Assessment of Urban Noise Pollution and Mitigation on Addis Ababa Congestion Hotspots: in the case of Megenagna

Imran Anwar Shibru

A thesis Submitted to the department of Urban Planning and Design
School of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for
Master of Science degree in Urban Planning and Design

Office of Graduate Studies
Adama Science and Technology University

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Approval Board of Reviewers

I, the advisors of the thesis entitled "**Assessment of Urban Noise Pollution and Mitigation on Addis Ababa Congestion Hotspots: in the case of Megenagna**" and developed by **Imran Anwar**, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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We, the undersigned, members of the Board of Examiners of the thesis by **Imran Anwar Shibru** have read and evaluated the thesis entitled "**Assessment of Urban Noise Pollution and Mitigation on Addis Ababa Congestion Hotspots: in the case of Megenagna"** and examined the candidate during the open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in **Urban Planning and Design**.

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Declaration

I hereby declare that this Master Thesis entitled **"Assessment of Urban Noise Pollution and Mitigation on Addis Ababa Congestion Hotspots: in the case of Megenagna"** is my original 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.

Imran Anwar Shibru		
Name of student	Signature	Date

Recommendation of Advisor

I, the Advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "**Assessment of Urban Noise Pollution and Mitigation on Addis Ababa Congestion Hotspots: in the case of Megenagna**". prepared under my guidance by **Imran Anwar Shibru** and submitted in partial fulfillment of the requirements for the degree of Masters of Science in Urban Planning and Design. Therefore, I recommend the submission of the revised version of the thesis to the department following the applicable procedures.

Dr. Daniel Lirebo______	________________________	________________
Major Advisor/Supervisor	Signature	Date

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List of Acronyms

GDP	Gross domestic product
AA	Addis Ababa
ArcGIS	Aeronautical Reconnaissance Coverage Geographic Information System
SPSS	IBM SPSS Statistics
WHO	World Health Organization
dB	Decibel
dB(A)	A-weighted decibels
SPL	Sound Pressure Level
SLM	Sound Level Meter
OSHA	Occupational Safety and Health Administration

Abstract

Megenagna is one of the most congested areas of the capital of Ethiopia, Addis Ababa. The study was confined to two Roundabouts and six roads radiating roads from Megenagna. Due to urbanization, this noise pollution has been increasing causing health consequences from discomfort to high levels of health risk for extended exposure. This study aimed to undertake a critical study of pollution in elevated sound levels. So that causes were identified, and mitigation measures can be suggested and taken. Noise pollution is of particular importance due to its physical and psychological effects on humans. Noise is an unwanted sound that affects the health and well-being of occupants. The study helps to better the users' and occupants' health and environmental well-being. Tthere was no comprehensive study on the level of noise pollution in Megenagna and its impact on residents and users of this route. There was also a lack of data on the sources and patterns of noise pollution in this area, and how they differ from other areas. Furthermore, there was no clear understanding of how to reduce and control noise pollution in Megenagna effectively. Sound Meter was be used for measuring sound levels. In this Descriptive and Experimental study, sound pressure levels were measured by a sound level meter in selected locations around the 6 roadways in Megenagna, which have a high load of traffic during daytime hours. Data was also collected from users, residents, occupants, and workers of the area as to how these present noises were affecting them. The collected data was studied using various statistical software to analyze their mean, frequency, and percentages to identify approaches to mitigate noise pollution in Megenagna. This study found that transportation, advertisement, and human noises exceeded the permissible limit of 65 decibels for commercial areas. The average noise levels during morning rush hour were found to be 78.9 dB, while during afternoon rush hour the average noise levels were 81.4 dB. Average noise measurement as a whole was 80.2dB. to mitigate this level noise measures such as designing area to accommodate more pedestrian and vehicle, establishing and enforcing noise regulations, promoting public education and awareness as well as encouraging the development and use of technology is needed.

Keywords: Assessment, Environment, Health, Mitigation, Noise, Pollution, Sound,

CHAPTER 1: INTRODUCTION

The purpose of this research is to investigate noise pollution in Megenagna, Addis Ababa. Noise pollution has been identified as a significant issue in the area, with potential negative impacts on the health and well-being of residents. This study aims to provide a comprehensive understanding of the issue by exploring its background, defining the problem statement, and outlining the objectives of the research. The significance of this study lies in its potential to contribute to the ongoing discussion on noise pollution in Megenagna, Addis Ababa, and provide valuable insights for future efforts to address the issue. The scope of this research is limited to Megenagna, Addis Ababa.

1.1. Background of the Study

Urbanization is the process of the increase in the population density of urban areas. This has been happening since the beginning of human settlements. In the past, cities were mainly established due to trade, commerce, or as administrative centers (Heyne & Fhoteringham, 2020). Nowadays, urbanization has emerged as a result of various factors, including industrialization, globalization, and technological advancements (Antrop, 2004). Urbanization has various economic benefits, such as increased job opportunities, and the concentration of markets (Cervero, 2013). However, urbanization has downsides, including increased congestion, pollution, crime rates, and poor living standards (McGinn et al., 2007).

The growth of cities over the last few decades has been accompanied by a global migration of population from rural to urban areas. Data from the World Bank states that in 1960, 33.6% of the world's population was urban, which has increased to 54.3% by 2016 (Stampini et al., 2016). Due to this influx of people seeking employment and improved access to various services, many cities have seen rapid growth in size without appropriate measures for efficient public transportation or environmental design (Azhar et al., 2011) Such developments have led to an abundance of private vehicles, resulting in not only traffic congestion but also higher levels of noise pollution (Armah et al., 2010).

At the 1972 World Environment Congress in Stockholm, noise was first identified as a major pollutant (Azhar et al., 2011). This recognition helped spur numerous research studies around the world crafted by the World Health Organization that highlighted how detrimental noise pollution can be to human health. The World Health Organization further concluded, in 2011, that noise pollution is one of the biggest environmental stressors present and negatively affects public health (Baste & Watson, 2022).

The concept of urban pollution refers to the introduction of poisonous or harmful substances and stimulants into cities and urban areas (Ali et al., 2019). Urban pollution may come from many types of sources, but the most influential are those emissions caused by human activities. The human-caused sources of pollution can be factories, industries, transportation, and so on, these are typically worsened in cities due to the local concentration of humans and human activities (Martínez-Bravo & Martínez-del-Río, 2019).

Noise is an intrusive external stimulus that can have negative physical and psychological effects. It has been proven to disturb activities and communication, creating noticeable annoyance and general discomfort (Ke et al., 2021). Cities due to these noises make them unhealthy for the occupants. Noise pollution distribution in each city around the world is highly influenced by its design. A lot of factors associated with urban noise pollution have been considerably affected by the volume of traffic, vehicle distribution, and traffic condition (Morillas et al., 2018a; N. Singh & Davar, 2004).

Noise is a unique environmental factor that affects different people differently; it is detected solely by the auditory system. Individuals living in or around large cities tend to experience noise most acutely, and the sources of this sound are often attributed to traffic, residential areas, and planes (Huss et al., 2010). When it comes to ambient factors such as air pollutants or electromagnetic fields, noise stands out due to its high volatility - making it one of the leading causes for concern amongst urban populations (Muzet, 2007a).

In many cities around the world where the city is highly populated 65% of the population is exposed to unhealthy levels of transportation noise. Noise levels measured 106 dB in most cities up to 112 dB in megacities. These levels have exceeded recommended exposure limits and are harmful if given a sufficient duration of exposure (Goines & Hagler, 2007).

Noise adversely affects general health and well-being in the same way as chronic stress. It adversely affects future generations by degrading residential, social, and learning environments with corresponding economic losses (Jariwala et al., 2017). According to the World Health Organization (WHO) in 2011, traffic noise may lead to annoyance and health effects, such as communication problems, headaches, sleep disturbance, stress, high blood pressure, an increased risk of heart disease, and hormonal effects. So the human perception of noise is highly affected in its work environment and productivity as well (Mehdi et al., 2011a).

Environmental noise is no longer viewed as a pesky side effect of progress, but rather as a serious environmental concern due to current studies that indicate that it can impact public health (Murphy & King, 2022). As such, governments and public administrations have made reducing noise pollution one of their primary objectives. but noise pollution has been increasing due to several factors such as urbanization, industrialization, and transportation (Mehdi et al., 2011b). The growth of cities and the development of infrastructure have led to an increase in construction activities and traffic, resulting in higher levels of noise pollution (Hammer et al., 2014; Madlener & Sunak, 2011).

Governments have implemented various measures such as setting noise standards. In Ethiopia, the stipulated noise levels for commercial and residential settings are 65dB and 55dB respectively, whereas the global standards set by the World Health Organization are 70dB and 45 dB. Unfortunately, these regulations are seldom enforced or taken into account. (Reta & Amente, 2021).

This leads to a high level of noise pollution in many areas, particularly in major cities like Addis Ababa.(Sekasi & Martens, 2021) Most of the noise pollution in Ethiopia comes from transportation, particularly from loud motorized vehicles and car horns. Other sources include construction sites, industrial facilities, and loud music from public places (Doda, 2017a).

Megenagna is an area in northern Addis Ababa, Ethiopia. Known for its two roundabouts and six radiating roads, it suffers from high congestion leading to greater noise pollution and wellbeing concerns for the locals, commuters, and users of the route (Bizualem et al., 2022).

Megenagna area is home to many businesses and commercial establishments, including banks, restaurants, and shops, which attract large numbers of people daily (Swaddle et al., 2015). The area also serves as a transportation hub, connecting various parts of the city through minibus taxis, buses, and other modes of public transportation (Bizualem et al., 2022).

Poor road infrastructure, with high traffic volume and a lack of public transportation alternatives, worsens the congestion problem in Megenagna (Engdasew, 2021). The result is increased pollution and longer travel times, which negatively impact the health and wellbeing of the people living and working in the area. Moreover, the noise from honking horns and vehicles moving slowly through the roundabouts adds to the stress and noise pollution problem (Fetene et al., 2022).

To address the issue of congestion in Megenagna, the government of Ethiopia, in collaboration with local authorities and stakeholders, has initiated several projects aimed at upgrading the road infrastructure, expanding public transportation options, and promoting sustainable transport solutions (Venter et al., 2018). These efforts include building new roads, constructing bus stations, and promoting biking and walking as alternative modes of transportation (McGinn et al., 2007).

The ongoing efforts to improve Megenagna's transport system are expected to benefit the residents and businesses in the area by reducing traffic congestion, improving air quality, and enhancing the overall quality of life (Deriba, 2015; Krzyzanowski et al., 2005).

1.2. Statement of the Problem

In an urban environment, the sound levels should be well below the limit considered to be harmful. In these environments, individuals in various settings such as residential areas, schools, hospitals, workplaces, and public places can enjoy an environment conducive to living, working, and learning (Ferreira-Baptista & De Miguel, 2005). Noise managed properly guides industrial operations, building construction, transportation, and recreational activities to create a peaceful and calm environment. In support of mass media and community mobilization, communities work with the government to guide and support policies and regulations to improve the quality of life through noise reduction approaches (Cooper et al., 2005).

The problem of the noisy environment is not new; however, noise has been recognized for many years as hazardous to health. Noise pollution is today accepted as a significant part of the larger problem of environmental pollution. The increasing attention directed to noise and it's perception by humans is reflected by the growing discussion on the subject (Guarnaccia, 2015).

Human noise perception is a complex issue that is influenced by several factors, including the type of noise, the level of noise, the duration of exposure to the noise, and the individual's own physiology and psychological state (Andrew et al., 2007). Some of the potential health effects of noise pollution include hearing loss, high blood pressure, sleep disturbance, and high-stress levels. Actions and studies should be done to regulate noise levels and raise public awareness as it branches to several problems (S. Stansfeld & Clark, 2015).

Noise also causes reduced productivity, especially in workplace environments. It can reduce productivity and concentration levels, leading to less efficient work. (Chandrasekar, 2011) As government and communities try to mitigate this pollution, high costs are also seen, One of the affected areas due to noise by health concerns, productivity, and cost is the Megenagna area located in Addis Ababa (Barber et al., 2009).

Megenagna is one of the highly used areas of the city as well as the country each day, many of the city residents and visitors from other cities and towns pass through, due to this it is highly used and congested. This resulted in it being one of the noisiest areas of the city. (Aklilu & Necha, 2018). Urban areas like Megenagna are facing a growing problem of noise pollution. We need to take a thorough investigation and address this issue to eliminate the harmful consequences associated with it (Goines & Hagler, 2007).

1.3. Objective of the Study

1.3.1 General objective

The general objective of this study is to critically examine and explore urban noise pollution by emphasizing its impact on human perception as well as various approaches to mitigate noise pollution in Megenagna, Addis Ababa.

1.3.2 Specific objectives

The specific objectives are:

1. To asses the levels of sound in noise hotspots of the area and the problems it creates.
2. To investigate the perception of noise by people exposed to noise pollution.
3. To identify mitigating approaches to reduce and eliminate noise pollution in the area

1.4. Research Questions

1. What are the levels, and major locations of noise in the area?
2. What is the perception of noise by people exposed to noise pollution?
3. What are the mitigating approaches that can be identified to reduce and eliminate noise pollution in the area?

1.5. Significance of the Study

This study has provided valuable knowledge as it is one of the studies to investigate the cause and mitigations of noise pollution in one of the centers of Addis Ababa, Megenagna. It is significant because it contributes to a better understanding of noise pollution, and its environmental, ecological, financial, and health problems. However, the study cannot be generalized to other areas since the study areas in the other settings are different.

The study is relevant in formulating noise management policies by the government and defining priorities for Noise Control in the country. The study is also important for academic institutions and their teaching staff, the new findings on causes and mitigating factors of noise pollution and its adverse health effects. The report of the study is important for the residents who have an opportunity to have new knowledge and awareness as to how much noise in their community/town is too much for human health and can therefore be mitigated.

