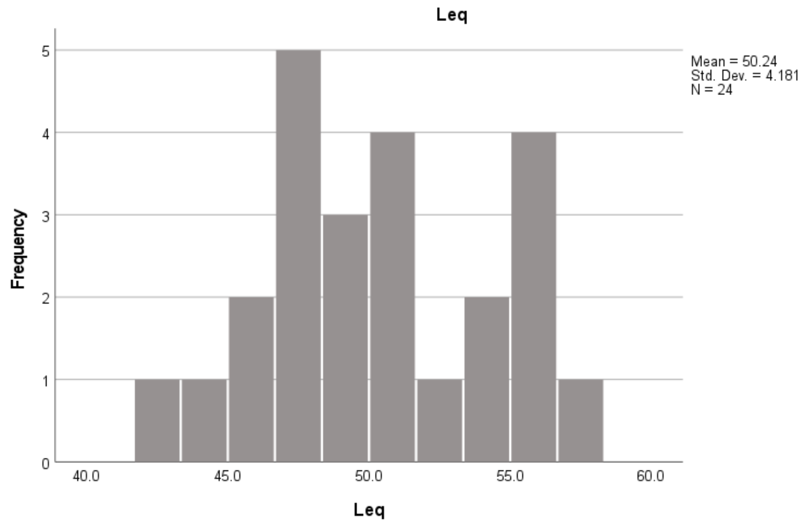

Figure 4.26: *Goro Highschool's average equivalent noise level and its standard deviation*

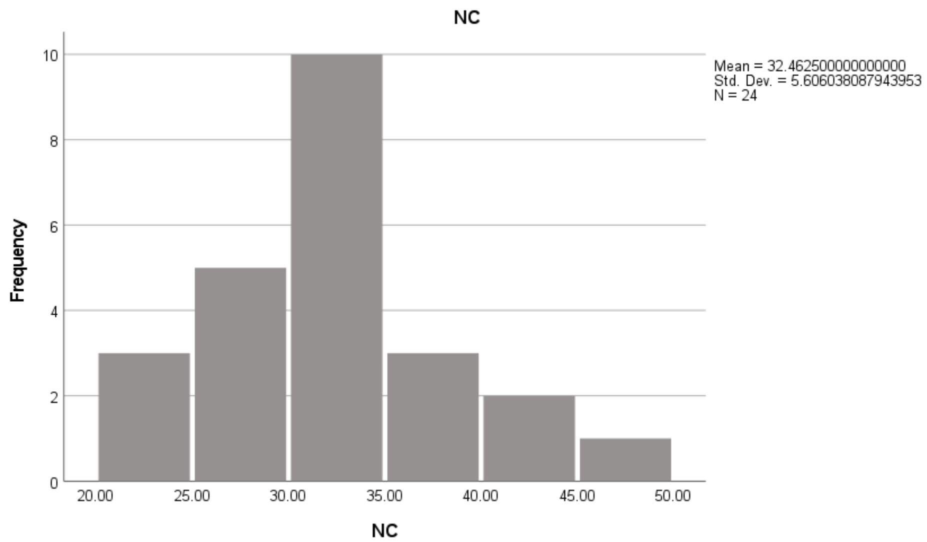

Figure 4.27: *Goro Highschool's average Noise climate and its standard deviation*

Table 4.68, figure 4.28 and figure 4.29 illustrate that in the ODA Special Boarding School, the average L_{10} was 64.32 dB(A) with a standard deviation of 2.45, the average L_{50} was 39.62 dB(A) with a standard deviation of 3.92, the average L_{90} was 32.06 dB(A) with a standard deviation of 1.31.

The average equivalent noise level was 46.1 dB(A) with a standard deviation of 7.23, the average L_{NP} was 78.36 dB(A) with a standard deviation of 8.27 and the average noise climate was 32.26 dB(A) with a standard deviation of 3.01. Most frequent equivalent noise levels were between 40 dB(A) and 45 dB(A) while the most frequent noise climate was between 30 dB(A) and 32 dB(A).

Table 4.68*: Average values and standard deviations of the noise parameters in ODA Special Boarding School*

		L_{10}	L_{50}	L_{90}	Leq	LNP	NC
N	Valid	20	20	20	20	20	20
Mean		64.32	39.62	32.06	46.10	78.36	32.26
Std. Deviation		2.45	3.92	1.31	7.23	8.27	3.01

(Source: Author, 2024)

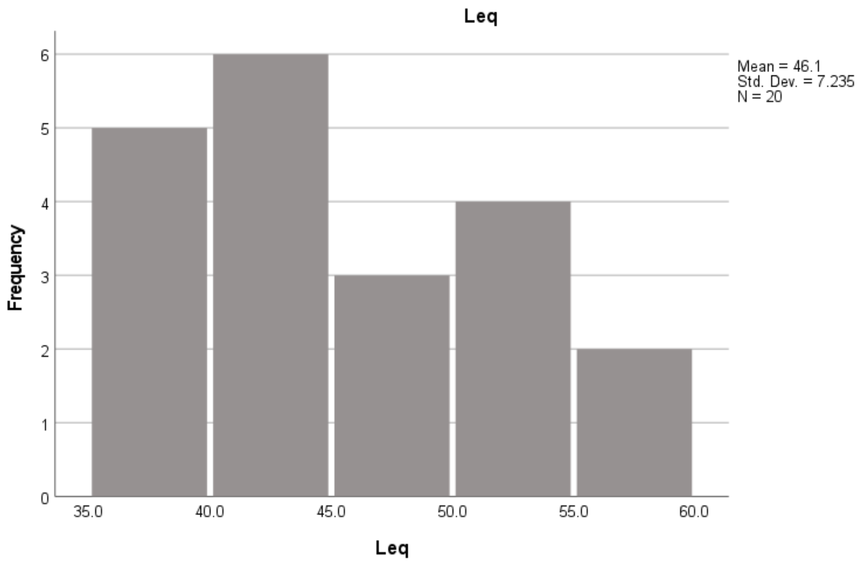

Figure 4.28: *ODA Special Boarding School's average equivalent noise level and its standard deviation*

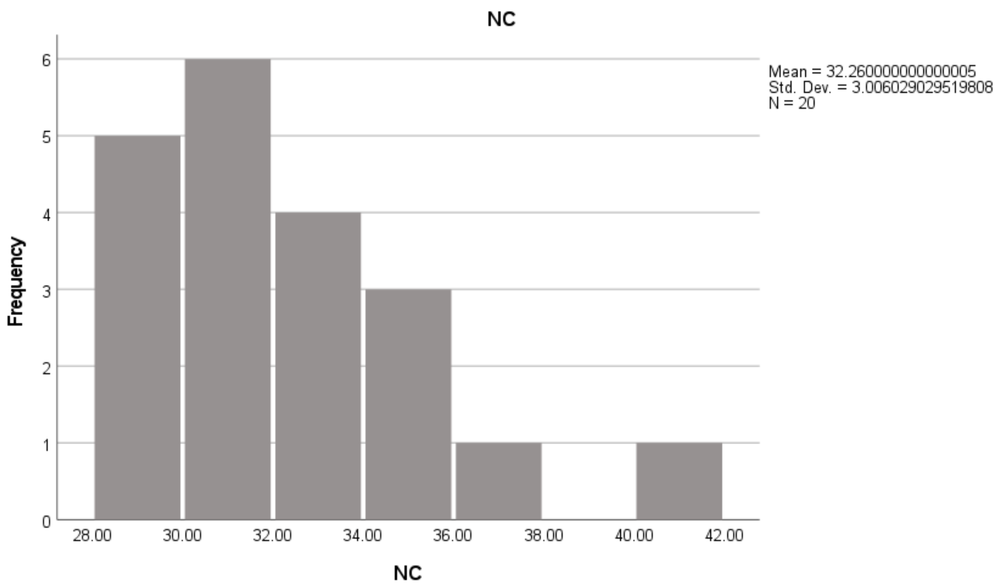

Figure 4.29: *ODA Special Boarding School's average Noise climate and its standard deviation*

Table 4.69, figure 4.30 and figure 4.31 illustrate that in the Rift Valley University, the average L_{10} was 70.8 dB(A) with a standard deviation of 4.94, the average L_{50} was 44.56 dB(A) with a standard deviation of 3.31, the average L_{90} was 39.53 dB(A) with a standard deviation of 4.15, the average equivalent noise level was 51.8 dB(A) with a standard deviation of 4.29, the average L_{NP} was 83.08 dB(A) with a standard deviation of 7.6 and the average noise climate was 31.27 dB(A) with a standard deviation of 5.97. Most frequent equivalent noise levels were between 50 dB(A) and 53 dB(A) while the most frequent noise climate was between 35 dB(A) and 40 dB(A).