A city can be designed, planned, and constructed with the concept of preventing noise pollution-causing practices. Cities intend to protect and preserve the environment and improve people's way of living. studying noise pollution in Megenagna is significant as it helps government identify areas with high health risks, environmental impact, urban planning, and economic impact. By identifying these areas, appropriate measures can be taken to reduce noise pollution levels and create healthier, more livable environments.

1.6. Scope of Study

The study looks at noise pollution in the Megenagna area of Ethiopia, including the six roads leading out of the two roundabouts in the area. This includes areas defined by local use of the area's naming. The study looks at both traditional sources of noise pollution, such as the high level of traffic congestion in Megenagna, as well as more modern sources and causes of noise pollution. To understand what qualifies as noise pollution or what it means to be polluted, the study uses parameters such as noise level and management of noise in urban contexts. Sound measurements in decibels are used to identify and address the appropriate levels that should be used. A sound level meter was used to measure the intensity of sound. A sound pressure level was used and noise was measured in decibels (dB). In temporal scope, the study looks at noise pollution on rush hour congestion from 7:00 am to 9:00 am and 4:00 pm to 6:00 pm. Respondents to the questionnaires were chosen and included in demographic data of age, gender, and frequency of visits to Megenagna.

1.7. Operational Definitions

Noise pollution is unwanted or excessive sound that can have deleterious effects on human health, wildlife, and environmental quality1. It is considered to be any unwanted or disturbing sound that affects the health and well-being of humans and other organisms2. Sound is measured in decibels. There are many sounds in the environment, from rustling leaves (20 to 30 decibels) to a thunderclap (120 decibels) to the wail of a siren (120 to 140 decibels)

A person's perception of noise pollution can be defined as the level of disturbance experienced by an individual due to unwanted or excessive sound. This perception can be influenced by several factors such as the individual's age, health status, cultural background, socioeconomic status, and environmental context. Similarly, individuals with sensitive hearing or pre-existing conditions such as tinnitus, hyperacusis, or anxiety disorders may be more susceptible to the adverse effects of noise pollution. The environmental context also plays a crucial role in shaping an individual's perception, as the same noise may be perceived differently in different settings such as a residential neighborhood, a busy street, or a workplace.

1.8. Organization of the Study

Chapter one introduces the topic of noise pollution and the problems it causes around the world and study area. It also addresses the objective, significance, and scope of the study. Chapter two determines what sound and noise mean, the types of noise pollution, causes, and practices that had been used to mitigate noise pollution. Chapter three discusses the steps to be taken to achieve the objective and gives answers to the problems. And show the geographic location, the approaches to studying, data collection and analysis systems, and instruments to be used in the study. Chapter 4 shows results on the types and levels of sound present, human perception of these noises, and a discussion on the mitigation measures of noise pollution. In Chapter 5, the Conclusion and recommendation are included.

CHAPTER 2: LITERATURE REVIEW

Despite its negative effects on health and quality of life, noise pollution has received relatively little attention in research across the world. However, over the last few decades, there has been an increasing interest in studying the impact of noise pollution on human health and well-being (Basner et al., 2014).

2.1. Conceptual Literature

2.1.1. Pollution

Pollution can be defined as a change in the physical, chemical, or biological characteristics of the air, water, soil, or other parts of the environment including visual and auditory senses that adversely affect the health, survival, or other activities of humans or other living things (Richmond et al., 2005). After pollution occurs, the polluted area is going to be no longer appropriate for use. Pollutants can be in the form of solid, liquid, or gaseous chemicals created as due to power plants, oil refineries, industrial facilities, manufacturing industries, and factories. Pollution can also take the form of extremely high heat, noise, light, or other electromagnetic radiation (Crini & Badot, 2010; Rastogi et al., 2022).

Pollution has a significant impact on the environment and all living organisms, including humans. It can cause respiratory problems, skin irritation, and other health problems. The pollution of waterways can harm aquatic life and pose a threat to humans who consume contaminated water (Martínez-Bravo & Martínez-del-Río, 2019). The contamination of soil can also limit crop growth and reduce biodiversity. Pollution contributes to climate change, which can have severe consequences for the environment and health (Bytnerowicz et al., 2007; Rathore et al., 2015).

Pollution is also a complex problem and affects people's lives in numerous ways other than health. Determining an acceptable level of pollution is often more of a political problem than a scientific problem (Bizualem et al., 2022). This is when jobs are at stake, as a manufacturing plant is forced to close or modify its operations (Richmond et al., 2005). While the health effects of pollution are well-documented, the economic effects are often less considered. But the costs of pollution in terms of economic growth, jobs, and human health are significant.

Most people think of pollution as a health problem. And as exposure to pollution can cause a range of health problems, the economic effects are often less considered (Mujtaba & Shahzad, 2021). According to the World Bank, the annual costs of pollution are estimated at $5 trillion that's 9 percent of the global GDP. And these costs are expected to rise as pollution levels increase (Peake & Ekins, 2017).

Prevention and reduction of pollution require appropriate and effective management practices, including regulations, policies, and technology solutions (McGinn et al., 2007). Adopting sustainable practices, reducing the use of fossil fuels, improving waste management, and increasing public awareness can also help reduce pollution. It is essential to recognize the impact of pollution, take measures to reduce it and protect the environment for future generations (Coglianese et al., 2003).

From the constant sound of traffic to airplane engines flying over our heads, noise can be a constant distraction and even lead to negative health effects. It is important to find solutions to reduce unnecessary noise, such as implementing noise reduction measures and promoting more efficient transportation systems (Goines & Hagler, 2007).

2.1.2. Urban Noise Pollution

Urbanization in Ethiopia has been associated with high levels of economic growth, averaging 10.4% between 2003 and 2013. Cities contribute to 38% of GDP with only 15% of total workforce. The government has identified urbanization as a priority area for investment and has developed policies to promote sustainable urban development. Create uncontrolled level of pollution (Bekele, 2021).

Urban noise pollution is a growing problem in many cities around the world. It is a type of environmental pollution that refers to the spread of unwanted or excessive sound that interferes with the daily lives of humans and animals, and ultimately affects physical and mental health and well-being.(Jariwala et al., 2017) Loud and constant noise can be very disruptive, making it impossible to concentrate, leading to headaches, stress, and disruption of sleep patterns (Jariwala et al., 2017).

One of the main causes of urban noise pollution is the use of machines, such as loudspeakers, generators, and construction equipment (Guarnaccia, 2015). Transport-related noise, such as from cars, buses, trains, and planes, is a huge contributing factor. These sources of noise, combined with poor urban planning, result in a significant increase in noise pollution levels (Kadhim et al., 2019).

Research on the impact of urban noise pollution on human health has shown evidence of chronic annoyance and sleep disturbance resulting in severe heart diseases or metabolic disorders (Goines & Hagler, 2007). The adverse health effects of noise from transportation are particularly pronounced around busy roads. Exposure to high noise levels is also known to cause problems such as hearing loss and impaired cognitive development in children. (Brainard et al., 2004).

The levels of noise pollution in cities are generally divided into two categories: ambient noise and specific sources of noise (Zhou et al., 2017). Ambient noise is the constant noise level in an area, which may include background noises such as traffic, construction, and other human activities. Specific sources of noise pollution include loud music, aircraft, and heavy machinery (Subramani & Sivaraj, 2012). Both ambient noise and specific sources of noise pollution contribute to the overall noise levels in a city and can have significant health impacts on residents. As such, it is crucial to implement noise regulations to mitigate the effects of noise pollution and promote a healthy environment (Kim et al., 2012).

Urban environments are notoriously noisy, and the levels of noise pollution in these areas can have a significant impact on the well-being of those who live and work there. The sources of noise can be diverse and include traffic, construction, industrial activities, and even human activity (Simmonds et al., 2014). Noise is measured in decibels (dB), and a safe level for extended exposure is considered to be around 70 dB. However, in many urban areas, the noise levels can average between 75 and 90dB, which can cause hearing damage and other health issues over time (Perspectives, 2003).

Many types of urban noise pollution can be mentioned. The noise generated by vehicles on the roads is a major source of urban noise pollution. Industrial activities such as manufacturing, construction, and mining produce high levels of noise.(Riediker & Koren, 2004) The noise generated from construction activities such as drilling, hammering, and sawing can be very disturbing to nearby residents. The noise generated from airplanes taking off and landing at airports can be a major source of noise pollution for people living nearby (Subramani & Sivaraj, 2012).

Noise generated from commercial activities such as shopping centers, cinemas, and music venues can be very loud and disruptive (Solé et al., 2013). Large outdoor gatherings, such as sports events or concerts, can generate high levels of noise that can be disturbing to nearby residents. Noise from public transport systems such as trains, buses, and trams can be a major annoyance for people living nearby (Vakili et al., 2020). Noise from human activities such as talking, shouting, and playing music can contribute to urban noise pollution, especially in crowded areas such as shopping streets, parks, and squares (Solé et al., 2013).

The United Nations Environment Programme (UNEP) recognizes urban noise pollution as one of the top emerging environmental threats of our time. UNEP acknowledges the importance of addressing noise pollution to ensure the health and well-being of people, as well as the preservation of the natural environment (Ivanova, 2010).

Urban noise pollution is a problem that affects us all. It is a serious health concern that requires attention from policymakers, city planners, and individuals (Konkani & Oakley, 2012). Measures such as reducing noise levels, promoting sustainable transportation, and incorporating green spaces and natural habitats into urban planning help to mitigate the impact of urban noise pollution (Riediker & Koren, 2004).

2.1.3. Mitigation of Noise Pollution

Noise pollution is a growing concern in urban areas as it affects the health and wellbeing of individuals. It is caused by various sources such as traffic, construction, industrial activities, and even recreational activities. However, there are several ways to mitigate and minimize noise pollution (Simmonds et al., 2014).

Installing noise barriers like green walls, sound insulation, or sound-absorbing materials can reduce noise levels. For instance, noise barriers can be installed near highways to reduce the impact of noise levels on surrounding communities (Fink, 2017). Creating noise zoning maps is also an effective approach to mitigating noise pollution. It involves mapping out zones for noise-sensitive areas like hospitals, schools, and residential areas. Such noise-sensitive areas are then protected by setting limits on the noise levels in that zone (D'Hondt et al., 2013).

Investing in efficient and affordable public transportation systems, such as buses, trains, and subways, can help reduce the level of traffic on the road. As well as encouraging the use of quieter modes of transportation such as bicycles, electric scooters, or walking can help reduce the number of cars on the road and promote a healthier lifestyle (Razzaque et al., 2010).

Implementing smarter traffic management systems, such as intelligent traffic lights or variable speed limits, can help improve traffic flow and reduce congestion (B. Singh & Gupta, 2015).

To mitigate noise pollution, various policies and regulations have been implemented by governments and local authorities. the implementation of noise limits for construction and transport activities, such as limiting the hours of operation and requiring the use of noise-reducing technologies (Vakili et al., 2020).

Zoning regulations are enforced to control the location and type of land use, minimizing the impact of noise on residential areas (Ko et al., 2011). Public education campaigns are also employed to raise awareness about the effects of noise pollution and encourage individuals to modify their behavior. These policies and regulations play a key role in mitigating noise and creating a healthier and more livable urban environment (Qian, 2010).

Mitigating and minimizing noise pollution requires a concerted effort from everyone. By adopting the measures above, it is possible to reduce noise levels in our environment, protect the health and wellbeing of individuals, and create a more peaceful and comfortable living environment (Konkani & Oakley, 2012).

2.1.4. Conceptual Framework

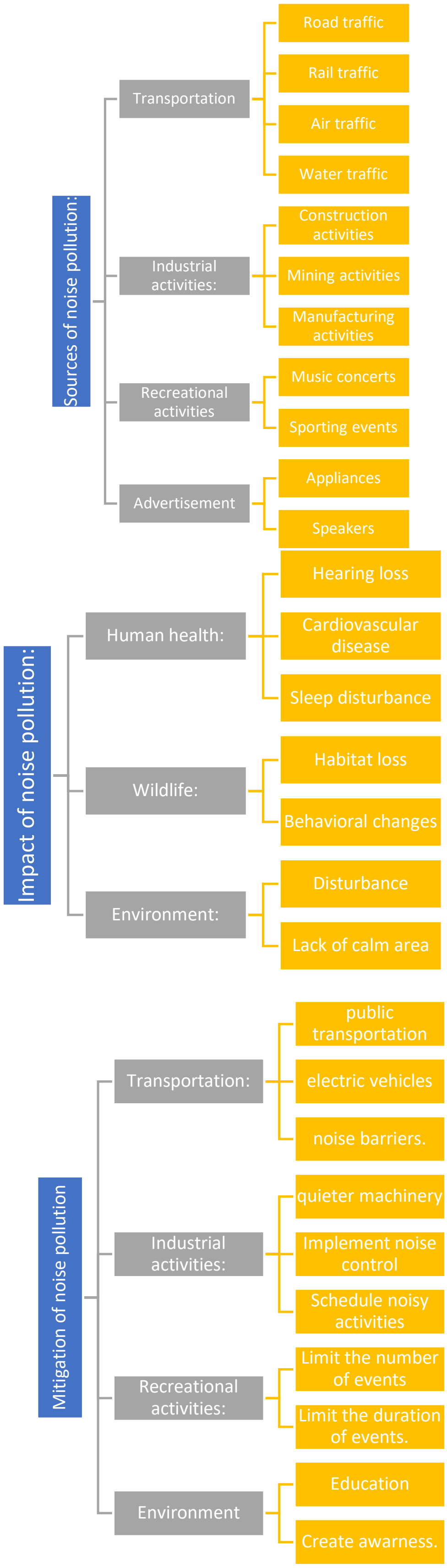


Figure 1 Conceptual frame work

2.2. Theoretical Review

Many studies have explored the effects of noise pollution on health. This paper aims to provide a comprehensive Theoretical review of the existing studies on noise pollution and its impact on human health and well-being.

2.2.1. Sound

Sound is energy made by the vibrations of molecules. When a molecule vibrates, they cause movement in the surrounding. These molecules bump into each other, causing other molecules to bump into and vibrate as well. This continuous movement is called sound waves, this movement of vibration keeps going until the molecules run out of energy (Thomas, 2014). Due to this reason, there is a series of collisions as the sound wave passes through the medium of the sound, but this molecule returns to its original place. These disturbed molecules all stop vibrating making them not wave traveling through them (Zhang et al., 2011).

Sound waves can travel through different mediums such as air, water, and solid objects. The speed and properties of the sound wave depend on the medium it travels through. Sound waves travel faster through solids than through liquids or gases (Maldovan, 2013).

The human ear is specifically designed to detect sound waves. When the sound waves enter the ear, they enter the ear canal and vibrate the eardrum. This vibration then triggers a chain reaction in the ear that ultimately sends the sound signal to the brain, where it is processed and interpreted as sound (Lewis et al., 2017).

Sound waves can have different frequencies and amplitudes, which determine the pitch and loudness of the sound. Lower-frequency waves produce lower-pitched sounds, while higher-frequency waves produce higher-pitched sounds. Similarly, larger amplitude waves produce louder sounds, while smaller amplitude waves produce less sounds (Y. Ma & Zhong, 2003).

Sound has many uses such as communication, music, and animal calls. It also plays an important role in various fields such as medicine, engineering, and technology. Knowing the properties and characteristics of sound helps us understand and manipulate it for various purposes (Theunissen & Elie, 2014).

In conclusion, sound is an integral part of our daily lives and has various uses and applications. From communicating with one another to exploring the depths of the universe, sound plays a crucial role in every aspect of our lives (Swift & Garrett, 2003).

2.2.1.1. Measurements of Sound

The lowest vibration people can hear is 20 vibrations/second. That would be very low to hear with a human ear. The highest vibration people can hear is 20,000 vibrations/second, which would be very high to hear with the human ear. (Tripathy, 2008) Pitch is similar to frequency. Frequency is the technical measurement of the pitch. while frequency is considered to be objective, pitch is considered to be completely subjective (McNeill et al., 2012).

Pitch can be described as the perceived highness or lowness of a sound, while frequency is the number of wave cycles that occur in one second. So, while two sounds might have the same frequency, they can still have different pitches depending on how they are perceived by the human ear (Brumm & Slabbekoorn, 2005). This is why two instruments playing the same note can still sound different - they might have the same frequency, but their unique overtones and timbres can affect the way we perceive their pitch (Oxenham, 2008).

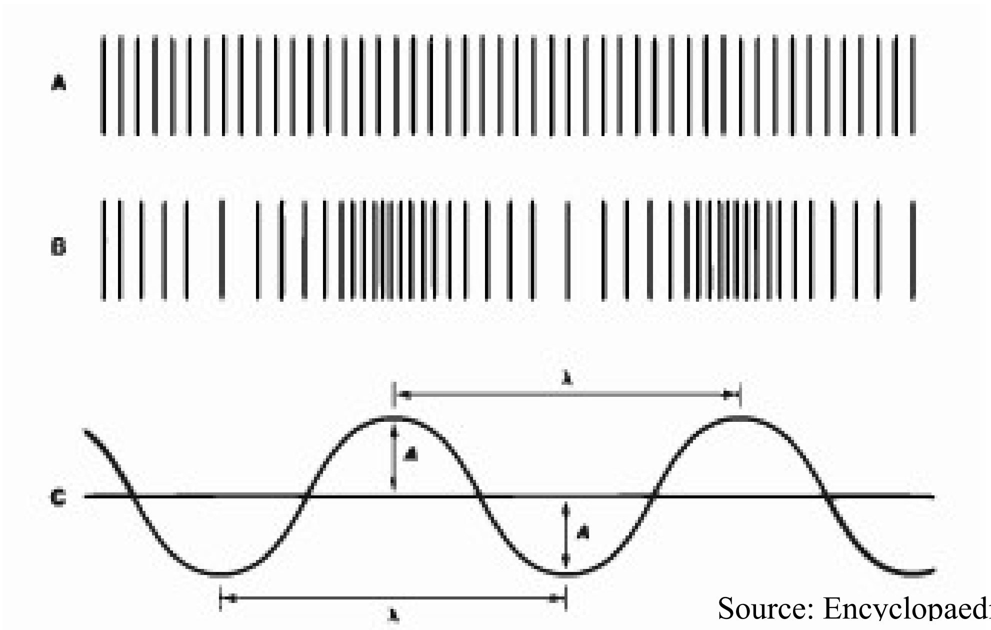
Pitch is measured in hertz (Hz), which represents the number of complete wave cycles that occur in one second. The higher the frequency, the higher the pitch. Our ability to perceive pitch is related to the functioning of the human ear (Lotto & Holt, 2011). Sound waves enter the ear and cause the eardrum to vibrate, which in turn causes tiny hairs inside the ear to move. These hairs send electrical signals to the brain, which interprets them as sound (Hurramovich, 2022).

In general, humans can perceive frequencies ranging from 20 Hz (low-pitched sounds) to 20,000 Hz (high-pitched sounds), although this range can vary depending on factors such as age and hearing damage.(Hanslmayr et al., 2007).

Amplitude (A) is the relative strength of sound waves which we perceive as loudness or volume.

Wavelength (λ) is the distance between adjacent identical parts of a sound wave

Frequency: A measure of the number of vibrations/ second.



Source: Encyclopaedia, Britannica Inc

Figure 2 Sound Wave

Hertz: The metric unit for frequency (1 Hertz (Hz) = 1 vibration/second).

Pitch: The quality of note behind the sound heard, it is a subjective definition of sounds as high or low in tone (Gil-Santos, 2010).

Decibel (dB), a unit for the ratio between two values of a power or root-power quantity on a logarithmic scale, power or intensity, also typically expressing amounts of acoustic or electric power, or for measuring the relative loudness of sounds (Stevens, 2012).

The decibel scale is logarithmic, which means that each increase of 10 decibels is equivalent to a multiplication of 10 in power or intensity. For example, a sound that is 10 dB louder than another sound has 10 times more power or intensity (Tarantola, 2001).

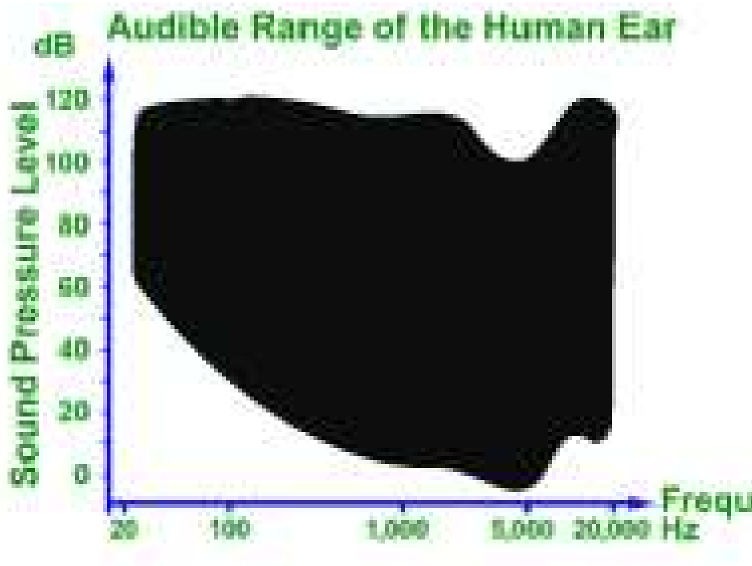
In terms of measuring sound levels, the reference point for 0 dB is the threshold of human hearing, which is the quietest sound that the average person can hear. A sound that is 10 times more powerful than the threshold of human hearing would be approximately 10 dB, while a sound that is 100 times more powerful than the threshold of human hearing would be around 20 dB (Tarantola, 2001).

The decibel scale is commonly used in audio engineering, telecommunications, and acoustics, among other fields. It provides a convenient way to express the relative magnitudes of power or intensity values that span a wide range of values (Frankel, 2009).

The decibel scale is an essential tool for measuring and expressing the magnitude of power or intensity values in various fields.(Ryherd et al., 2012) It enables us to quantify and compare different sound levels and signal strengths accurately Its convenient logarithmic nature makes it an effective method for representing values that vary from very small to extremely large magnitudes (Allen et al., 2005).

2.2.1.2. Safe level of sound

The National Institute on Deafness and Other Communication Disorders state, "Long or repeated exposure to sound at or above 85 decibels can cause hearing loss." So, a safe level of sound for humans can be placed at 85 decibels (Fink, 2017).



Source: Environmental Protection Department. The Government of the Hong Kong SAR

Figure 3 Audible Range of Human Ear

However, it's important to note that exposure time also plays a role in determining safe sound levels. Exposure to 85 decibels for a few minutes is less harmful than exposure to the same level for several hours. Some individuals may be more susceptible to hearing damage than others, depending on genetics, age, and other factors (Zhao et al., 2010).

It's also worth noting that exposure to sounds above 85 decibels can still cause temporary hearing damage, even if it's not enough to cause permanent hearing loss. Noise-induced hearing loss can be prevented by wearing earplugs or other hearing protection, limiting exposure to loud sounds, and taking breaks from noisy environments (Robinson et al., 2015).

In indoor spaces, according to the Occupational Safety and Health Administration (OSHA) in the United States of America, safe volume levels for indoor surroundings are ideally between 40-60 decibels (Bytnerowicz et al., 2007). This includes sound from any electronic equipment like televisions, headsets, or Bluetooth speakers. In outdoor settings, the OSHA also recommends that sound in outdoor locations should not exceed 60-80 decibels. This encompasses sounds from construction sites, traffic, and other activities (Wei et al., 2015).

2.2.1.3 Perception of sound

Perception of sound is the ability to recognize and interpret the auditory sensation produced by vibrations in the air, which are detected by the ear.(Brumm & Slabbekoorn, 2005) This is a complex and dynamic process involving the transmission, processing, and integration of sensory information from different sources, which allows us to identify and locate sounds, discriminate between different types of sounds, and extract meaning and emotion from them. (Hartmann, 2004) The study of the perception of sound is essential for understanding how the human brain and auditory system work, and how we interact with the environment and communicate with others through speech and other sounds (Pasley et al., 2012).

Humans hear sound through a complex process that involves many different parts of the ear. It all starts with the outer ear, which is the part you can see, including the earlobe and ear canal. Sound waves enter the ear canal and vibrate the eardrum, which in turn vibrates the three tiny bones in the middle ear.(Rathore et al., 2015) These bones then send the vibrations to the cochlea, a spiral-shaped organ in the inner ear. Inside the cochlea, thousands of tiny hair cells convert the vibrations into electrical signals, which are then sent to the brain through the auditory nerve. The brain then interprets these signals as sound, allowing us to hear and respond to our environment. This process is incredibly complex and precise, allowing us to differentiate between different pitches, volumes, and tones of sound (Van De Water, 2012).

Humans hear sound all the time, whether it's the sound of a bird chirping, a car honking, or someone talking. However, our perception of sound can vary greatly depending on several factors, including the frequency and volume of the sound, the context in which it is heard, and even individual physiological differences (Zentner et al., 2008).

Frequency perception: One of the key factors that affect our perception of sound is its frequency. Human ears are most sensitive to sounds within the range of 20 to 20,000 Hz, with different parts of the audio spectrum being perceived differently.(Mojo et al., 2015) Low-frequency sounds are often felt more than heard, while high-frequency sounds are more likely to be perceived as sharp or piercing (De Martino et al., 2015).

Loudness perception: Another important factor in sound perception is loudness, which is determined by the intensity or amplitude of a sound wave. Humans tend to perceive sounds that are louder as being more intense or impactful, even if they have the same frequency (Yang & Kang, 2005). This can be influenced by several factors, including the acoustic environment, individual hearing ability, and even psychological factors such as attention and mood (Khalfa et al., 2004).

Contextual factors: Our perception of sound is also heavily influenced by the context in which it is encountered. For example, the same sound might be perceived differently in different environments, such as a crowded street versus a quiet room. Other contextual factors that can affect how we perceive sound include cultural beliefs, personal experiences, and individual expectations or biases (Khalfa et al., 2004).

Speech perception: One area of sound perception that is particularly important is speech. Humans are uniquely adept at perceiving and understanding speech, which involves complex processes such as identifying individual phonemes, deciphering grammar and syntax, and interpreting semantic meaning. While much of this process is automatic and subconscious, it can be affected by several environmental and individual factors (Diehl et al., 2004).

Music perception: Another aspect of sound perception that is of great importance to many people is music (Martellotta et al., 2009). Musical perception involves not only recognizing individual notes and rhythms but also interpreting the emotional and artistic qualities of a piece of music. This can involve a range of cognitive and emotional processes, including memory, attention, and aesthetic judgment (Trehub & Hannon, 2006).

Limitations of perception: While humans are capable of perceiving a wide range of sounds, our perception is not perfect. For example, there are many sounds outside of our audible range, and our ability to distinguish between different sounds can be affected by hearing loss, aging, or other factors (Doda, 2017b). Additionally, our brains can sometimes be fooled by auditory illusions, such as when two sounds seem to be coming from the same source even if one is closer than the other (De Martino et al., 2015).

Individual differences: Another important aspect of sound perception is individual differences in hearing ability and sensitivity. For example, some people are more sensitive to high frequencies than others, while others may have trouble hearing certain ranges of sound because of hearing loss or other factors (Pennghan, 2020). Additionally, individual experiences and expectations can also affect how we perceive sound, such as when someone is accustomed to hearing a particular dialect or accent (Drager, 2011).