Table 4.69: *Average values and standard deviations of the noise parameters in Rift Valley University*

		L_{10}	L_{50}	L_{90}	Leq	LNP	NC
N	Valid	24	24	24	24	24	24
Mean		70.80	44.56	39.53	51.80	83.08	31.27
Std. Deviation		4.94	3.31	4.15	4.29	7.60	5.97

(Source: Author, 2024)

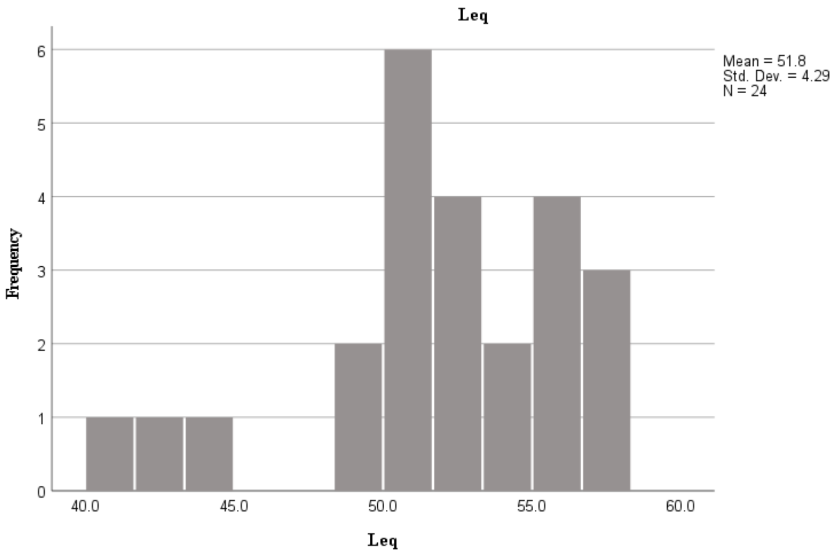

Figure 4.30: *Rift Valley University's average equivalent noise level and its standard deviation*

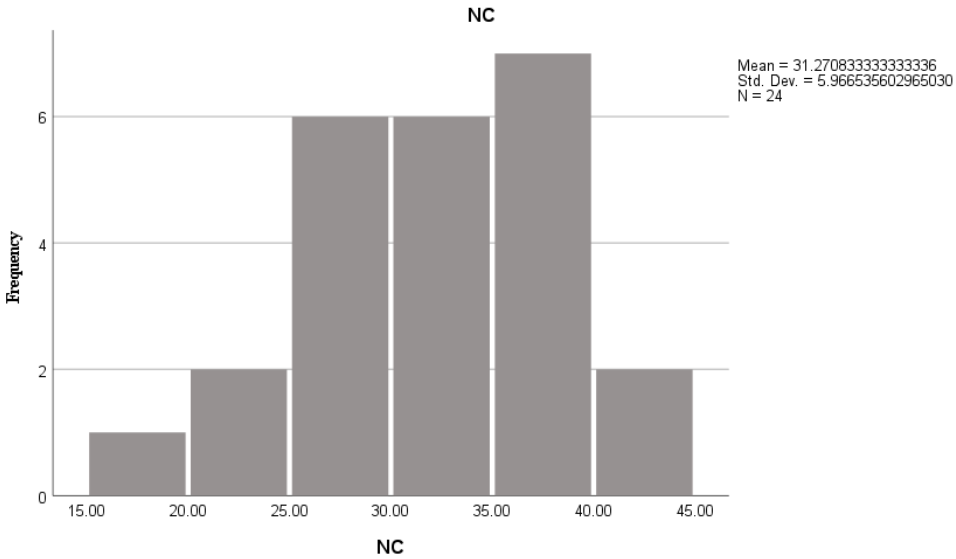

Figure 4.31: *Rift Valley University's average Noise climate and its standard deviation*

Table 4.70, figure 4.32 and figure 4.33 illustrate that in the St. Mary School, the average L_{10} was 70.72 dB(A) with a standard deviation of 4.07, the average L_{50} was 41.68 dB(A) with a standard deviation of 2.71, the average L_{90} was 37.28 dB(A) with a standard deviation of 3.92, the average equivalent noise level was 52.73 dB(A) with a standard deviation of 3.32.

The average L_{NP} was 86 dB(A) with a standard deviation of 6.53 and the average noise climate was 33.26 dB(A) with a standard deviation of 6.49. Most frequent equivalent noise levels were between 50 dB(A) and 52 dB(A) while the most frequent noise climate was between 30 dB(A) and 32 dB(A).

Table 4.70: Average values and standard deviations of the noise parameters in St. Mary School

		L_{10}	L_{50}	L_{90}	Leq	LNP	NC
N	Valid	22	22	22	22	22	22
Mean		70.72	41.68	37.28	52.73	86.00	33.26
Std. Deviation		4.07	2.71	3.92	3.32	6.53	6.49

(Source: Author, 2024)

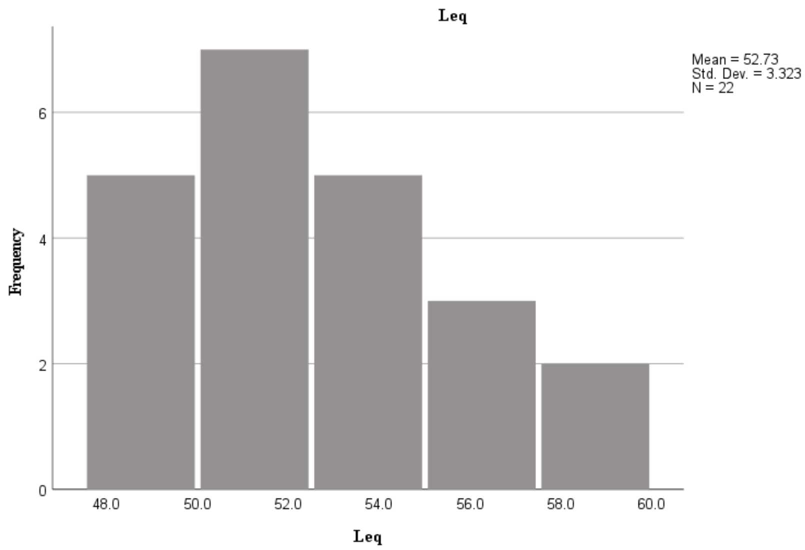

Figure 4.32: *St. Mary School's average equivalent noise level and its standard deviation*

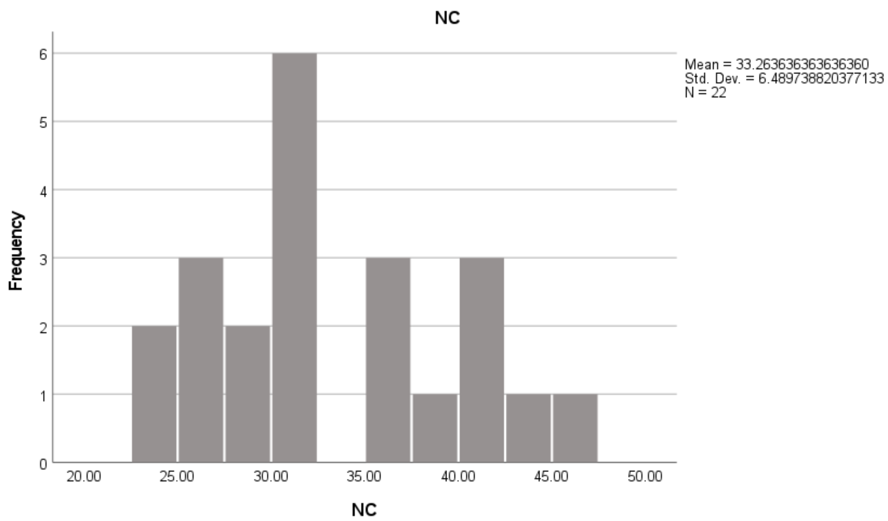

Figure 4.33: *St. Mary School's average Noise climate and its standard deviation*

4.3.11. Noise level comparison between the study areas

Table 4.71: *Average noise descriptor values of each study area*

Study areas	L_{10}	L_{50}	L_{90}	Leq	L_{NP}	NC
Adama General Hospital	63.01	41.74	36.17	53.43	80.26	26.84
Adama Referral Hospital	77.45	53.02	42.55	59.18	94.08	34.90
Sister Aklesia Memorial Hospital	71.56	44.83	41.63	54.58	83.60	29.02
Adama Highschool	72.66	43.30	38.92	47.93	81.64	33.71
Goro Highschool	69.39	41.75	36.93	50.24	82.70	32.46
ODA Special Boarding School	64.32	39.62	32.06	46.10	78.36	32.26
Rift Valley University	70.80	44.59	39.53	51.80	83.08	31.27
St. Mary School	70.72	41.68	37.28	52.73	86.00	33.26

Amongst the selected study areas, Adama Referral Hospital scored higher noise level in every noise parameter used for analysis. The lowest L_{10} and NC was recorded in Adama General Hospital which indicates that the noise level around that area is stable and does not fluctuate as much as the other study areas. The lowest L_{50}, L_{90}, Leq and LNP was recorded in ODA Special Boarding School which indicates that the overall noise pollution level is lower than the other study areas.

4.3.12. Linear Multiple Regression

4.3.12.1. Equivalent noise level (Leq)

The result for the noise parameter Leq (dependent variable) is illustrated below. The analysis was to test if the independent variables L_{90}, L_{10} and L_{50} account for the variance in Leq.

Table 4.72: *Regression predicting Leq*

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.801[a]	.642	.637	4.74434
a. Predictors: (Constant), L_{90}, L_{10}, L_{50}				

In the table above, the R square of the model summary is the measure of the amount of variance in the dependent variable that is caused by the independent variables when taken as a group. R^2=0.642; taken as a set, the predictors (independent variables) L_{10}, L_{50} and L_{90} were responsible for 64% of the variance in the equivalent noise level.

Table 4.73: *Beta coefficients of Leq*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.319	2.720		.117	.907
	L_{10}	.393	.053	.423	7.378	.000
	L_{50}	.264	.090	.219	2.944	.004
	L_{90}	.340	.097	.249	3.498	.001
a. Dependent Variable: Leq						

The coefficient in table 4.73 indicates, the effect of each of the predictors individually and checks where the given predictor is significant on its own. Seeing at the p-values of the predictors, L_{10} (B=0.393; p=0.000), L_{50} (B=0.264; p=0.004), and L_{90} (B=0.340; p=0.001) tested each at Alpha = 0.05. All of independent variables have a significant impact on the equivalent noise level.

Generally, the researcher aimed to investigate whether L_{10}, L_{50} and L_{90} has a significant impact on the equivalent noise level or not. The hypothesis was put as follows.

H1: There is a significant impact of L_{10} on the equivalent noise level.

H2: There is a significant impact of L_{50} on the equivalent noise level.

H3: There is a significant impact of L_{90} on the equivalent noise level.