Emotional impact: One important aspect of sound perception that is often overlooked is its emotional impact. Sounds can elicit powerful emotional responses, such as the feeling of joy or awe when hearing a beautiful piece of music, or the instinctual fear response when hearing a loud or sudden noise (Bello et al., 2019). This emotional impact can be influenced by a variety of factors, like individual experiences and cultural context (Bänziger et al., 2012).

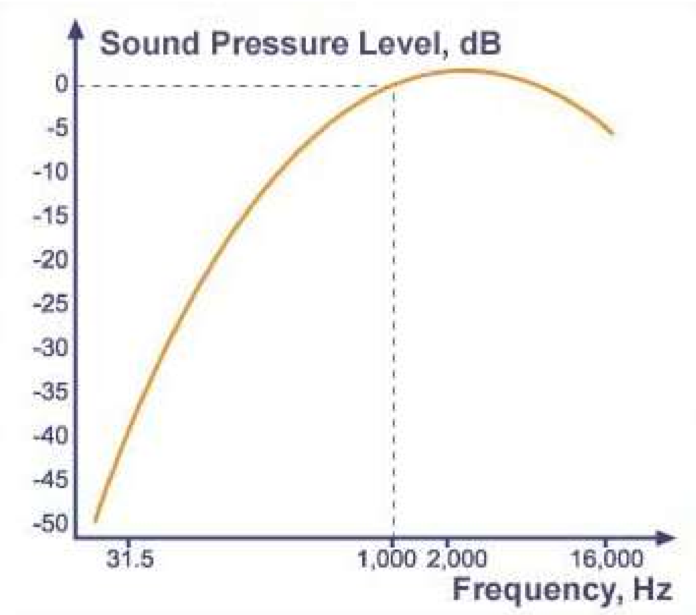
Cross-sensory perception: it's worth noting that sound perception is not always strictly auditory in nature. Our brains are capable of integrating auditory information with other sensory inputs, such as vibrations feedback, to create a more robust overall perception (Sharifi Nowghabi & Talebzadeh, 2019). This can be seen in phenomena such as haptic, where certain sounds are perceived as having vibrations or other sensory qualities (Haverkamp, 2009).

Evolutionary perspective: it's worth considering sound perception from an evolutionary perspective (Yuan et al., 2019). Understanding and interpreting sounds has likely been a crucial survival tool for humans and other animals throughout history, helping us to detect predators, communicate with others, and gather information about our environment. As a result, the way we perceive sound has likely been shaped by millions of years of evolutionary pressure and adaptation (Swaddle et al., 2015).

The response of the human ear to sound is dependent on the frequency of the sound and this has led to the concept of weighting scales (Raimbault & Dubois, 2005). In the "A-weighting" scale, the sound pressure levels for the lower frequencies and higher frequencies are reduced by certain amounts before they are combined to give one single sound pressure level value. This value is designated as dB(A). The dB(A) is often used as it reflects more accurately the frequency response of the human ear. A perceived loud noise has a high dB or dB(A) value and a soft noise has a low one (Holden et al., 2011).

To measure a person's perception of noise pollution, various subjective and objective methods can be used (Münzel et al., 2021a). Subjective methods include self-reported questionnaires or interviews that ask individuals to rate their level of annoyance or disturbance caused by noise. These methods are useful in capturing the complexity of human perception and its variability across different population groups (Zannin et al., 2003).

Objective methods, on the other hand, use instruments to measure the physical parameters of sound such as sound pressure level, frequency, and duration (Pennghan, 2020). While objective measures are useful in quantifying the intensity of noise, they may not reflect the actual impact of noise on human health and well-being. Therefore, a combination of subjective and objective methods may provide a more comprehensive assessment of noise pollution perception (J. Ma et al., 2009).



Source: Environmental Protection Department. The Government of the Hong Kong SAR

Figure 4 Perception of Sound

2.2.3. Noise

Noise is a type of sound that is deemed unwanted. Noise can have different sources human vocal cord, a running engine, a loudspeaker, an operating machine, or a tool. When sounds are difficult to hear and are disturbing the receiver of the sound, they are unwanted so they are called noise (Picciulin et al., 2010). There are 3 types of noise categories. These are Environmental noise that refers to the noise that comes from external sources, such as traffic noise, aircraft noise, and outdoor recreational activities. Occupational noise is the noise that is produced in workplaces by equipment or machinery. And Recreational noise includes music played at high volumes or noisy events, such as concerts or festivals (Muzet, 2007b).

Prolonged noise exposure can have negative effects on health, including hearing loss, stress, sleep disturbances, and cardiovascular problems. It is important to protect oneself from excessive noise exposure by wearing earplugs. (S. A. Stansfeld & Matheson, 2003) There are also regulations in place to protect individuals from excessive noise exposure in the workplace and public areas. These regulations aim to ensure that noise levels are not harmful to human health and well-being (Akhil & Vishwambhar, 2014).

Overall, noise can have a significant impact on our daily lives, and understanding its sources and effects is important for creating a healthy and comfortable environment. By taking steps to avoid or minimize noise exposure, individuals can improve their quality of life and safeguard their health (Wong et al., 2014).

Noise is a form of pollution that is often overlooked despite its negative impact on human well-being and the environment. Noise is called pollution when it exceeds the level that is harmful or disruptive to human health or the natural environment (Goines & Hagler, 2007). The World Health Organization recommends that the maximum noise level for residential areas should not exceed 55 decibels during the day and 40 decibels at night. When noise levels exceed these limits, It is crucial to take steps to reduce noise pollution to protect our health and the environment (Ko et al., 2011).

2.2.4. Noise Pollution

Noise pollution is defined as unwanted or excessive sound that can have negative effects on human health and quality of life. It can be caused by many sources, including transportation, construction, and industrial activities (Morillas et al., 2018b). There are two main types of noise pollution: environmental noise and occupational noise. Environmental noise is unwanted sound in our surroundings. Occupational noise is exposure to loud sounds from work activities (Sheppard et al., 2020).

Noise pollution can have a range of negative effects on health, including hearing loss, sleep disturbance, stress, and cardiovascular disease. It can also impact the quality of life by causing annoyance, frustration, and decreased concentration. There are several ways to reduce noise pollution, including soundproofing and noise mitigation (Jariwala et al., 2017).

These exposures have a negative impact on human health. environmental noise pollution can cause hearing loss, sleep disturbance, cardiovascular diseases, and other causes that lead to decreased quality of life by causing stress, irritation, and annoyance (Pennghan, 2020).

Even animals either domestic or urban dwellers can be disturbed and scared by loud noises, leading to distress, changes in behavior patterns, and even death. It also has great impacts on natural habitats which change the natural habitats of wildlife, leading to changes in their behaviors, migration patterns, or even extinction (Münzel et al., 2014).

Noise pollution can also interfere with communication and adversely affect human health. It may include loud, bothersome sounds, or it may be a series of low-level noises that accumulate over time. In either scenario, interfere with communication both indoors and outdoors (Münzel et al., 2014). Land use conflicts between communities and neighbors in areas with high levels of noise pollution can create land use conflicts, including the inability to attract or retain tenants or attract customers (Song & Knaap, 2004).

Another effect of noise pollution is the inability to find peace and calm. This can be caused due to traffic congestion (Ahmed & Gadelmoula, 2022). Traffic congestion can cause noise pollution, contributing to urban congestion, which leads to more extensive noise pollution. This means people are often unable to find peace and calm, sleep, or work correctly, which impacts their health and well-being (Yang & Kang, 2005). Recently urban centers, transportation systems are designed to provide quieter modes of transport systems. This is due to increasing awareness and concerns about noise pollution and its negative impact on human health and well-being, as well as the environment (Cheng et al., 2015).

People with adequate awareness of noise pollution avoid unnecessary noise-generating activities. They understand the negative impact of noise on their health and well-being as well as that of others. They take steps to reduce noise pollution in their own lives and encourage others to do the same (Francis et al., 2011).

One effective way to promote a quieter environment is to use headphones or earplugs while listening to music or watching videos. Individuals can also avoid honking unnecessarily while driving, by keeping their vehicle's exhaust system and car horns in good working order. (Prashanth Mohan et al., 2008). Turning off unnecessary electronic devices is another simple step that individuals can take to reduce noise pollution. Avoiding loud parties and social gatherings at night also helps promote a peaceful neighborhood (S. Stansfeld & Clark, 2015).

Properly insulating homes and offices is another way to minimize outside noise. By choosing quiet mechanical or electronic devices over noisy ones individuals can contribute to a more soundproof environment (S. Stansfeld & Clark, 2015). It is also important to encourage factories and industries to use quiet machinery and equipment to prevent noise pollution.

Taking small steps towards a quieter environment can help reduce noise pollution, leading to a more peaceful and enjoyable living experience (Shrouf et al., 2014).

Overall, people who are aware of the harmful effects of noise pollution take responsibility for their actions and do their part to keep the environment quiet and peaceful. By being mindful of their noise output and working towards a quieter, more sustainable environment, these individuals are taking steps towards creating a healthier world (Francis et al., 2011).

2.2.4.1. Sources of Noise Pollution

Sources of noise pollution can come from various activities in the environment. The first source of noise pollution is transportation (Vukić et al., 2021). Vehicles such as cars, buses, motorcycles, and trucks produce loud noises that contribute to noise pollution. The use of airplanes and helicopters, especially during take-offs and landings, generates a deafening sound that disturbs nearby residents (Münzel et al., 2021a).

Aircraft noise from planes taking-off, landing, or flying overhead causes high levels of noise pollution. Despite many efforts to reduce engine noise and sound insulation systems, aircraft noise pollution remains a significant challenge, particularly in densely populated areas with large airports (Vukić et al., 2021). There is a need for continued research and investment in technologies and approaches that can mitigate the impact of aircraft noise on human health and the well-being of the urban environment (Sookpuwong & Chompoo-Inwai, 2019).

Another sector that disturbs the urban environment is the Construction industry. Construction activities are also common sources of noise pollution (Vukić et al., 2021). The construction industry is one of the noisiest sectors that pose a potential threat to the health of workers and nearby residents. The main sources of noise in construction sites are blasting, drilling, jackhammering, and heavy machinery (Ahmed & Gadelmoula, 2022). The use of heavy machinery, such as bulldozers, cranes, and drills, produces high-level noise that can cause hearing problems for workers and people living in nearby areas. Industrial plants that produce loud noises, like generators and motors, can also contribute to noise pollution (Murphy & King, 2022).

Factories and other industrial facilities located in urban areas also generate a significant amount of noise. This is particularly true for facilities that operate 24/7, and for those that use large machinery or heavy equipment (Ahmed & Gadelmoula, 2022).

Another source of noise pollution is the recreational or entertainment sector. Activities such as music, concerts, and sporting events can generate high decibels of sound that lead to hearing loss and tinnitus, especially for people who are exposed to these sounds for long periods.(Kadhim et al., 2019) Also, indoor entertainment centers such as cinemas, clubs, and casinos can produce excessive noise, especially during peak hours. The use of fireworks, firearms, and explosives can also contribute to noise pollution (Pennghan, 2020).

Even non-recreational institutes like religious institutions can generate noise pollution, especially during religious rituals, such as the call to prayer in Islam, the ringing of church bells in Orthodox Christian Churches, and the chanting of worship in Protestant Christian Churches. These practices can disturb the peace and tranquility of the surrounding residential areas, leading to complaints from residents (Doda, 2017b).

Several studies have analyzed the impact of religious noise on the surrounding environment. A study published in the Journal of Environmental Health Science and Engineering in 2019 found that the call to prayer in mosques in urban areas exceeded the recommended noise levels, Even though calls to prayer and other religious activities are necessary they should not exceed the recommended level of noise (Harcourt et al., 2023).

Advertisements have become a necessary part of modern media and the business world. These ads are designed to capture the attention of the viewers and promote products or services. While advertisements can be beneficial for businesses and consumers, they also contribute to noise pollution (Kelley et al., 2022).

Advertisements often contain loud and obnoxious sounds that are intended to attract the visitor's attention. These sounds can be anything from jingles to voices shouting loud slogans or catchphrases. The noise from these ads can be irritating and harmful to individuals (Sharifi Nowghabi & Talebzadeh, 2019).

In conclusion, noise pollution is a major environmental problem that affects people's daily lives. As such, mitigating noise pollution requires concerted efforts from individuals, businesses, and governments on each of these sources (Yuan et al., 2019).

Table 1: Sources and Levels of Sounds

Sound	Decibel Level (dB)
Animal sounds	20-130
Snoring	40-70
Household appliances	40-80
Television	50-70
Music	60-110
Conversation	60-65
Garbage disposal	70-100
Machinery noise	70-110
Vacuum cleaner	70-80
Traffic noise	70-85
Church bells	70-90
Alarm clock	70-90
Construction work	80-120
Car horn	100-110
Siren	110-120
Thunder	120
Rock concert	120-140
Fireworks	140
Jet engine	140-180
Gunshot	140-190

2.2.4.2. Mitigating Measures of Noise Pollution

Noise can be mitigated at the receiver's end by, wearing earplugs or along the transmission path by erecting sound barriers along major roads. These approaches do not, however, reduce noise emissions but instead put the burden of mitigation on the receiver (Lam et al., 2021). Alternatively, noise can be mitigated at the source such as by using machines with quieter engines, acoustically treating noisy buildings, muffling jackhammers for roadwork, and stopping unnecessary honking. These actions are commonly encouraged and incentivized through a regulatory framework that uses fines and other penalties to raise the cost of emitting noise (Bello et al., 2019).

Soundproofing materials can also be used for buildings close to transportation routes, including double-glazed windows, foam insulation, and sound-absorbing panels (Ryherd et al., 2012). Implementing efficient traffic management systems, such as peak-hour traffic restrictions, speed limit enforcement, and reducing vehicle traffic, can significantly reduce transport-related noise. Encouraging the adoption of vehicles with low noise emissions, such as electric vehicles or alternative fuel cars, is another option (Münzel et al., 2021b; V. Singh et al., 2020).