Table 4.74: *Regression analysis summary for Leq*

Hypothesis	Regression weights	Beta coefficient	R^2	F	t-value	p-value	Hypothesis supported
H1	$L_{10}\rightarrow$Leq	.393	.642	130.422	7.378	.000	Yes
H2	$L_{50}\rightarrow$Leq	-264	.642	130.422	2.944	.004	Yes
H3	$L_{90}\rightarrow$Leq	-340	.642	130.422	3.498	.001	Yes

(Source: Author, 2024)

4.3.12.2. Noise Climate (NC)

The result for the noise parameter NC (dependent variable) is illustrated below. The analysis was to test if the independent variables L_{90} and L_{10} account for the variance in NC.

Table 4.75: *Regression predicting NC*

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.988[a]	.977	.977	.97592
a. Predictors: (Constant), L_{90}, L_{10}				

In the table above, the R square of the model summary is the measure of the amount of variance in the dependent variable that is caused by the independent variables when taken as a group. R^2=0.977; taken as a set, the predictors (independent variables) L_{10} and L_{90} were responsible for 98% of the variance in the noise climate.

Table 4.76: *Beta coefficients of NC*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.294	.558		2.317	.021
	L_{10}	.981	.010	1.304	95.842	.000
	L_{90}	-1.003	.015	-.908	-66.705	.000
a. Dependent Variable: NC						

The coefficient in table 4.76 indicates, the effect of each of the predictors individually and checks where the given predictor is significant on its own. Seeing at the p-values of the predictors, L_{10} (B=1.304; p=0.000) and L_{90} (B=-0.908; p=0.001) tested each at Alpha = 0.05. The negative beta value for all variables indicates that when L_{90} increases NC decreases. Both of the independent variables have a significant impact on the noise climate.

Generally, the researcher aimed to investigate whether L_{10} and L_{90} has a significant impact on the noise climate or not. The hypothesis was put as follows.

H1: There is a significant impact of L_{10} on the noise climate.

H2: There is a significant impact of L_{50} on the noise climate.

Table 4.77: *Regression analysis summary for NC*

Hypothesis	Regression weights	Beta coefficient	R^2	F	t-value	p-value	Hypothesis supported
H1	$L_{10} \rightarrow NC$	.981	.977	4606.980	95.842	.000	Yes
H2	$L_{90} \rightarrow NC$	-1.003	.977	4606.980	-66.705	.000	Yes

(Source: Author, 2024)

4.3.13. Inter Factor Correlation

Pearson's *r* varies between +1 and -1. The strength of the relationship between variables is strong if it is 0.7 and above, moderate if it is 0.4 – 0.69, week if it is 0.1 – 0.39, and has no relationship if the value is 0 to 0.1. In the table below, the relationship under their variable category is highlighted. The r value for the correlation of Leq and NC was 0.324 which indicates that they have a week positive relationship (see table 4.78).

Table 4.78: *Correlation between Leq and NC*

		Leq	**NC**
Leq	Pearson Correlation	1	.324**
	Sig. (2-tailed)		.000
	N	222	222
NC	Pearson Correlation	.324**	1
	Sig. (2-tailed)	.000	
	N	222	222
**. Correlation is significant at the 0.01 level (2-tailed).			

(Source: Author, 2024)

4.4. COMPARISON WITH WHO GUIDELINE

4.4.1. Leq of Adama General Hospital

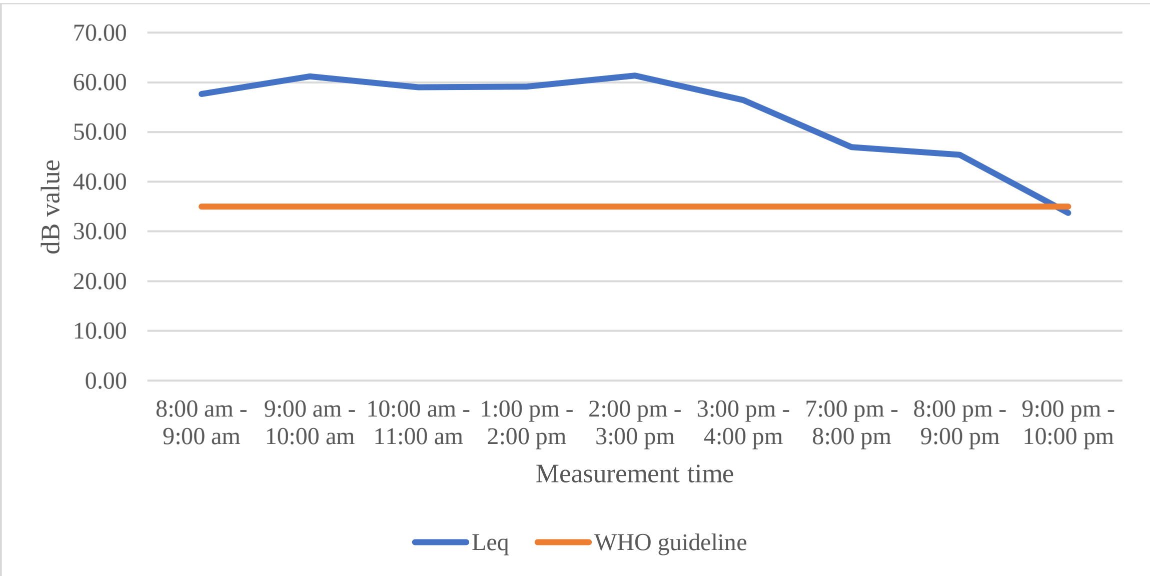

Figure 4.34: *Comparison between Leq and WHO guideline of the evening measurement in Adama General Hospital*

Figure 4.34 indicates that for the majority of the time measured the equivalent noise level (Leq) of Adama General Hospital was higher than the recommended permissible limit put by WHO. Relatively, the evening time has less noise compared to the morning and afternoon measuring times. Starting from 9:15 pm, the Leq falls under the permissible noise limit recommended by WHO.

4.4.2. Leq of Adama Referral Hospital

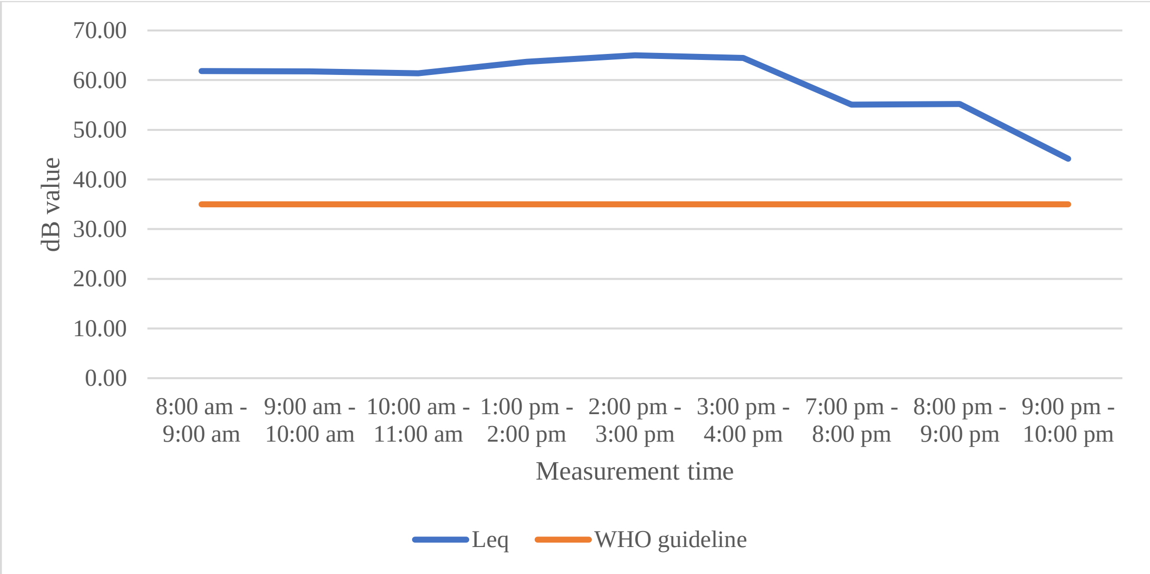

Figure 4.35: *Comparison between Leq and WHO guideline of the evening measurement in Adama Referral Hospital*

Figure 4.35 indicates that all of the time measured the equivalent noise level (Leq) of Adama Referral Hospital was higher than the recommended permissible limit put by WHO. Relatively, the evening time has less noise compared to the morning and afternoon measuring times. It was noisier in the hospital during the afternoon.

4.4.3. Leq of Sister Aklesia Memorial Hospital

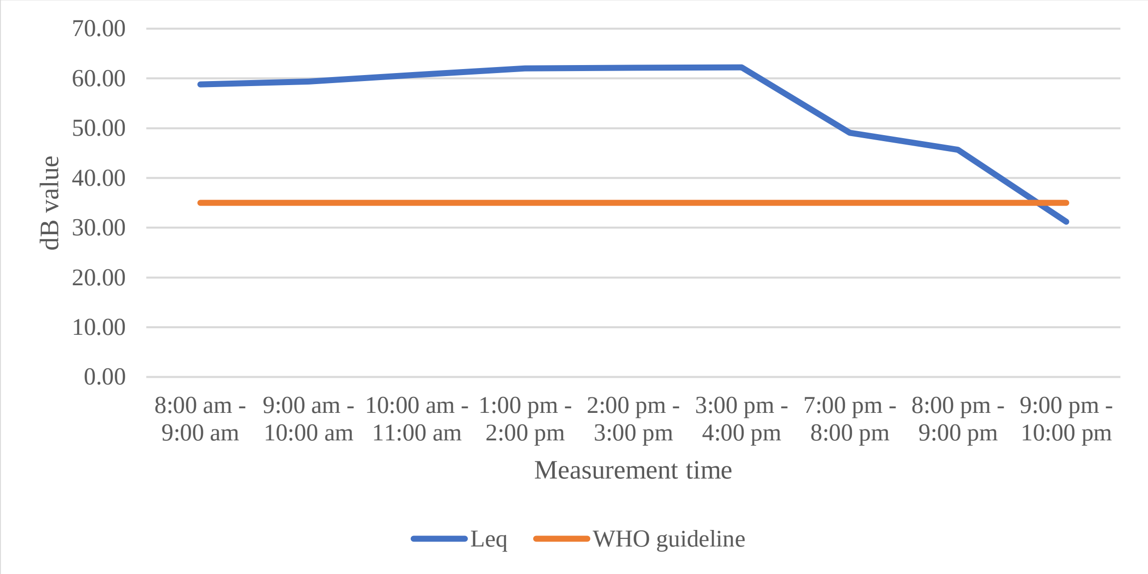

Figure 4.36: *Comparison between Leq and WHO guideline of the evening measurement in Sister Aklesia Memorial Hospital*

Figure 4.36 indicates that for the majority of the time measured the equivalent noise level (Leq) of Sister Aklesia Memorial Hospital was higher than the recommended permissible limit put by WHO. Relatively, the evening time has less noise compared to the morning and afternoon measuring times. Starting from 9:00 pm, the Leq falls under the permissible noise limit recommended by WHO and it was noisier in afternoon.