Noise mitigation in aircraft is a critical element in ensuring maximum environmental management. Various technologies such as efficient engines, noise-reducing inserts, improved airframe design, and advanced operational procedures have been developed and implemented to reduce noise levels generated by aircraft during take-off, landing, and cruising (Lam et al., 2021). The use of noise shields in the engines, quieter landing gear, and aerodynamic wingtip devices are some of the most effective measures adopted by airlines to reduce noise pollution. In addition, increasingly stringent regulatory requirements and community pressure have driven the aviation industry to continuously invest in new noise mitigation technologies and practices, leading to considerable reductions in noise levels around airports in recent years (Ranasinghe et al., 2019).

To mitigate the impact of noise in the construction industry, several measures can be taken, such as the installation of noise barriers like walls and fencing to reduce noise pollution in nearby residential areas. Scheduling construction work during the day when noise levels are less disruptive can also help (Huang et al., 2019). Rotating workers to limit their exposure to high noise levels is another effective way. Equipment known for generating high levels of noise can be modified with exhaust silencers to reduce noise pollution. Education and training programs can be organized for workers and residents to teach them about the harmful effects of noise pollution and how to mitigate its impact (Razzaque et al., 2010). Finally, it is crucial to choose machinery that generates less noise while still being efficient. The implementation of these measures would create a healthier and safer environment for both workers and nearby residents (Kishore et al., 2021; Vukić et al., 2021).

Noise mitigation in recreational or entertainment settings is of utmost importance to ensure the safety and comfort of both people in entertainment and neighboring residents. The excessive noise produced by concerts, festivals, sports events, and other leisure activities can result in hearing damage, stress, and annoyance (Hegarty, 2020). Therefore, measures such as sound barriers, acoustic panels, and strategic placement of speakers can be implemented to reduce noise levels.(Maldovan, 2013). Furthermore, institutions should adhere to local noise regulations and take into account the proximity of the surrounding community to avoid disrupting their peace. Ultimately, proper noise management practices can enhance the overall experience of the visitors while preserving the well-being of everyone involved (Roberts & Neitzel, 2019).

Effective noise mitigation approaches in factories are essential for reducing the risks associated with prolonged exposure to high levels of noise. Installing sound-absorbing materials on walls, ceilings, and floors can help to limit sound transmission and prevent the reflection of noise within a factory. (Chowdhury & Siraj, 2023) The use of noise barriers, such as partitions or curtains, can also help to reduce noise levels across different work areas. In addition, implementing engineering controls such as machinery enclosures or noise-attenuating silencers can significantly reduce sound emissions from industrial equipment. Regular maintenance of these measures is critical for ensuring that noise levels remain within acceptable limits, and effective training and communication programs can also help to promote workplace safety and reduce the risk of noise-related injuries or health problems (Chou et al., 2021).

Noise mitigation in advertisements is essential to ensure that the message being conveyed is clear and effective. Advertisers must focus on reducing distracting and unwanted sounds, such as background noise, echo, or static, that can interfere with the viewers' ability to absorb the information being presented (Wei et al., 2015). This can be achieved by implementing soundproofing solutions, using high-quality sound equipment, and carefully selecting and editing audio to create a seamless and engaging audio-visual experience (Fahmy, 2020).

Noise mitigation from religious institutions can be achieved through several measures. External sound barriers such as walls or fences can be erected to reduce the impact of noise on nearby residents (Huang et al., 2019). High-quality sound insulation can also be installed in the building itself to dampen noise levels. Scheduling of events can be carefully managed to avoid disturbing times for nearby residents (Ackah et al., 2021).

Sound systems and microphone use in religious institutions can be monitored and adjusted to ensure that excessive noise is not being produced and the quality of sound being produced. Finally, encouraging respectful behavior from congregants can also help to reduce noise levels and improve relationships with nearby residents. Overall, a combination of approaches is effective in mitigating noise associated with religious institutions (Martellotta et al., 2009).

Noise pollution has grave consequences on our well-being and the environment. Mitigating noise pollution is, therefore, a crucial step towards maintaining a healthy and sustainable environment. Effective noise reduction approaches can range from practical actions by stakeholders like legislating noise limits and employing noise-reducing technologies.(Zannin et al., 2006).

Individuals can also take simple measures, like planting trees and bushes for vegetative barriers, earmuffs, and earplugs in noisy environments, reducing public noise pollution. In sum, there is a need for efforts on mitigation measures to reduce and prevent noise pollution's adverse effects on society and the environment (Sharma et al., 2021).

2.2.4.3. Medical Impacts of Noise Pollution

Noise pollution is a type of environmental contamination that has been associated with a range of medical problems, including hearing damage, cardiovascular disease, psychological disorders, and sleep disturbances. Among the most common medical problems associated with noise pollution is hearing damage, as exposure to loud noise over prolonged periods can cause irreversible damage to the inner ear or hearing loss (Jariwala et al., 2017).

Cardiovascular disease is also closely linked to noise pollution, with exposure to high levels of noise leading to an increase in blood pressure, heart rate, and the release of stress hormones such as cortisol and adrenaline, elevating the risk of developing hypertension, heart attack, and stroke. Additionally, noise pollution has been found to have negative impacts on psychological health, with stress, anxiety, depression, and irritability being common symptoms reported by those exposed to noisy environments (Münzel et al., 2014).

Noise pollution can also impact sleep quality, with exposure to loud noise causing disruptions in sleep patterns, leading to difficulties falling asleep, reducing the amount of deep sleep, and interrupting REM cycles, resulting in a range of sleep disorders, including insomnia and sleep apnea.(Huang et al., 2019) Poor sleep quality caused by noise pollution can have a significant impact on overall health and well-being, leading to daytime fatigue, reduced immune function, and increased risk of accidents and errors (S. A. Stansfeld & Matheson, 2003).

The World Health Organization (WHO) in 2011, recognizes seven negative health effects related to noise pollution on human beings. These adverse effects range from hearing loss, impaired speech recognition, and cognitive impairment in children, to sleep disruption, cardiovascular diseases, and stress-related illnesses(Impaired Task Performance) as well as negative social behavior and annoyance reactions (Organization, 2011).

Hearing loss

Hearing loss due to noise (also known as noise-induced hearing loss) is a type of hearing loss that is caused by prolonged exposure to loud noises. When the ears are exposed to loud sounds, the delicate structures within the ear can become damaged, leading to hearing loss. This type of hearing loss is often gradual and can be permanent (Perspectives, 2003).

It can also occur suddenly, for example, when exposed to an extremely loud explosion or gunshot. People who work in noisy environments, such as construction workers, musicians, or factory workers, are at higher risk of developing hearing loss due to noise. Prevention measures, such as wearing earplugs or limiting exposure to loud noises, can help protect against hearing loss due to noise (Jariwala et al., 2017; Slabbekoorn, 2019).

Impaired speech recognition

Impaired speech recognition due to noise refers to the difficulty in accurately understanding spoken language when there is excessive background noise present. When noise levels exceed a certain threshold, it makes it harder for the brain to distinguish between the speaker's voice and the background noise. This interference can confuse, making it difficult to identify and understand speech correctly. The degree of noise and the individual's hearing ability can also influence the severity of the speech recognition impairment. This can lead to communication difficulties, especially in busy and noisy environments such as restaurants, public transport, and sports arenas (Mattys et al., 2012).

Cognitive impairment in children

Cognitive impairment refers to the decline or decrease in the cognitive processes or abilities of an individual. It includes functions such as memory, learning, attention, and decision-making. Research has shown that noise exposure can have a negative impact on the cognitive abilities of children. The noise can lead to difficulty in concentrating, learning, and processing information. Exposure to excessive noise at an early stage of development can cause long-term impacts on cognitive functions such as speech and reading comprehension (Gupta et al., 2018; Thompson et al., 2022).

Sleep disruption

Sleep disruption due to noise refers to the inability to sleep or the interruption of sleep caused by loud or disturbing sounds. It is a common problem for people living in noisy environments, such as near busy roads, airports, or construction sites. Noise can interfere with the quality and duration of sleep, causing fragmented and restless sleep, and may result in daytime fatigue, irritability, and reduced productivity. Soundproofing or reducing noise levels can help sleep disruption due to noise (Jariwala et al., 2017; Ryherd et al., 2012).

Cardiovascular diseases

Cardiovascular diseases due to noise refer to health problems that result from exposure to high levels of noise. Noise can cause an increase in blood pressure and heart rate, leading to a higher risk of heart attack, stroke, and other cardiovascular diseases. Exposure to noise for prolonged periods can also cause inflammation in the arteries, which can lead to the build-up of plaque and increase the risk of atherosclerosis. Studies have shown a clear link between exposure to noise pollution and cardiovascular diseases, making it important to take measures to reduce noise exposure whenever possible (Münzel et al., 2014).

Stress-related illnesses

Stress-related illnesses due to noise refer to health problems that can arise from exposure to high levels of noise. Prolonged noise exposure can cause stress and anxiety, leading to various physiological and psychological disorders such as high blood pressure, heart disease, insomnia, headaches, and depression. Noise pollution is known to be a common stressor that can affect an individual's quality of life, leading to a decrease in concentration, productivity, and overall well-being. People who are exposed to loud and persistent noise over an extended period, such as those who work in factories or airports, are at a higher risk of developing stress-related illnesses due to noise (Ryherd et al., 2012; S. Stansfeld & Clark, 2015).

Negative Social Behavior and Annoyance Reactions

Negative social behavior refers to the undesirable or unpleasant actions that individuals display in response to certain stimuli, including noise. Annoyance reactions due to noise refer to the negative emotional responses that people feel when they are exposed to loud or unpleasant sounds, which can be disruptive to their daily lives (Ryherd et al., 2012).

Noise pollution can be a significant cause of negative social behavior and annoyance reactions. When individuals are exposed to excessive noise, they may become irritable, aggressive, and more prone to conflict with others. This can cause tension and hostility in social situations and can ultimately lead to discord within relationships, families, and communities (Belojevic et al., 2003).

Medical problems caused by noise pollution are diverse and can significantly impact an individual's overall health and well-being. While noise pollution can be found in a range of environments, including workplaces, residential areas, schools, and entertainment venues, taking measures to reduce exposure to high levels of noise, such as the use of earplugs, ensuring the proper urban design and using of soundproofing features, and advocating for noise regulations can significantly improve overall health outcomes (Goines & Hagler, 2007).

2.2.4.4. Noise Pollution in Developing Contries

Environmental noise pollution is growing in developing countries because of an increase in the levels of urbanization, industrialization, and transportation systems.(Hurramovich, 2022) The degree of environmental noise exposure of urban populations is directly related to the level of society's development. In densely populated areas, urbanization, industrialization, and vehicle fleet growth have increased noise emissions and imissions. Exposure to environmental noise significantly threatens human health and the quality of life of millions of people (Bogale et al., 2022).

Developing countries are particularly vulnerable to the negative effects of noise pollution due to inadequate regulations and enforcement mechanisms (Asnake et al., 2021). However, there are ways to mitigate noise pollution such as using quieter machinery and equipment, implementing noise control measures such as sound insulation and sound barriers, scheduling noisy activities during off-peak hours, limiting the number of events held in residential areas, using sound barriers around event venues, limiting the duration of events, and using quieter appliances (Morillas et al., 2018b).

2.2.5. Noise Measurements

Noise measurement is an important tool for assessing environmental noise levels, and understanding their effects on human health and well-being. It involves the use of specialized instruments and techniques to measure and analyze sound waves in the environment, and to quantify their intensity, frequency, and other key characteristics (Belojevic et al., 2003).

The most common unit of measurement used to describe the intensity of noise is the decibel (dB). This is a logarithmic scale that compares the sound pressure level (SPL) of a signal to a reference sound pressure level. The human ear can detect sounds ranging from about 0 dB (absolute silence) to 140 dB (pain threshold), with exposure to levels above 85 dB for extended periods leading to hearing damage over time. This measures noise an important aspect of noise pollution reduction (Peters et al., 2016).

Noise measurement is often done using specialized equipment such as sound level meters, noise dosimeters, or spectrograms. Sound level meters measure the intensity or sound pressure level (SPL) of a sound wave in decibels and can give real-time readings or averaged readings over a period. Noise dosimeters, on the other hand, are worn by individuals to measure their exposure to noise over a day or more. Spectrograms measure the frequency spectrum of a sound wave and are useful for identifying the specific frequencies that may be causing issues (Takahashi et al., 2012).

Sound level meters, also known as decibel meters, are devices that measure the intensity of sound in a particular environment. These devices are often used by professionals in the music industry, industrial sectors, and researchers studying environmental noise pollution. Sound level meters work by detecting sound waves and converting them into sound pressure levels (SPL), which are measured in decibels (dB). They can measure a wide range of sounds, from the faintest whispers to the loudest industrial noises. Sound level meters are essential tools for ensuring that sound levels remain within safe limits to protect human hearing and prevent noise pollution in the environment (Kurt et al., 2009).

2.2.6. Legal Frameworks of environmental issues in Ethiopia

The legal framework for environmental protection in Ethiopia is primarily based on the environmental policy of the country, which was first implemented in 1997. This policy sets the foundation for the legal framework in the country and outlines the principles of environmental protection. The Constitution of Ethiopia also includes provisions related to environmental protection, which make it the duty of the government to ensure that the environment is protected and conservation practices are promoted (Mojo et al., 2015).

Ethiopia has many environmental laws and regulations created to address specific issues. These include the Forest and Wildlife Conservation and Development Proclamation, which seeks to protect natural forests and wildlife habitats, and the Environmental Impact Assessment Proclamation, which mandates the consideration of environmental concerns before any project is implemented. Environmental Pollution Control Proclamation is a legal instrument that aims to reduce air, water, noise, and soil pollution that poses significant risks to public health and the environment in Ethiopia. Overall, the legal frameworks in Ethiopia are comprehensive and are aimed at promoting sustainable development and protecting the environment (Ruffeis et al., 2010).

The Environmental Pollution Control Proclamation of Ethiopia was enacted in 2008 to address various types of pollution that pose a threat to the country's ecosystems and human health. The proclamation sets mandatory standards for industrial, agricultural, and domestic activities to minimize pollution and protect the environment. It also outlines the government's responsibility to monitor and enforce compliance with the regulations and prescribes penalties for violations (Asnake et al., 2021).

The Environmental Noise Pollution Control Proclamation in Ethiopia aims to regulate and monitor the level of noise pollution in the country. The proclamation establishes noise level limits for various types of activities such as industries, construction, vehicles, and residential areas. In Ethiopia, the stipulated noise levels for commercial and residential settings are 65dB and 55dB respectively, whereas the global standards set by the World Health Organization are 70dB and 45 dB respectively. Unfortunately, these regulations are seldom enforced or taken into account. Even though poor enforcement of these regulations is seen, the existence of these regulations reflects Ethiopia's commitment to sustainable development and the health and well-being of its citizens and future generations (Bogale et al., 2022; Doda, 2017b).

2.2. Empirical Review

Noise pollution is a growing concern around the world. Empirical studies have been conducted to investigate the impact of noise pollution on individuals and the environment. These studies have explored various aspects of noise pollution, such as the sources of noise, its perspective, measurement, and urgency of mitigation. This empirical review aims to bring together and analyze the findings of such studies to provide a comprehensive understanding of the effects of noise pollution.

2.2.1. Observations on Noise Pollution

According to (Khaiwal et al., 2016) study on noise levels, the loudest noise comes from ambulance vans (87-104 dB). Other loud noises include bus horns and security whistling, both of which have sound pressure levels above 90 dB. According to (Noor Nahyoon et al., 2016) study on noise levels, it is observed that the average noise level in roadside positions is about 82 dBA, which exceeds the acceptable limit. According to (Razzaque et al., 2010) study on noise levels, traffic noise is measured at the spots along highway areas which are commercial in nature and as such form the commercial hub of the town. The minimum and maximum noise levels observed at the highway are 60.1dB (A) and 110.2 dB (A) respectively. The source is predominantly attributable to motor vehicular traffic.

So, by these observations vehicular pollution of noise is vastly greater compared to other sources. These noises also vary from place to place making the result of one area unreliable to use in another location. As said by the studies roadside pollution are high and is increasing rapidly over time.

2.2.2. Perspectives on Noise Pollution

Given that no two people are the same, it is impossible to say that noise pollution affects everyone in the same way. However, it is reasonable to say that noise pollution can have negative effects on people's health.

According to (Noor Nahyoon et al., 2016) Noise pressure levels were highly variable and significant at the different sampling zones/locations and were the manifestation of diverse man-made activities in these zones. It is well known that noise above a certain level has the potential to damage human health depending on its intensity, frequency, and duration of exposure, as well as the individual's susceptibility.

According to (Razzaque et al., 2010) dwellers of Dhaka city are exposed to high-level noise for a sufficient duration of time which puts them at risk of serious health hazards.

According to (Khaiwal et al., 2016) respondents to the study. More than half of the respondents were moderately sensitive to noise whereas 12.4% of them were highly sensitive to noise. Another 10.3% were very sensitive to noise. More than half of the respondents (55.6%) reported disturbance during sleeping due to noise. A total of 43.4% of respondents get disturbed during studying, whereas 38.4% of respondents feel disturbed during working hours due to loud noise Almost all the respondents (97%) regarded traffic as the major source of noise.

These studies have shown that exposure to high levels of noise can have potential health risks, including sleeping and working disturbances. This is especially true in urban settings, where noise levels are often high.

2.2.3. Standards in Measurement of Noise

According to the study of (Noor Nahyoon et al., 2016) noise levels in the 'A' weighting network were measured using Sound Level Meter. The meter was held 1.3 to 1.5 m above the ground surface. Noise measurements were carried out continuously for the period of ten days with seven hours of monitoring per day with a gap of one hour after every hour of reading.

According to (Razzaque et al., 2010) noise levels have been measured at ten major locations from 8 AM to 10 PM. Sound Level Meter (SLM) was placed at a height of about 1.5 m with the help of a tripod. Noise levels have been measured at every 5 min intervals and the values of these measurements have been recorded. From the recorded values of noise level, noise parameters have been estimated.

According to (Khaiwal et al., 2016) integrating Sound Level Meter, which measures noise levels as dB(A). SLM was installed above 1.2 m using a tripod. Each location was monitored for 24 h including both day and night observations. Time from 6 am to 10 pm was as daytime and from 10 pm to 6 am was referred to as nighttime as per The Noise Pollution (Regulation and Control) Rules, 2000. Sound levels at weekends and weekdays were also investigated. ICBEN questionnaire was adopted to conduct a noise survey around the sampling site to know the perception of the exposed individuals regarding the effect of noise in their life

So, as we understand from these measurement techniques using 1.5m as height to approximate the level of human ear position is required, and not all studies use this for their study. Using intervals that best illustrates different part of the day is required as studies use different intervals. Studies show sound level meter must be calibrated to suit the test area.

2.2.4. Urgency of Mitigating Noise Pollution

According to (Khaiwal et al., 2016) noise levels monitored in and around sensitive areas are well above the permissible standards. To effectively tackle noise, awareness of the government and the public is needed.

According to (Noor Nahyoon et al., 2016) it is predicted that shortly the frequency of noise complaints increase significantly because of a rapid increase in population, business activities, and industrialization.

According to the study of (Razzaque et al., 2010) high-level environmental noise for a sufficient duration of time puts people at risk of serious health hazards. Therefore, urgent measures should be taken to control the level of noise pollution in the city.

As the studies say urgent measures from the government as well as awareness from the public are required to tackle noise pollution. This issue always increases over time becoming harder to combat. Cities should be built in consideration of noise pollution and how to prevent it.

2.4. Research Gaps

In Addis Ababa, the capital city of Ethiopia, the problem of noise pollution is particularly severe in Commercial areas, such as Megenagna. Despite the efforts of the government to control noise pollution, the problem persists, and research on the topic remains limited. There is, therefore, a research gap on the causes, and solutions to noise pollution in Megenagna needs addressing (Moore et al., 2003).

The lack of research on noise pollution in Megenagna is particularly concerning because of the potential health impacts on residents and users of this route. Studies conducted in other countries have identified high levels of noise pollution as a significant cause of hearing loss, stress, and cardiovascular diseases (Nelson et al., 2005).

Due to the lack of research, it is difficult to assess the level of exposure to noise pollution in Megenagna and its impact on residents. As a result, there is a need for further research to identify the sources of noise pollution, its impact on human health and well-being, and how to mitigate its effects. Magnitude of this sound varies from one area to another, making it difficult to rely on results from one place for another. Studies further show that levels of noise pollution near highways and roads have exponentially increased over time. Increase also varies from city to city (S. A. Stansfeld & Matheson, 2003).

It is also noted that to accurately measure the sound level, the height of the sound meter should be set at 1.5m (the average human ear position). It is also essential to consider different time intervals that best demonstrate the sound levels during different parts of the day. This should be taken into consideration depending on the congestion of different cities and areas differently. Furthermore, the sound meter must be calibrated according to the area being tested (Razzaque et al., 2010).

Noise pollution poses a particular challenge to businesses, including hotels, restaurants, and entertainment establishments. Noise pollution from such establishments is a significant concern for the users of Megenagna, with unnecessary loud noises (Hunashal & Patil, 2012).

Further research is needed to examine the impact of noise pollution, its impact on human perception, and effective approaches for mitigating noise pollution (Goines & Hagler, 2007). Overall, addressing the research gap on noise pollution in Megenagna would provide essential guidance for policymakers, urban planners, and residents on approaches for mitigating the negative effects of noise pollution. In light of these studies, the government should take immediate action, as well as make people more aware of the dangers of noise.

CHAPTER 3: METHODOLOGY

This section discusses the methodology that was used for acquiring the necessary information to answer the questions of Noise pollution in Megenagna and throughout the city. It explains how the data was retrieved, followed by a description of the method for the analysis and presentation of the data that was collected.

3.1. Description of the study area

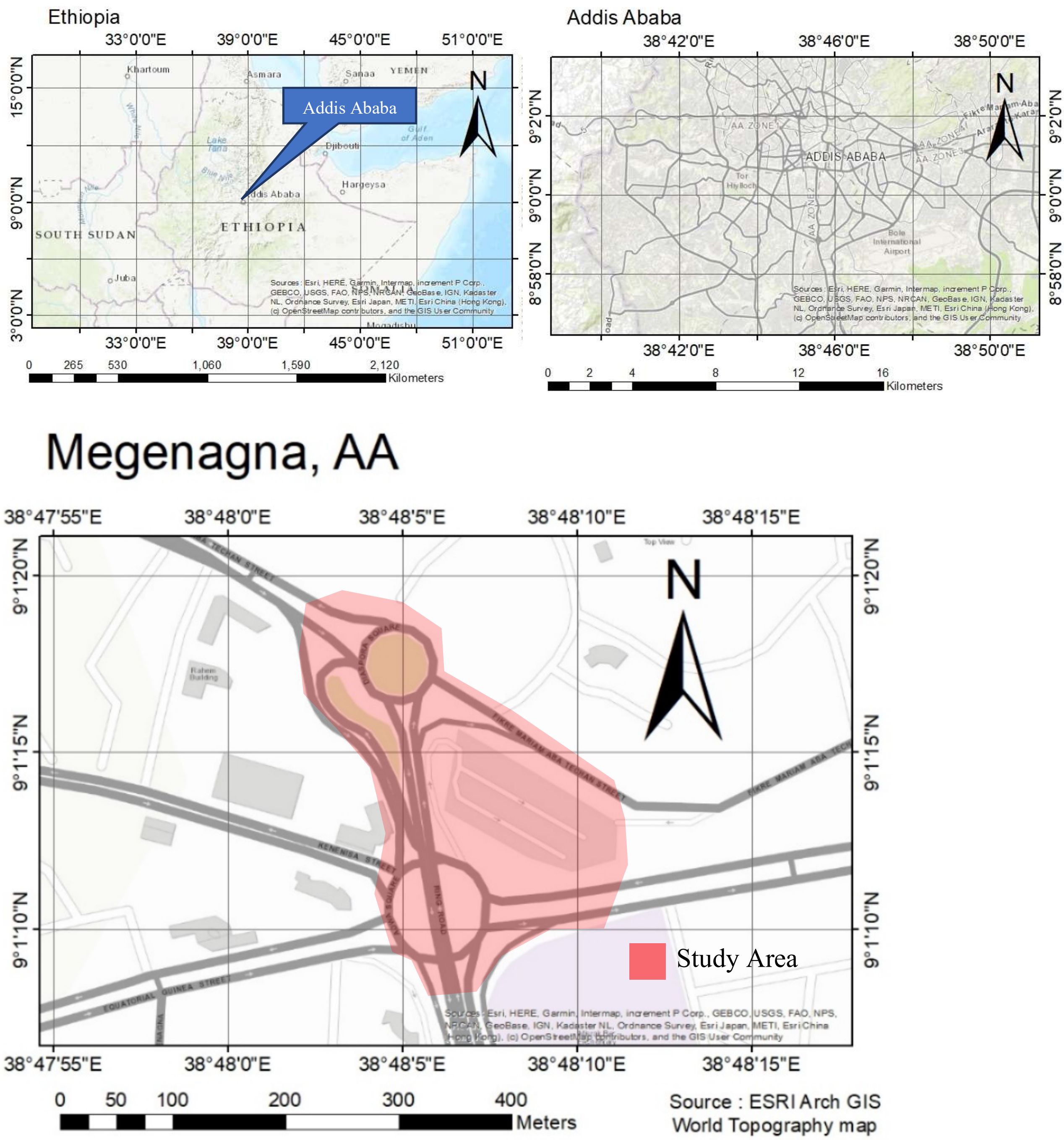


Figure 5 Study Area

Megenagna is a bustling commercial center in the heart of Addis Ababa, Ethiopia. The area is a major transportation hub as it provides access to different parts of the city. It is home to several shopping centers, restaurants, cafes, and entertainment establishments, making it a favorite destination for many people. Megenagna is a vibrant neighborhood that offers residents and visitors an urban experience that is unparalleled in Addis Ababa. Megenagna is an excellent representation of Addis Ababa's urban culture, bustling with life and vitality (Bekele, 2021; Teshale, 2017).

Megenagna is located slightly north of the center of Addis Ababa. Addis Ababa is Ethiopia's capital city and the headquarter of African Union, which locates about 2440 m above sea level. The geographical coordinates of the center of the Megenagna are $9^{\circ}\ 00'\ 17''$ N latitude and $38^{\circ}\ 49'\ 39''$ E longitude. With a total area of more than $64000m^2$. The population of Addis Ababa is estimated at 6,384,569, with an annual growth rate of 3.8%. The total area of Addis Ababa is estimated at 53,920.4 hectares (Kifle Arsiso et al., 2017). The study was conducted around selected areas of Megenagna.

Megenagna's renowned shopping centers are popular destinations for residents throughout the city. These malls feature a wide range of shops and stores selling everything from clothes, shoes, and jewelry to electronics and household items. Shoppers can find almost anything they need in Megenagna. All malls offer a unique shopping experience with a wide range of shops, cafes, and restaurants to cater to all tastes and preferences (Teshale, 2017).