4.4.4. Leq of Adama Highschool

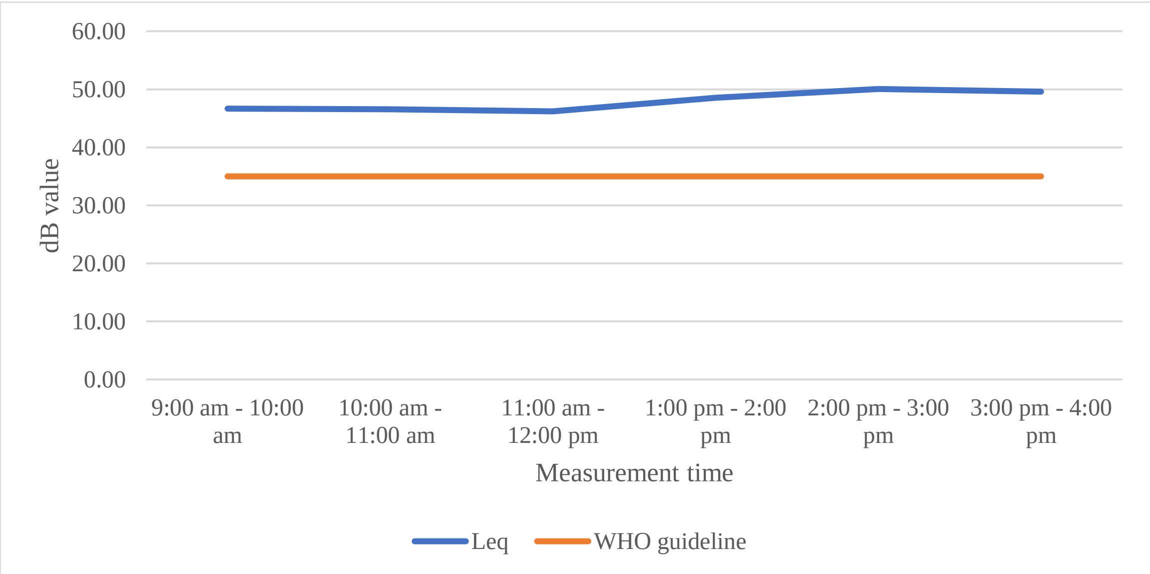

Figure 4.37: *Comparison between Leq and WHO guideline of the afternoon measurement in Adama Highschool*

Figure 4.37 indicates that for the all of the time measured the equivalent noise level (Leq) of Adama Highschool was higher than the recommended permissible limit put by WHO. The above figure indicates that relatively the morning time has less noise compared to the afternoon.

4.4.5. Leq of Goro Highschool

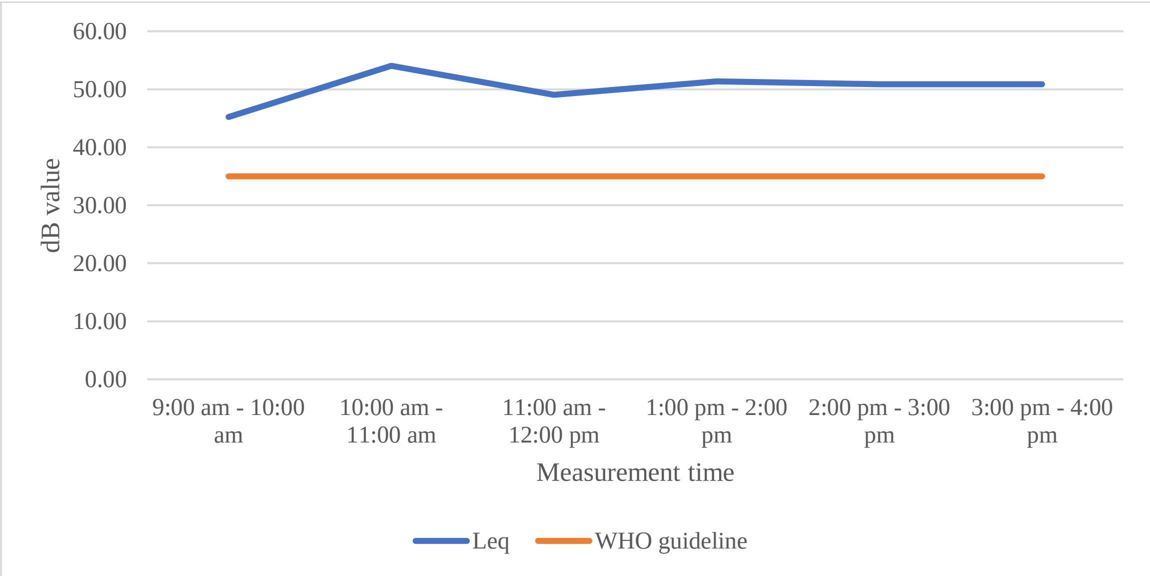

Figure 4.38: *Comparison between Leq and WHO guideline of the afternoon measurement in Goro Highschool*

Figure 4.38 indicates that for the all of the time measured the equivalent noise level (Leq) of Goro Highschool was higher than the recommended permissible limit put by WHO. The above figure indicates that relatively the morning time has less noise compared to the afternoon.

4.4.6. Leq of ODA Special Boarding School

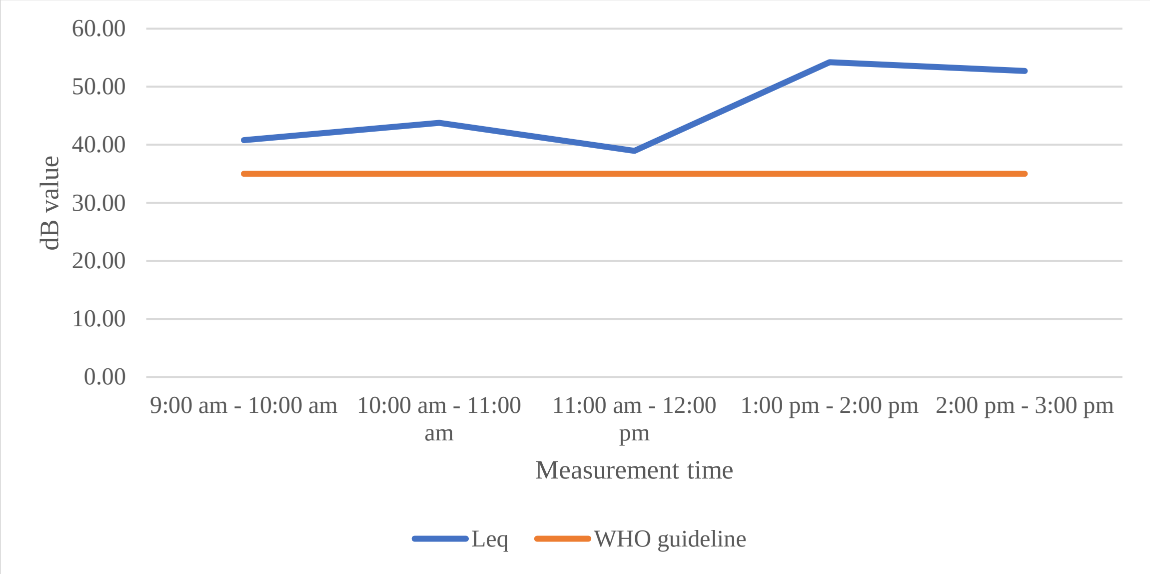

Figure 4.39: *Comparison between Leq and WHO guideline of the afternoon measurement in ODA Special Boarding School*

Figure 4.39 indicates that for the all of the time measured the equivalent noise level (Leq) of ODA Special Boarding School was higher than the recommended permissible limit put by WHO. The above figure indicates that relatively the morning time has less noise compared to the afternoon.

4.4.7. Leq of Rift Valley University

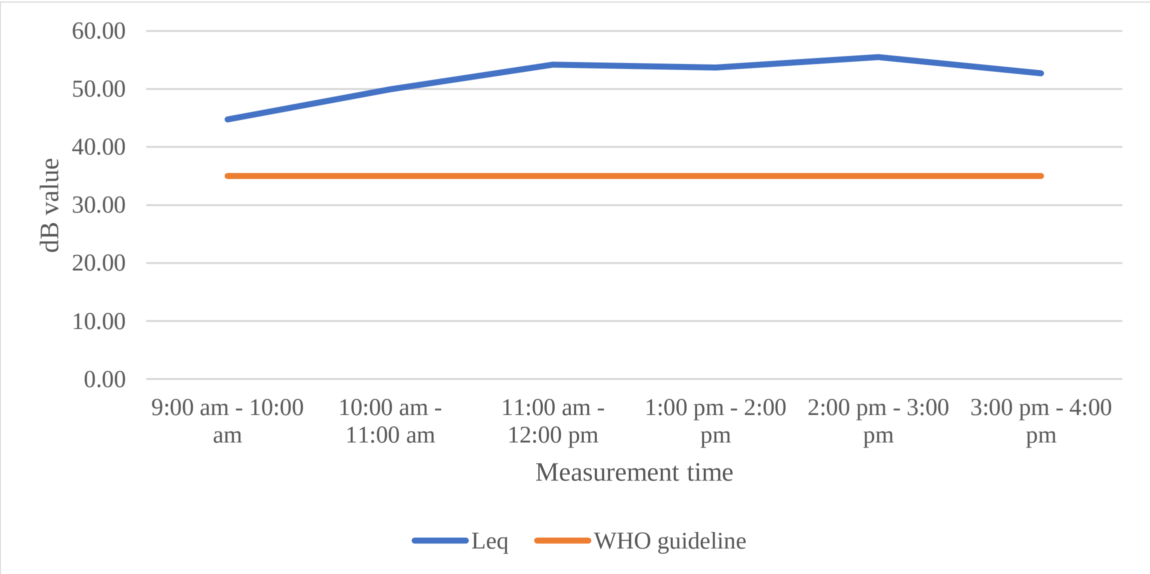

Figure 4.40: *Comparison between Leq and WHO guideline of the afternoon measurement in Rift Valley University*

Figure 4.40 indicates that for the all of the time measured the equivalent noise level (Leq) of Rift valley university was higher than the recommended permissible limit put by WHO. The above figure indicates that relatively the morning time has less noise compared to the afternoon.