Megenagna is a bustling area in Addis Ababa, Ethiopia, known for its two prominent roundabouts, the Diaspora Square and the Adwa Square. These roundabouts are the epicenter of the vibrant community connecting different parts of the city. The Diaspora Square, located on the north side of Megenagna, is a major landmark of the area. The Fikre Mariam Aba Techan Street that crosses the square connects the northwest and southeast sides of Megenagna. The Adwa Square, located on the south side of the area, is another major landmark. This roundabout serves as a crucial transit point for several roads that connect the different parts of the city. Kenenisa Street emerges from Adwa Square and extends to the west, while Equatorial Guinea Street heads southwest from the roundabout. Another significant road that passes through Megenagna is the Bole Ring Road. It starts from Diaspora Square and passes through Adwa Square via an overpass before continuing southward. Additionally, one unnamed road also heads eastward from Adwa Square.

Another aspect of Megenagna that makes it popular among locals and tourists is the concentration of modern cafes and restaurants. The area boasts a mix of traditional Ethiopian and international food restaurants. These restaurants offer a perfect place to unwind after a long day of work, making them a great place to be with friends and family (Jonga, 2012).

Megenagna is highly sought after by people who want to be close to all the amenities that Addis Ababa has to offer. The area is well connected to the city's major roads and highways, making it easy to access other parts of the city and an ideal environment for people to live, work, and stay (Bekele, 2021).

3.1.1. Selection Criteria

Megenagna was selected for this noise pollution study due to various reasons. Megenagna area often has heavy traffic flow and busy streets, leading to high noise levels generated by vehicles and people. This excessive noise pollution can have detrimental effects on the health and well-being of the visitors to the area. Additionally, Megenagna often has outdoor markets, which are known to generate high levels of advertisement noise pollution, further adding to the noise levels in the area.

Furthermore, Megenagna is often a densely populated area, with a high number of visitors and commercial buildings, which can exacerbate noise pollution levels. Thus, a noise pollution study in Megenagna is not only essential to measure the noise levels but also to identify measures to mitigate noise pollution and improve the quality of life for the Visitors of Megenagna.

3.2. Study Design

To collect data on noise pollution in Megenagna, a combination of quantitative and qualitative data collection methods was used. First, quantitative data on noise levels were measured using noise level meters in various locations throughout the area. This provided information on the average noise levels in the area, as well as identifying any hotspots of particularly high noise levels. Qualitative data on the sources and impacts of noise pollution was collected through surveys and interviews with residents, business owners, and local officials. These surveys investigated residents' perceptions of the severity of noise pollution, the main sources of noise pollution, and the impacts of noise pollution on their health and quality of life.

The data collected were analyzed using both descriptive and inferential statistics. Descriptive statistics were used to summarize the quantitative data on noise levels, while inferential statistics were used to identify any significant relationships between noise levels and other variables, such as the time of day, and the day of the week. The qualitative data was analyzed thematically to identify common themes and patterns in the residents' perceptions and experiences of noise pollution. The findings of this research provides important insights into the levels and impacts of noise pollution in Megenagna, which can be used to inform policies and approaches to mitigate the effects of noise pollution in the area.

3.3. Study Approach

Measurement devices to collect quantitative data and user interviews and surveys to gather qualitative information on local sound levels were used. The aim was to more accurately gauge the noise pollution in the area as well as its impacts.

To gather quantitative information, measurements of noise levels in the identified study area were taken. This was done using a sound level meter. The measurements were taken at various times of the day to get a comprehensive understanding of the noise levels in the area.

To gather qualitative information, interviews were conducted with residents, business owners, and workers in the area, as well as distributed surveys to gather data on their experiences with noise pollution. Subjects were asked questions about how noise affects their daily lives, their health, and their well-being, as well as their thoughts on potential solutions. Several solutions were recommended.

By utilizing these quantitative and qualitative data, a comprehensive understanding of noise pollution, its impacts, and potential solutions to create a better living environment for the local community were able to be provided.

3.4. Data type and sources

3.4.1 Primary Data

The first step in analyzing noise pollution is to measure the noise levels in different areas. This primary data was collected by using SLMs to measure the noise levels in different areas of the site. SLMs were placed in different locations on the site at different times of the day to get a comprehensive understanding of the noise levels. The data collected through these instruments were then used to analyze to determine the average noise level in different areas.

Apart from measuring noise levels, it is also important to understand people's perceptions of noise pollution. This Primary data was collected through questionnaires with people in different areas of the site to gain insight into their experiences with noise pollution. The questionnaires were conducted with closed-ended questions to get a better understanding of the issue. The interviews revealed that noise pollution was a major concern for people, and they were highly affected by it. These interviews helped in understanding the issues faced by people concerning noise pollution and how it affects their daily lives.

Primary data was crucial in analyzing noise pollution on the site, as it helped in understanding both the physical dimensions of the problem and the social dimensions. It provided data on noise levels in different areas, enabling policymakers to devise appropriate solutions to mitigate the problem. Overall, the use of primary data is critical in tackling noise pollution, ensuring that solutions are tailored to fit the unique characteristics of the Megenagna area.

3.4.1 Secondary Data

Secondary data was utilized in a study on noise pollution and its perception. To understand noise pollution, the researcher reviewed relevant documents and reports. This type of data provided insights into the frequency, intensity, and sources of noise pollution over time.

Moreover, the researcher used papers and scientific databases to understand the effect of noise pollution on human health and behavior. This secondary data indicated the impact of long-term exposure to high levels of noise pollution. Furthermore, the researcher explored the existing policies and regulations regarding noise pollution and its control. The secondary data revealed the various noise thresholds and permissible limits for different areas concerning different sources of noise pollution. Maps were used as secondary data to gather information on geographical features and boundaries, which were then used to create a spatially distributed study. They were also used to study location-based noises to identify major hotspots and analyze them accordingly.

In conclusion, secondary data played an essential role in the study of noise pollution and its perception. Secondary data collection methods provided a wealth of information for the researcher, allowing them to understand the complex nature of noise pollution and its impact on human life more comprehensively.

3.5. Study Population

There are different sources of sound as the Megenagna is one of the centers of the city. These sources are noise sources that are included in the area allocated around Megenagna. The cars that pass through Megenagna, as well as different advertisements located in Megenagna, were part of the population. Users, residents, occupants, and workers of the area were also included as sources of sound and demographically classified for analysis of the effect of the noise.

Demographic data such as the age and gender of participants were asked as well as their health status, any hearing issues, and their attitudes towards noise pollution. The study also included both objective and subjective measures of noise exposure, such as sound level measurements and self-reported noise annoyance levels. Participants were asked to identify the specific sources of noise that they find disturbing, and how they cope with exposure.

Overall, the study population included a diverse range of individuals who were exposed to varying levels and types of noise pollution, to capture a comprehensive understanding of how different individuals perceive and respond to noise pollution in their daily lives.

3.6. Sample Size

The sample size has included the people that use, live, or dwell as well as work in Megenagna. A margin of error that can be tolerated with the discrepancy between the sample size and the population had a recommended value of 5%. And with recommended 95% confidence level for research. And with an unknown population size of Megenagna residents, workers, users, and commuters (Richardson, 2013).

Using a population proportion of 50% in sampling results in the largest possible sample size for a given level of precision and confidence, providing a conservative estimate for sample size calculation.

Based on this information, to calculate the sample size:

$n = (Z^2 * p * (1-p)) / E^2$

where:

- n is the sample size
- Z is the Z-score for the desired confidence level (1.96 for 95% confidence level)
- p is the population proportion (0.5 in this case)
- E is the margin of error (0.05 in this case)

Plugging in the values, we get:

n = (1.96^2 * 0.5 * 0.5) / 0.05^2

n ≈ 385

So, for a 95% confidence level and a margin of error of 5%, a sample size of 385 was needed.

The measuring distance of an average sound meter is 15m-30m so taking the median of 22.5m as the measuring range. A sound meter. can measure a radius of 22.5 meters which is a total of 1590.4m^2. So to cover the total area of 64000m^2 of Megenagna 40 locations are required. So 40 locations were chosen for noise level measurement using purposive sampling. This method was used to select locations that were deemed to be particularly relevant or important for the study. The locations were chosen based on their noisy environment and expert judgment to ensure that the results accurately reflect the noise levels in the area.

Total area of Megenagna = 64000m^2
Measuring the distance of an average sound meter=15-30m
Median Range of measurement= 22.5m
Area of measurement= π(Range of measurement)^2

$$= \pi(22.5\text{m})^2$$

$$= 1590.4 \text{ m}^2$$

$$\text{Required number of measurement locations} = \frac{\text{The total area of Megenagna}}{\text{Area of measurement}}$$

$$= \frac{64000\text{m}^2}{1590.4 \text{ m}^2}$$

$$= 40.24 \approx 40$$

3.7. Sampling Techniques

Sampling is a crucial step in the process of research as it helps to ensure that the collected data is an accurate representation of the entire population being studied.

3.7.1. Sampling technique for sound-level data

In this research, the sampling for sound-level data was used specifically in sensitive, highly used areas to ensure maximum representation of the entire population. To accomplish this, the researcher employed the use of purposive sampling, which is also known as judgment sampling. This method involves using the expertise and judgment of the researcher to select the best locations that provide the most useful sound-level data for the results.

These areas were carefully selected because they had high levels of usage and were particularly sensitive. The researcher understood that these areas played significant roles in the larger population and it was therefore important that they were properly represented in the collected data. By selecting these specific areas for sampling, the researcher was able to capture a comprehensive understanding of the sound levels within the different environments present in the population.

3.7.2. Sampling technique for surveys or questionnaires

To properly study the effects of noise pollution, the researcher needs to gather data through the use of surveys or questionnaires. The sampling technique used in gathering this data is random sampling. This method involves randomly selecting individuals within a population to participate in surveys or questionnaires.

Once the sample is selected, the researcher sub-grouped the participants based on their age and frequency of visits to the area affected by noise pollution. This helped the researcher to better understand how different age groups and individuals who have different frequencies of visits to an area react to noise pollution. As younger people may be more tolerant of noise pollution than older adults or people who frequently visit an area with high levels of noise pollution may be more aware of its negative effects.

By sub-grouping individuals based on their age and frequency of visits, researchers obtained a more comprehensive picture of how noise pollution affects different populations. This can help to inform policy decisions and interventions to reduce noise pollution in specific areas. Overall, the use of random sampling and sub-grouping techniques are essential tools for researchers studying noise pollution and other environmental problems that affect the health and well-being of individuals in a community.

3.8. Study Instrument

Noise pollution has become a major concern for contemporary society. The adverse effects are not only restricted to hearing loss but also extend to physiological issues, including stress, anxiety, high blood pressure, and heart diseases. To measure the degree of noise pollution in a particular area, a hand-held sound meter was used in the study. This device could accurately measure the noise levels and aid in the assessment of the causes and sources of noise.

The study used a portable sound meter to measure the decibel levels in the area for the selected locations. The samples were taken by placing the sound meter at an average height of 1.5 m, which is recommended by the average human height for hearing. This is the height where the most significant impact of noise pollution is felt. By measuring the noise levels at this height, we were able to evaluate the impacts of noise pollution on the environment and human health (Zhou et al., 2017).

Figure 6 Sound Level Meter

3.9. Data Collection

To gain a thorough understanding of the noise levels in the study area, a sound level meter was used to accurately measure the noises present. This device was calibrated both before and after use following international standards, ensuring that the measurements obtained were accurate and reliable. The sound level meter was placed at a height of 150cm above the ground, to capture the full range of noises present.

To ensure that the measurements taken were representative of the noise levels experienced during peak congestion hours, tests were performed between 07:00-9:00 am and 4:00-6:00 pm. To capture maximum noise level readings, the sound level meters were placed close to the roadways according to the selected study locations.

In addition to the objective measurements obtained through the use of sound level meters, data was also collected through questionnaires with users, residents, occupants, and workers of the area. These questionnaires provided insights into how the present noises have been affecting the individuals who are most impacted by them. By combining objective measurements with subjective experiences, a comprehensive understanding of the noise levels in the study area was obtained.

3.10. Data Analysis and Interpretation

After collecting large amounts of raw data, the next step was to analyze it to gain valuable insights. To do this, various statistical software tools were employed. One such tool was ArcGIS, which was used to analyze the spatial variation of the sample. Another tool used was Microsoft Excel, which was used to analyze the mean and standard deviation of the data collected from measurements.

The spatial variation analysis was crucial to simplifying the complex raw data into a more manageable mean results' noise map. Overall, the statistical analysis using ArcGIS proved vital for both the noisy and quiet areas of the sample distribution in the study area.

Data analysis also required an organized approach to systematically reach and arrange the various sources of information gathered throughout the study. These included interview transcripts, filled questionnaires, field notes, and other materials that could help increase understanding of the respondent's subjective experiences.

To analyze the data, different software like SPSS and Excel were used to apply both descriptive and statistical methods, such as frequencies, and percentages. These tools allow for a more structured and meaningful interpretation of the raw data collected from respondents.

Finally, all the data was processed and presented clearly, allowing the findings to be easily interpreted and understood by the intended audience. Overall, the data analysis stage was a crucial part of the research project and enabled the researchers to draw meaningful mitigation measures from the collected data.

3.11. Validity and Reliability of the Data

To ensure the validity and reliability of the study, the researchers used a variety of methods to gather data on noise pollution in the study area. These methods included noise measurements, interviews with residents, and field observations. The researchers also took steps to ensure that the data was collected in a rigorous and transparent manner. For example, they used calibrated sound level meters to measure noise levels and conducted interviews with a representative sample of residents to ensure that the results were representative of the population as a whole. The questionnaire was not filled out by the respondents themselves but rather by the researcher and 5 additional data collectors. Since the study was conducted with different ideas from the interviews and field observations.