4.4.8. Leq of St. Mary School

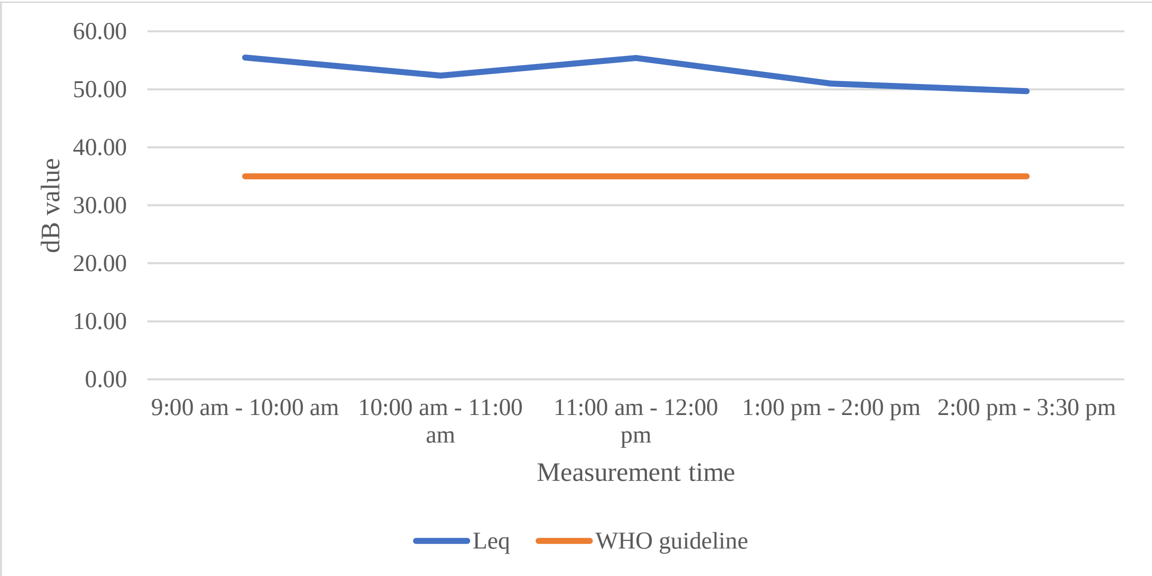

***Figure 4.41**: Comparison between Leq and WHO guideline of the afternoon measurement in St. Mary School*

Figure 4.41 indicates that for the all of the time measured the equivalent noise level (Leq) of St. Mary School was higher than the recommended permissible limit put by WHO. The above figure indicates that relatively the afternoon time has less noise compared to the morning.

4.5. DISCUSSION

There are various activities that account for the noise pollution around silent zones such as educational and healthcare facilities. These noise sources can be industrialization, transportation, construction and building services noise, social events and noise from leisure activities. This research studied various potential noise sources around five educational facilities and three healthcare facilities by using different criteria. The criteria are: noise level of the potential noise sources, distance of the noise sources from the study areas, impact of the noise on the users, temporal variability and accessibility to measurement.

The most common noise sources found were traffic noise, noise inside the study areas and noise that comes from commercial activities around the study areas. Other noise sources around the study areas were religious institutions and they had a raised noise level but due to their distance from the study areas and low temporal variability they were not considered as polluters.

Spatial distribution (distance)

The closest noise source to the study areas was the noise that comes from within the study areas. In the case of the hospitals, noise within the hospital was being generated from the waiting areas, reception areas and mostly the corridors. The corridors of the hospitals were busy with visitors which eventually make lots of noise that disturbs the bedridden patients and disrupt services given in the hospitals. In the case of the educational facilities, noise within the school was being generated from the playgrounds and the hallways. From the schools, St, Mary school has the closest playground to the classrooms which account for a higher noise in break times.

Transportation was the closest noise source to the study areas next to the noise generated within the study areas. All of the selected study areas are located near main roads that are often crowded with traffic which results in higher noise level in the study areas. Within the study areas the rooms that are given special attention during this research were patient rooms, intensive care units, operating theatre and class rooms and the distance measured stating from these rooms. From the hospitals, Sister Aklesia Memorial Hospital was the closest to traffic noise which was only 19.29m away from it. The furthest hospital from the selected study areas was Adama General Hospital with the distance of 79.55m.

From the schools, St. Mary School was the closest to traffic with the distance of 32.18m. The furthest school from the selected study areas was Goro Highschool with the distance of 52.87m.

The other noise sources closer to the study areas were commercial activities. These commercial activities include shops, cafes, restaurants, game zones and etc. These activities use a speaker which eventually results in higher noise level in the schools and hospitals. From the hospitals, Sister Aklesia Memorial Hospital was the closest to the nearest commercial place with the distance of 48.98m. The furthest hospital from the commercial places nearby was Adama General Hospital with a distance of 113.05m.

From the schools, Adama Highschool was the closest to the nearest commercial place with the distance of 51.8m. The furthest school from commercial activities near the school was ODA Special Boarding School with the distance 172.21m.

There also other potential noise sources around the study areas mostly religious institutions. Eyesus Church which is found around Adama Referral Hospital was found within a distance of 144.96m, Heavy truck garage which is found around Adama Highschool was found within a distance of 70.75m. Holy Trinity Church, Ay al Ansal Mosque and Selase Gospel Light Church which are found around Goro Highschool were found within the distance of 184.1m, 92.44m and 118.71m respectively. Adam 09 Full Gospel Church which is found around ODA Special Boarding School was found within a distance of 109.49m. St. Gabriel Church which is found around Rift Valley University was found within a distance of 85.14m. St. Mary Church is the closest religious institution to the St. Mary School within a distance 69.48m.

Impact

The impact of these noise sources towards the users were analysed using questionnaire survey in which 372 respondents participated. Although there were some users that were concerned about the noise that was being generated, the result from this particular study shows that majority of the people were unaware of the impact of noise pollution on their health and day-to-day activities. Some of the respondents were referring to it as a luxurious problem to worry about.

Out of the 372 respondents, 62 respondents claimed that they were never bothered by any of these noise sources. The rest 310 respondents claimed that there a noise disturbance even though the magnitude varies. 9 respondents were highly concerned about the noise disturbance claiming that there was always a disturbance. 62 respondents said that the frequency is average and majority of the respondents (240 respondents) rated the frequency of the disturbance as “rare”. Those 7 respondents described the noise level as being extremely high while 59 respondents described it as low. 79 respondents described the noise level high and 216 respondents described it as moderate. The ones that claimed the noise level concerning also indicated that the noise level raises during afternoon.

The other issue covered under the impact study was the effect of the generated noise. 87 respondents said that the noise generated affects the teaching learning process in school as well as the service provided in hospitals. Out of these respondents, 11 of them described the effect as an adverse impact while 76 respondents said that it is manageable.

The noise level also varies depending on the areas within the study areas. 94% of the respondents have experienced this noise level difference between different areas. The noise level tends to increase in areas like hallways, cafes inside the compounds, playgrounds, waiting rooms and reception areas.

The respondents also ranked these potential noise sources based on their level of impact. Most of the respondents across the study areas have put traffic noise as the primary noise source with an average ranking of 1.85 and standard deviation of 0.894, its highest ranking being first and its lowest ranking being fourth. Noise that come from different commercial activities in and around the study areas has been put second with an average ranking of 2.12 and standard deviation of 0.909, its highest ranking being first and its lowest ranking being fourth. Noise that is generated within the study areas has been put third with an average ranking of 2.38 and standard deviation of 0.922, its highest ranking being first and its lowest ranking fourth. Other noise sources were ranked fourth by the respondents with an average ranking of 3.62 and standard deviation of 0.852.

The regression model showed the contribution level of noise level of the noise sources and their distance from the study areas to the impact of the noise level to the respondents. The results showed that the more distant the noise source is the lesser the impact and the louder the noise gets the more the impact.

Noise level of the noise sources

The criteria were analysed for each noise sources using Analytic Hierarchy Process to give them their weight based on their significance. By this analysis noise level of the sources accounts for 46% of the score, spatial distribution (distance) accounts for 20% of the score, impact accounts for 20% of the score, temporal variability accounts for 9% of the score and accessibility for measurement accounts for 4% of the score. Final score of the noise sources were calculated by multiplying the score with their weights.

In most of the study areas the three pollutant noises were traffic noise, noise within the study areas and noise that is generated from commercial activities. The exceptions were Adama General Hospital in which the commercial activities around the hospitals scored 0.53 which was below the average score (0.59). A huge deducting factor was the distance of these activities from the hospital which was 113.05m. The average noise level generated from the commercial activities was 63.96 dB(A) but it is reduced to 23 dB(A) when travelled that distance which makes it a non-polluter.

Noise generated in the Sister Aklesia Hospital also falls short of being a noise source the noise level with a score of 0.51 the noise level being a huge factor. Commercial activities around ODA Special Boarding School were also one of the exceptions with the score of 0.53 the distance from the school being a huge reduction factor. The other exception was the commercial activities around St. Mary School with a score of 0.53 and distance being a reduction factor.

Other potential noise sources were also labelled as non-polluters due to their distance from the study areas and their lack of temporal variability. Eyesus Church within the distance of 144.96m from Adama Referral Hospital (0% temporal variability), Heavy truck garage within the distance of 70.75m from Adama Highschool (9% temporal variability), Holy Trinity Church, Ayub al Ansar Mosque and Selase Gospel Light Church within the distances of 184.1m, 92.44m and 118.71m from Goro Highschool respectively (0% temporal variability), Adama 09 Full Gospel Church within the distance of 109.49m from ODA Special Boarding School (0% temporal variability), St. Gabriel Church within the distance of 85.14m from Rift Valley University (0% temporal variability) and St. Mary Church within the distance of 69.48m (0% temporal variability) were the ones regarded as non-polluters.

Noise level analysis of the study areas

Noise level of each study areas was measured by using an instrument called sound level meter (SLM). The noise parameters measured were L_{10}, L_{50}, L_{90} and equivalent noise level (Leq). The calculated noise parameters were noise climate (NC) and noise pollution level (L_{NP}). The equivalent noise level was also calculated to make sure the measurement and the calculation were reliable.

The average equivalent noise level in Adama General Hospital was 18.43 dB(A) higher than the permissible noise limit in hospitals suggested by WHO. The average equivalent noise level in Adama Referral Hospital was 24.18 dB(A) higher than the permissible noise limit in hospitals suggested by WHO. The average equivalent noise level in Sister Aklesia Memorial Hospital was 19.58 dB(A) higher than the permissible noise limit in hospitals suggested by WHO. The average equivalent noise level in Adama Highschool was 12.93 dB(A) higher than the permissible noise limit in hospitals suggested by WHO. The average equivalent noise level in Goro Highschool was 15.24 dB(A) higher than the permissible noise limit in hospitals suggested by WHO.

The average equivalent noise level in ODA Special Boarding School was 11.1 dB(A) higher than the permissible noise limit in hospitals suggested by WHO. The average equivalent noise level in Rift Valley University was 16.8 dB(A) higher than the permissible noise limit in hospitals suggested by WHO.

The average equivalent noise level in St. Mary School was 17.73 dB(A) higher than the permissible noise limit in hospitals suggested by WHO. The highest equivalent noise level from the hospitals was recorded in Adama Referral Hospital while the lowest was of Adama General Hospital. The highest equivalent noise level from the schools was recorded in St. Mary School while the lowest was of ODA Special Boarding School.

The highest average L_{10} recorded was that of Adama Referral Hospital's which was 77.45 dB(A). This indicates that 10% of the measured time the noise in that area exceeded 77.45 dB(A). The lowest average L_{10} recorded was that of Adama General Hospital's which was 63.01 dB(A). The highest average L_{50} recorded was that of Adama Referral Hospital's which was 53.02 dB(A). This indicates that 50% of the measured time the noise in that area exceeded 53.02 dB(A). The lowest average L_{50} recorded was that of St. Mary School's which was 41.68 dB(A). The highest average L_{90} recorded was that of Adama Referral Hospital's which was 42.55 dB(A). This indicates that the background noise in that hospital exceeds 42.55 dB(A).

The lowest average L_{90} recorded was that of ODA Special Boarding School which was 32.06 dB(A). From the selected study areas, Adama Referral Hospital has an overall higher noise level in every noise parameter. Even its background noise which was supposed to be lower was higher than the permissible noise level suggested by WHO.

The lowest noise climate indicates that there is much less difference between the background noise and the highest noise in the study areas. The lowest NC was from Adama General Hospital with an average value of 26.84 dB(A). The highest noises measured and the background noises of the hospital were relatively low. The highest NC was from Adama Referral Hospital with an average value of 34.9 dB(A). The highest noises measured and the background noise of the hospital were relatively higher than the rest of the study areas.

Equivalent noise level was obtained by both physical measurement and calculation. The values obtained were much similar to each other with Pearson's r value of 0.967. For more accuracy, the measured values of Leq were used for this research.

Another correlation analysis was made for equivalent noise level and noise climate to understand the characteristics of their relationship. The r value for the correlation of Leq and NC was 0.324 which indicates that they have a week positive relationship.

The regression analysis made for Leq indicated that the noise parameters L_{10}, L_{50} and L_{90} predict 64% of the variance in the equivalent noise level. The regression analysis made for NC indicated that the noise parameter L_{10} and L_{90} predict 98% of the variance in the noise climate.

CONCLUSION AND RECOMMENDATION

CONCLUSION

This study mainly provides the information of noise level in designated silent zones in Adama town. These selected study areas were composed of three healthcare facilities and five educational facilities namely, Adama General Hospital, Adama Highschool, Adama Referral Hospital, Goro Highschool, ODA Special Boarding School, Rift Valley University, Sister Aklesia Memorial Hospital and St. Mary School. These silent zones were supposed to be regulated to optimize functionality as well as to keep the wellbeing of the users of these facilities but this study shows that the noise level in these areas exceeds the standard permissible noise limit suggested by WHO which was 35 dB(A).

Hospitals generate noise from waiting areas, reception areas, and corridors, which disturb bedridden patients and disrupt services. Educational facilities generate noise from playgrounds and hallways, with St. Mary School having the closest playground to classrooms. Transportation is the closest noise source, as all study areas are located near main roads crowded with traffic, resulting in higher noise levels. Patient rooms, intensive care units, operating theatres, and class rooms were the most affected. Sister Aklesia Memorial Hospital is the closest to traffic noise, while Adama General Hospital was the furthest. St. Mary School was the closest from traffic, while Goro Highschool was the furthest. Commercial activities, such as shops, cafes, restaurants, and game zones, also contribute to noise levels. Religious institutions, such as Eyesus Church, Holy Trinity Church, Ay al Ansal Mosque, and Selase Gospel Light Church, were also close to the study areas. These sources contribute to the noise levels in the study areas.

The study analyzed noise sources using Analytic Hierarchy Process, focusing on noise level, spatial distribution, impact, temporal variability, and accessibility for measurement. The three main pollutant noises were traffic noise, noise within the study areas, and noise generated from commercial activities. Commercial activities around the Adama General Hospital scored below the average score of 0.59, with a significant deducting factor being the distance from the hospital. The noise level in Sister Aklesia Hospital was also below the average, while commercial activities around St. Mary School scored 0.53. Other potential noise sources were labeled as non-polluters due to their distance and lack of temporal variability.

Eyesus Church, Heavy truck garage, Holy Trinity Church, Ayub al Ansar Mosque, Selase Gospel Light Church, Adama 09 Full Gospel Church, St. Gabriel Church, and St. Mary Church were considered non-polluters. The final score of noise sources was calculated by multiplying the score with their weights.

The study also analyzed the impact of noise sources on users using a questionnaire survey of 372 respondents. The results showed that most people were unaware of the impact of noise pollution on their health and daily activities. Out of the 372 respondents, 62 were never bothered by noise, while 310 reported noise disturbances. The frequency of disturbances varied, with some respondents describing them as "rare." The noise level also affected teaching and hospital services, with 94% experiencing varying levels between different areas.

The respondents ranked potential noise sources based on their level of impact. Traffic noise was ranked as the primary noise source, followed by commercial activities, noise generated within the study areas, and other noise sources. The regression model showed that the more distant the noise source, the lesser its impact on users, and the louder the noise, the more impact it would cause. The study also found that the noise level of the noise sources and their distance from the study areas significantly influenced the impact of the noise level on respondents.

Generally, the study focused on analyzing the noise levels in various hospitals and schools using a sound level meter (SLM). The noise parameters measured were L_{10}, L_{50}, L_{90}, and equivalent noise level (Leq), with the calculated noise parameters being noise climate (NC) and noise pollution level (L_{NP}). The highest equivalent noise level was recorded at Adama Referral Hospital, while the lowest was at Adama General Hospital. The highest average L10 was 77.45 dB(A), indicating that 10% of the measured time the noise exceeded 77.45 dB(A). The lowest average L_{50} was 53.02 dB(A), with 50% exceeding 53.02 dB(A). The highest average L_{50} was 41.68 dB(A), and the lowest average L_{90} was 32.06 dB(A). The lowest noise climate was found at Adama General Hospital, with an average value of 26.84 dB(A), and the highest NC was at Adama Referral Hospital, with an average value of 34.9 dB(A). The correlation analysis for equivalent noise level and noise climate showed a week-positive relationship, with the noise parameters L_{10}, L_{50}, and L_{90} predicting 64% and 98% of the variance in the equivalent noise level, respectively. All of the study areas have a noise level above the permissible limit suggested by WHO.

RECOMMENDATION

Based on the findings of this study, it is evident that the noise levels in designated silent zones within Adama town's healthcare and educational facilities exceed the World Health Organization's recommended limit of 35 dB(A). To address this critical issue and enhance the wellbeing and functionality of these zones, the following comprehensive recommendations are proposed:

Public Awareness and Education

- Educate the public, including students, hospital staff, and local residents, about the impacts of noise pollution on health and productivity. Public campaigns can use various
- Offer training sessions for facility staff on noise management techniques and the importance of maintaining a quiet environment. This training can empower staff to effectively manage noise within their respective areas.

Legislation

- There is a proclamation written which recognizes noise as one of the environmental pollutions but there are no further standards put to direct the implementation of that proclamation. To address the issue of noise pollution, a series of standards, laws and regulations should be formulated as a country. Other countries' standard can also be adopted to develop those standards.

Adama Land Administration

- When planning the structural plan of the town, extra considerations should be made for silent zones such as hospitals, schools, institutions and residential areas. They should be located where there is a reduced amount of noise. Industrial areas, main roads and commercial districts should be in a manageable distance from the silent zones.
- When conducting Environmental Impact Assessment and Suitability Analysis, the impact of the environment on the projects should also be studied.
- Conduct periodic noise level assessments using sound level meters and other instruments to ensure compliance with noise regulations. These assessments should be systematic and cover all critical areas.

- Implement strict enforcement of noise regulations, including penalties for non-compliance, to ensure that noise levels are kept within permissible limits. A robust enforcement mechanism is crucial for the effectiveness of noise control policies.

Control of Internal Noise Sources

- Schedule high-noise activities, such as playground recess and commercial deliveries, during times that are least disruptive to the facility's primary functions. This temporal management can help minimize noise exposure during critical periods.
- Designate and enforce quiet zones within facilities where silence is critical, such as in libraries, study rooms, and hospital wards. Clear signage and strict adherence to these zones can maintain a tranquil environment essential for recovery and learning.

Commercial Activity Regulation

- Implement stricter zoning regulations to control the establishment and operation of commercial activities near silent zones. These regulations should include limits on operating hours and noise levels. Work with local businesses to adopt noise-reducing practices, such as using quieter equipment and maintaining noise control measures. Regular inspections and incentives for compliance can enhance adherence to these practices.

Traffic Noise Mitigation

- Introduce traffic calming measures such as speed bumps, roundabouts, and traffic diversions to reduce the flow and speed of vehicles near silent zones. These measures can significantly lower the noise levels by decreasing the volume and speed of traffic. Stopovers should also be reduced.

General Design Considerations

Site Design (Zoning)

Site design can have a major impact on acoustics, as noise sources outside can significantly impact noise levels inside. Consider the following when selecting a site for a healthcare and educational facilities:

- Consider all existing and future sources of noise that have the potential to be transmitted through the exterior shell of the building into the building's interior.

- Conduct site measurements to determine the impact of noise from the surrounding, external environment; plan the site and design the building's façade to mitigate any impacts.
- Establish lower outdoor sound levels (a day-night average of 50 dB) in outdoor areas through noise barriers or shielding strategies.

Space Planning

Space planning can have a significant impact on the acoustic environment. Determining what spaces will be adjacent to each other and how the space should be laid out takes careful consideration of how specific areas are going to be used, the level of privacy that is needed, and the desired background noise level, among other factors. Consider the following design considerations for space planning:

- Create single-bed or at most two-bed (as opposed to multibed) patient rooms as they are associated with several positive outcomes including reducing the number of hospital-acquired infections; improving patient sleep and privacy; facilitating better communication with parents and families; improving perceptions of social support; decreasing stress for staff; and improving patient satisfaction. Advocating for single-patient rooms in hospitals (during new construction, expansion, or renovation projects) demonstrates a commitment to meeting patients' privacy, safety, and dignity needs.
- Decentralize nurses' stations as this may minimize corridor traffic, in turn reducing noise generation and allowing nurses to see and hear their patients more effectively.
- Create separate, acoustically private spaces for families of patients to gather to reduce noise levels elsewhere in the hospital.
- Out patients and bedridden patients should not be treated in a proximate space. Noise sensitive areas such as intensive care units, operating theatres and patient rooms should be isolated.
- Class rooms should be located further from the playgrounds as well as the fence of the compound which is besides the main road and other noise sources.
- A proper playground should be provided for the students to reduce the noise that is created as the result of playing near the class rooms and libraries.
- Staff gathering spaces and playgrounds should be located further from the areas which require silence and have to properly buffered to reduce the noise.

Space planning alone will not result in an adequate acoustic environment. Walls, floors, and ceilings should also be designed to support privacy and minimize noise transmission. Materials and finishes selected for ceilings, walls, and flooring can greatly impact the acoustic environment.

When designing for acoustical privacy it is important to include the composite action of all adjacent building components. The composite sound performance of walls, ceilings, doors and floors will greatly impact the overall sound performance. The combination of individual components' acoustical performance and installation details will alter the overall performance.

Future Studies

- Other studies regarding noise pollution - with different study areas should be conducted to have a more complete and comprehensive understanding of the condition in Adama town to make it easier to enforce rules and regulations.
- Other noise parameters that are not included in this research should also be used to analyze other aspects of noise pollution. This research used percentile sound levels (L_{10}, L_{50} and L_{90}), Equivalent Noise Level (Leq), Noise Climate (NC) and Noise Pollution Level (L_{NP}). There are other excluded noise parameters such as: Lmax, Lmix, Lpeak, Traffic Noise Index (TNI) and Day-Night Average Sound Level (DNL). These parameters can give a different perspective for the upcoming researches.
- Even though the research used mixed research approach, it is more focused on the quantitative analysis. Future studies should concentrate more on the qualitative analysis to have a better understanding about the perception of the users and health and environment impact of noise pollution. This needs collaboration with different professions so that is encouraged.

Special Acknowledgement

This research project is funded by Adama Science and Technology University under the grand number:

ASTU/SM-R/1035/24

Adama, Ethiopia

References

Abbaspour, M., Karimi, E., Nassiri, P., Monazzam, M. R., & Taghavi, L. (2015). *Hierarchal assessment of noise pollution in urban areas–A case study*. Transportation Research Part D: Transport and Environment, 34, 95-103.

Alam, W. (2011). *GIS based assessment of noise pollution in Guwahati city of Assam, India.* International journal of environmental sciences, 2(2), 731-740.

Armstrong Ceiling Systems. (2003). *Rx for healthcare speech privacy: A balanced acoustical design.* Retrieved April 1, 2010, from http://www.armstrong.com/common/c2002/content/files/7728.pdf

Ayyub Zinvand Iorestani, Seyes Ali Mousavi, Raja Ebadaty, (2012). *Monitoring Rail Traffic Using Wsn.* Ijcset; 2(6):280-128.

Baloye, D. O., & Palamuleni, L. G. (2015). *A comparative land use-based analysis of noise pollution levels in selected urban centers of Nigeria.* International journal of environmental research and public health, 12(10), 12225-12246.

Bogale, G. G., Sisay, T., Mekonen, A. M., & Aemiro, M. T. (2022). *Spatial distribution of health-risky road traffic noise pollution in Dessie City, North East Ethiopia.* PloS one, 17(7), e0270589.

Chhatwal, G. R., & Satake, M. M. M. (1989). *Environmental noise pollution and its control.* Anmol Publications Pvt. Limited.

Chowdhury, S. C., Razzaque, M. M., Helali, M. M., & Bodén, H. (2010). *Assessment of noise pollution in Dhaka city.* In 17th International Congress on Sound and Vibration, Cairo, Egypt, 2010-07-18-2010-07-22.

de Paiva Vianna, K. M., Cardoso, M. R. A., & Rodrigues, R. M. C. (2015). *Noise pollution and annoyance: An urban soundscapes study.* Noise & health, 17(76), 125.

Deshpande, A., Guestrin, C., Madden, S., Hellerstein, J. M., & Hong, W. (2005, January). *Using Probabilistic Models for Data Management in Acquisitional Environments.* In CIDR (Vol. 5, pp. 317-328).

Doda, D. (2017). *An Assessment of Noise Pollution in Addis Ababa: The Case of Bole Michael Community Area.* partial fulfillment of the requirement for the Degree of Master in Development management.

Eriksson, C. Et Al., (2012). *Residential Traffic Noise Exposure Assessment – Application and validation of Environmental Noise Directive maps.*

FDRE. (2002). *Environmental pollution control proclamation.* Federal Negarit Gazeta.

FDRE. (2005). *The Criminal Code of the Federal Democratic Republic of Ethiopia. Article 815 Sub-article 1&2.*

Fiedler, P. E. K., & Zannin, P. H. T. (2015). *Evaluation of noise pollution in urban traffic hubs—Noise maps and measurements.* Environmental Impact Assessment Review, 51, 1-9.

Forns, J., Dadvand, P., Foraster, M., Alvarez-Pedrerol, M., Rivas, I., López-Vicente, M., ... & Sunyer, J. (2016). *Traffic-related air pollution, noise at school, and behavioral problems in Barcelona schoolchildren:* a cross-sectional study. Environmental health perspectives, 124(4), 529-535.

FTA, (2018). *Transit Noise and Vibration Impact Assessment Manual.* U.S. Department of Transportation Federal Transit Administration and Office of Planning and Environment 1200.

Goshu, B. S., Mamo, H., & Zerihun, S. (2017). *Urban noise: a case study in Dire-Dawa city, Ethiopia.* Eur J Biophy, 5(1), 17-26.

Hammer, M. S., Swinburn, T. K., & Neitzel, R. L. (2014). *Environmental noise pollution in the United States: developing an effective public health response.* Environmental health perspectives, 122(2), 115-119.

Hunashal, R. B., & Patil, Y. B. (2012*). Assessment of noise pollution indices in the city of Kolhapur, India.* Procedia-Social and Behavioral Sciences, 37, 448-457.

Jariwala, H. J., Syed, H. S., Pandya, M. J., & Gajera, Y. M. (2017). *Noise pollution & human health: a review. Noise and Air Pollutions: Challenges and Opportunities, Ahmedabad:* LD College of Eng.

Johnson, S. P. (2001). *The earth summit: The United Nations conference on environment and development (UNCED)*. The Earth Summit, 1-540.

Juang, D. F., Lee, C. H., Yang, T., & Chang, M. C. (2010). *Noise pollution and its effects on medical care workers and patients in hospitals*. International Journal of Environmental Science & Technology, 7, 705-716.

Keerthana, (2013). *Analysis of Noise Pollution in Tirupur City.* Scholars Journal of Engineering and Technology 1(3): 154-168.

Khan, J., Ketzel, M., Kakosimos, K., Sørensen, M., & Jensen, S. S. (2018). *Road traffic air and noise pollution exposure assessment–A review of tools and techniques.* Science of the total environment, 634, 661-676.

Ma, J., Li, C., Kwan, M. P., & Chai, Y. (2018). *A multilevel analysis of perceived noise pollution, geographic contexts and mental health in Beijing.* International journal of environmental research and public health, 15(7), 1479.

Mahmoud, R. M., Abbas, H. A., & Yaseen, R. H. (2019). *Assessment of Noise Pollution and Architectural Solutions for The Colleges and Universities.* REVISTA AUS, 26, 445-453.

Morillas, J. M. B., Gozalo, G. R., Montes-Gonzalez, D., Vílchez-Gómez, R., & Escobar, V. G. (2021). *Variability of traffic noise pollution levels as a function of city size variables.* Environmental Research, 199, 111303.

Moroe, N., & Mabaso, P. (2022). *Quantifying traffic noise pollution levels: a cross-sectional survey in South Africa.* Scientific Reports, 12(1), 3454.

Olayinka, O.S. (2012). *Noise pollution in urban areas: the neglected dimensions*. Environmental Research Journal, 6(4), 259-271.

Parbat, D. K., & Nagarnaik, P. B. (2007). *Assessment and modeling of noise levels at major road intersections in an Indian intermediate city.* Journal of research in science, computing and engineering, 4(3), 1-1.

Sakr, A. G., El-Dars, F. M., & Hewehey, M. I. (2020). *Monitoring Noise Levels Along The Greater Cairo Urban Region Ring Road in Egypt*. Journal of Environmental Science, 49(2), 1-25.

Thompson, R., Smith, R. B., Karim, Y. B., Shen, C., Drummond, K., Teng, C., & Toledano, M. B. (2022). *Noise pollution and human cognition: An updated systematic review and meta-analysis of recent evidence.* Environment international, 158, 106905.

Wikipedia contributors. (2023). Adama. Wikipedia. https://en.wikipedia.org/wiki/Adama

Woolner, P., & Hall, E. (2010). *Noise in schools: a holistic approach to the issue.* International journal of environmental research and public health, 7(8), 3255-3269.

World Health Organization. (2018). *Environmental noise guidelines.* World Health Organization.

World Health Organization. (2022). *Environmental noise guidelines.* World Health Organization.

Yang, W., He, J., He, C., & Cai, M. (2020). *Evaluation of urban traffic noise pollution based on noise maps.* Transportation Research Part D: Transport and Environment, 87, 102516.

Zannin, P. H. T., Engel, M. S., Fiedler, P. E. K., & Bunn, F. (2013). *Characterization of environmental noise based on noise measurements, noise mapping and interviews: A case study at a university campus in Brazil.* Cities, 31, 317-327.

APPENDICES

Appendix 1: Field Observation Checklist (Noise source identification)

Study areas	Noise source description	Frequency of occurrence	Duration of noise	Time of occurrence	Temporal variability (%)	Accessibility for measurement (%)
Adama General Hospital						
Adama Referral Hospital						
Sister Aklesia Memorial Hospital						
Adama Highschool						
Goro Highschool						
ODA Special Boarding School						
Rift Valley University						
Sister Aklesia Memorial Hospital						

Appendix 2: Questionnaire One (Healthcare facility users)

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF CIVIL ENGINEERING AND ARCHITECTURE

DEPARTMENT OF URBAN PLANNING AND DESIGN

MSc Program

Dear respondent, I am currently studying for a master's degree in urban planning and design at Adama Science and Technology University and this is the questionnaire I have prepared for my research "Analysis and Assessment of Noise Pollution Level in Silent Zones: The Case of Adama Town". There are three healthcare facilities and five educational institutions selected for this specific study and this healthcare center is one of the study areas. The questionnaire consists of 21 questions and it will take no longer than 5 – 10 minutes of your time to complete. All responses will be kept anonymous and no one will be identifiable in the research.

PART I

Personal information of respondents

1. Age

○ 15 – 25 ○ 26 – 35 ○ 36 – 45 ○ 46 – 55

○ 56 – 65 ○ 66 and above

2. Gender

○ Male ○ Female

3. Which religion follower are you?

○ Orthodox ○ Muslim ○ Protestant ○ Others

4. Do you have a hearing impairment?

○ Yes ○ No

PART II

Questions in detail

5. What are the possible noise sources around this area?

   ____

   ____

   ____

6. If there is/are noise source(s) rank them by their amount of noise they generate.

   ____

   ____

   ____

   ____

   ____

7. How often are you disturbed by noise when you come to this healthcare center?

○ Always ○ Sometimes ○ Rarely ○ Never

8. How do you rate the noise pollution in this healthcare center?

○ Extremely high ○ High ○ Moderate ○ Low

9. If your answer to question 8 is "extremely high" or "high", at what time does the noise pollution becomes extremely high or high?

○ Morning ○ Afternoon ○ Evening

10. Does the noise affect the service given by this healthcare center?

○ Yes ○ No

11. If the answer to question 10 is "yes", how much does it affect the service?

○ It has an adverse impact

○ It is manageable

12. Have you noticed any differences in noise levels between different areas of this healthcare center (e.g., lobby, examination rooms)?

○ Yes ○ No

13. If your answer for question 13 is “yes”, where is the noise disturbance higher?

____

14. Do you think there are rules and regulations in Ethiopia to control noise pollution?

○ Yes ○ No

15. If your answer for the above question is” yes”, why do you think that the responsible organs are reluctant to hear the outcry and give immediate solution to the problem?

____

____

____

Appendix 3: Questionnaire Two (Educational facility users)

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF CIVIL ENGINEERING AND ARCHITECTURE

DEPARTMENT OF URBAN PLANNING AND DESIGN

MSc Program

Dear respondent, I am currently studying for a master's degree in urban planning and design at Adama Science and Technology University and this is the questionnaire I have prepared for my research "Analysis and Assessment of Noise Pollution Level in Silent Zones: The Case of Adama Town". There are three healthcare facilities and five educational institutions selected for this specific study and your school is one of the study areas. The questionnaire consists of 21 questions and it will take no longer than 5 – 10 minutes of your time to complete. All responses will be kept anonymous and no one will be identifiable in the research.

PART I

Personal information of respondents

1. Age

○ 15 – 25 ○ 26 – 35 ○ 36 – 45 ○ 46 – 55
○ 56 – 65 ○ 66 and above

2. Gender

○ Male ○ Female

3. Which religion follower are you?

○ Orthodox ○ Muslim ○ Protestant ○ Others

4. Do you have a hearing impairment?

○ Yes ○ No

PART II

Questions in detail

5. What are the possible noise sources around this area?

____

____

____

6. If there is/are noise source(s) rank them by their amount of noise they generate.

____

____

____

____

____

7. How often are you disturbed by noise during school hours?

○ Always ○ Sometimes ○ Rarely ○ Never

8. How do you rate the noise pollution in this school?

○ Extremely high ○ High ○ Moderate ○ Low

9. If your answer to question 8 is “extremely high” or “high”, at what time does the noise pollution becomes extremely high or high?

○ Morning ○ Afternoon ○ Evening

10. Does the noise affect the teaching learning process of this school?

○ Yes ○ No

11. If the answer to question 10 is “yes”, how much does it affect the teaching learning process of this school?

○ It has an adverse impact

○ It is manageable

12. Have you noticed any differences in noise levels between different areas of the school (e.g., classrooms, playground)?

○ Yes ○ No

13. If your answer for question 13 is "yes", where is the noise disturbance higher?

____

14. Do you think there are rules and regulations in Ethiopia to control noise pollution?

○ Yes ○ No

15. If your answer for the above question is" yes", why do you think that the responsible organs are reluctant to hear the outcry and give immediate solution to the problem?

____

____

____

Appendix 4: Noise Level Measurement of healthcare facilities and their noise sources

Morning	L_{10}	L_{50}	L_{90}	**Leq**
8:00 am - 8:15 am				
8:15 am - 8:30 am				
8:30 am - 8:45 am				
8:45 am - 9:00 am				
9:00 am - 9:15 am				
9:15 am - 9:30 am				
9:30 am - 9:45 am				
9:45 am - 10:00 am				
10:00 am - 10:15 am				
10:15 am - 10:30 am				
10:30 am - 10:45 am				
10:45 am - 11:00 am				
Afternoon				
1:00 pm - 1:15 pm				
1:15 pm - 1:30 pm				
1:30 pm - 1:45 pm				
1:45 pm - 2:00 pm				
2:00 pm - 2:15 pm				
2:15 pm - 2:30 pm				
2:30 pm - 2:45 pm				
2:45 pm - 3:00 pm				
3:00 pm - 3:15 pm				
3:15 pm - 3:30 pm				
3:30 pm - 3:45 pm				
3:45 pm - 4:00 pm				
Evening				
7:00 pm - 7:15 pm				
7:15 pm - 7:30 pm				
7:30 pm - 7:45 pm				
7:45 pm - 8:00 pm				
8:00 pm - 8:15 pm				
8:15 pm - 8:30 pm				
8:30 pm - 8:45 pm				
8:45 pm - 9:00 pm				
9:00 pm - 9:15 pm				
9:15 pm - 9:30 pm				
9:30 pm - 9:45 pm				
9:45 pm - 10:00 pm				

Appendix 5: Noise Level Measurement of educational facilities and their noise sources

Morning	L_{10}	L_{50}	L_{90}	**Leq**
9:00 am - 9:15 am				
9:15 am - 9:30 am				
9:30 am - 9:45 am				
9:45 am - 10:00 am				
10:00 am - 10:15 am				
10:15 am - 10:30 am				
10:30 am - 10:45 am				
10:45 am - 11:00 am				
11:00 am - 11:15 am				
11:15 am - 11:30 am				
11:30 am - 11:45 am				
11:45 am - 12:00 pm				
Afternoon				
1:00 pm - 1:15 pm				
1:15 pm - 1:30 pm				
1:30 pm - 1:45 pm				
1:45 pm - 2:00 pm				
2:00 pm - 2:15 pm				
2:15 pm - 2:30 pm				
2:30 pm - 2:45 pm				
2:45 pm - 3:00 pm				
3:00 pm - 3:15 pm				
3:15 pm - 3:30 pm				
3:30 pm - 3:45 pm				
3:45 pm - 4:00 pm				