3.12. Methodological Chart

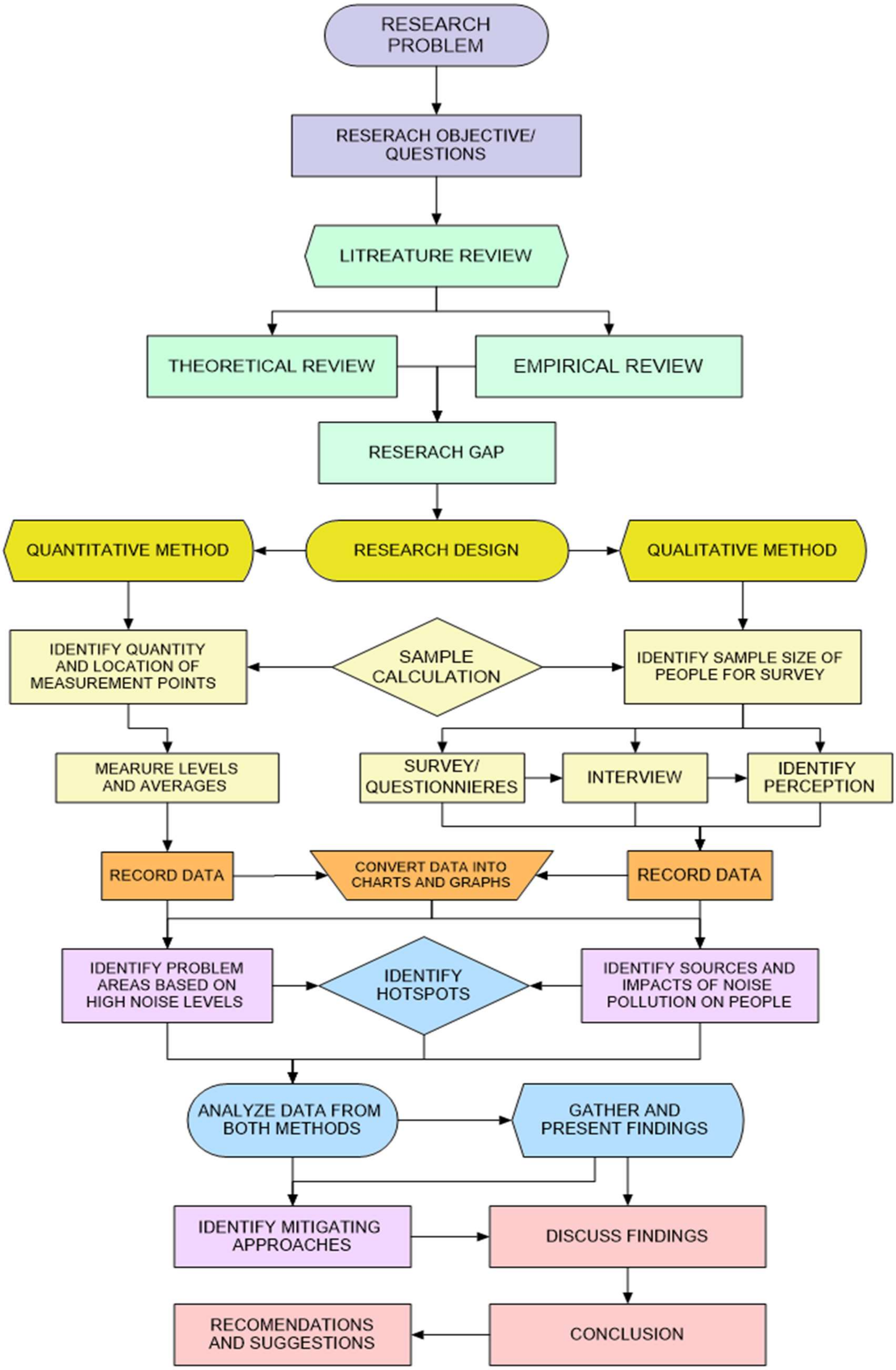


Figure 7 Methodological Chart

3.13. Ethical Consideration

The study was conducted with great care and consideration for the participants' rights and well-being. It was important to ensure that the participants were aware of their rights and that they had the freedom to decide whether they wanted to participate or not. The participants were informed of the purpose of the study, the risks and benefits of participation, and the funding sources. To ensure confidentiality and privacy, no personally identifiable information was collected and the data gathered was kept hidden from all parties.

The researcher was also aware of the potential for harm and took careful steps to minimize this risk. The study did not disrupt the work, traffic flow, or day-to-day routines of Megenagna, and the researchers made every effort to minimize any disturbances during data collection.

To maintain the integrity and accuracy of the study, the researcher was diligent in their efforts to avoid plagiarism or research misconduct. The findings of the study are, therefore, representative of the facts gathered with the highest level of ethical standards. Overall, the researcher placed a strong emphasis on ethical conduct, which underscores the validity and reliability of the results obtained.

CHAPTER 4: RESULTS AND DISCUSSION

The main results of the study were outlined through the use of tables, graphs, and charts, which detailed the data collected from the noise measurements and survey responses. Key trends, patterns, and differences were identified and compared with the research objectives and hypotheses set out at the beginning of the study, with a particular focus on interpreting and explaining the results concerning the research questions and existing literature. Any unexpected or contradictory findings were addressed, and possible explanations were discussed. Overall, these findings offer valuable insights into noise and noise perception, which could be of benefit to those working and living in highly noisy areas.

4.1 Main Findings

4.1.1 In Relation to Previous Studies

Observations on Noise Pollution

Table 2 Observations on Noise Pollution

Ravindra Khaiwal, 2016	Ambulance vans =87-104 dB Bus horns and security whistling = >90 dB
Rajiv B. Hunashala, 2012	Roadside positions = 82 dBA
Sanjib Chandra Chowdhury, 2010	Highway = 60.1 - 110.2 dB

Perspectives on Noise Pollution

Table 3 Perspectives on Noise Pollution

Ravindra Khaiwal, 2016	• 12.4% of respondents were highly sensitive to noise. • 55.6% of respondents reported disturbance during sleeping due to noise
Rajiv B. Hunashala, 2012	• Noise pressure levels were highly variable and significant at the different sampling zones/locations
Sanjib Chandra Chowdhury, 2010	• Dhaka city is exposed to high levels of environmental noise and is at risk of serious health hazards.

Measurements of Noise

Table 4 Measurements of Noise

Ravindra Khaiwal, 2016	• The meter was placed at 1.2 m using a tripod • Time from 6 to 10 pm for daytime and from 10 pm to 6 am for nighttime
Rajiv B. Hunashala, 2012	• The meter was held 1.3 to 1.5 m above the ground • Period of ten days with seven hours interval
Sanjib Chandra Chowdhury, 2010	• Placed at a height of about 1.5 m with the help of a tripod. • Measurements at every 5 min interval

The urgency of Mitigating Noise Pollution

Table 5 Urgency of Mitigation

Ravindra Khaiwal, 2016	• The noise was above the permissible standards • Awareness of government and the public is needed.
Rajiv B. Hunashala, 2012	• The rapid increase in population, business activities, and industrialization.
Sanjib Chandra Chowdhury, 2010	• There is the risk of serious health hazards. Therefore, urgent measures should be taken to control the level of noise pollution in the city

4.1.2 From Site Survey

The site survey of the Megenagna area was a critical process that involves collecting data and identifying the sources of noise pollution. The survey assessed the highly noisy areas upon measurement of selected locations and highly disturbed and risk of health concern people due to the noise pollution present.

During multiple site surveys, a thorough analysis of noise pollution was conducted to determine the decibel levels of various sources, this was done through the use of sound level meters. Noise found on the sites was from traffic, people conversing, loudspeakers, as well as spoken advertisements, and construction noises, which were the main sources in the area. noises heard seldomly are of religious institutions and aircraft noise The measurements were taken at key locations within the area, and from these various sources.

The findings from the survey helped to develop noise maps of the area and make recommendations for reducing noise pollution by the measurement taken. Community engagement was also an important part of the site survey process. Residents of the Megenagna area were questionnaire and their perceptions of noise pollution were recorded. This feedback helped to identify areas of concern and prioritize solutions that would have the biggest impact on improving the quality of life in the area.

Overall, the site survey of the Megenagna area was a crucial step in understanding and addressing noise pollution in the community. By collecting data, engaging with residents, and developing targeted solutions, the survey helped to create a healthier and more livable environment assessment for all.

4.2 Noise Measurements

40 locations in different areas across the Megenagna were selected to ensure the representativeness of the noise levels. Timeframes were decided for the study based on the busiest hour that was in the morning and evening and every day of the week for Megenagna. Time ranges from 7:30 am up to 9:30 am and 4:00 pm up to 6:00 pm. Measurements were taken from May 8, 2023, up to May 14, 2023.

Sound level meters were used to measure the noise levels at each location. These meters were calibrated before the study to ensure accuracy. At each location, a sound level meter was placed at a height of about 1.5 meters from the ground and was in place for a predetermined period of 1 Minute. The period varied depending on the location typically around 1 minute.

The sound level meter provided continuous readings of the noise levels in decibels (dB) during the time it was in place. Using these readings, the average dB level was determined for each location. After all measurements were taken, the data was analyzed to determine the average noise level at each location including patterns in the data, such as peak noise levels and differences in noise levels between locations. The results of the noise level measurements were compiled into this study, which included a summary of the findings.

The results of the study show that the noise levels during rush hours in Megenagna are well above the acceptable levels recommended by the World Health Organization as well as the Environmental Noise Pollution Control Proclamation in Ethiopia.

The average noise levels during morning rush hour were found to be 78.9 dB, while during afternoon rush hour the average noise levels were 81.4 dB. This is significantly higher than the recommended maximum noise level of 65 dB for commercial areas.

The study also highlights that noise pollution in Megenagna is not just caused by traffic congestion but also by other factors such as loud music from various shops and bars. Additionally, the lack of maintenance of vehicles, especially public vehicles, contributes to noise pollution.

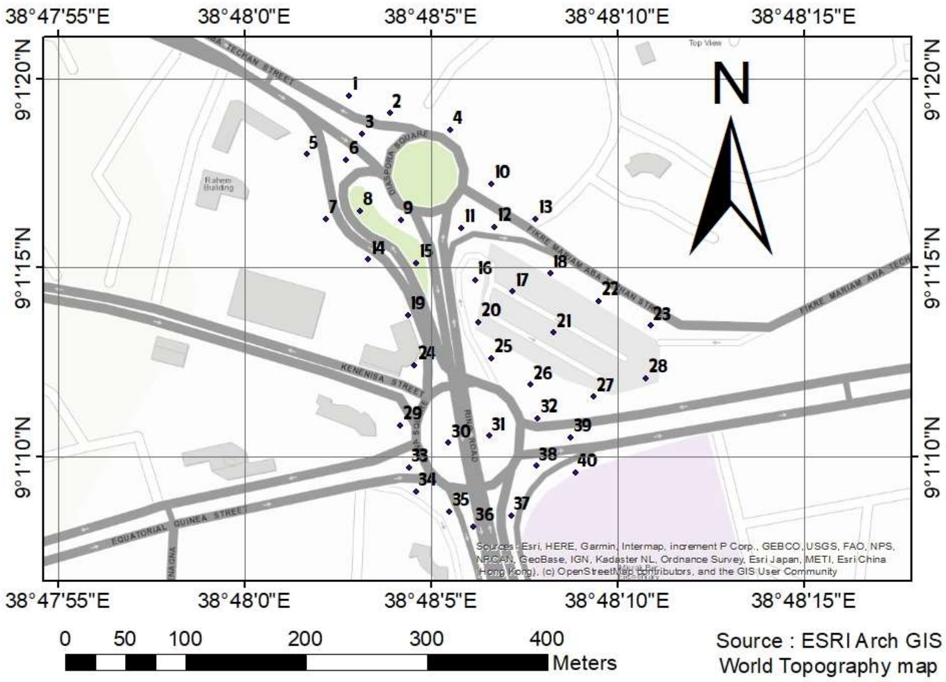


Figure 8 Measurement Locations

Noise measurement locations were selected based on a site survey taken in the area. To best represent the area, dispersed measurement locations were selected so that the full area of Megenagna was represented. Distance between measurement locations ranges from 30 m up to 60m based on the area's congestion level. These locations were given numbers for ease of collection, analysis, and presentation of data of the areas. The selection and placement of measurement locations were carried out with great care to ensure that the noise level data collected was accurate and representative of the Megenagna area.

Table 6 Noise Measurements

Day of Week	Time of Day	Location Number																																						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Monday	**Morning**	79.9	79.0	80.3	78.8	83.0	79.6	77.4	75.3	77.1	79.7	80.5	83.1	76.3	80.0	77.0	81.9	76.8	80.6	79.9	77.3	76.9	78.8	82.6	84.5	77.2	77.1	75.1	77.8	84.7	74.4	78.6	74.9	78.8	78.9	76.2	78.9	77.7	79.7	77.4	80.6
	Evening	85.3	83.2	81.8	82.3	85.6	86.0	84.7	80.5	81.4	84.6	81.3	87.4	81.4	85.8	76.2	83.9	82.5	76.4	75.1	80.1	85.0	83.2	82.1	85.1	81.4	83.1	84.5	80.3	75.0	78.7	79.6	83.4	80.8	84.5	80.5	79.7	81.9	84.3	81.0	83.5
Tuesday	**Morning**	80.6	82.5	78.4	77.9	81.3	78.4	82.7	80.4	84.7	77.6	81.1	74.4	78.7	78.8	77.5	82.6	74.3	76.6	77.4	76.4	76.0	84.7	80.1	77.0	76.2	85.4	77.8	82.7	82.5	79.7	77.2	82.6	75.0	78.8	77.4	77.2	79.9	75.0	80.5	76.2
	Evening	87.4	80.8	80.5	81.3	75.6	80.3	83.9	79.0	79.6	76.5	84.7	80.3	85.3	82.3	76.3	75.1	81.8	82.3	85.4	84.4	85.3	83.5	81.0	79.3	79.6	85.6	77.9	87.4	83.0	76.3	82.5	75.6	85.3	83.7	83.5	79.0	82.3	83.5	84.8	81.4
Wednesday	**Morning**	78.9	76.4	80.9	85.9	76.3	80.0	76.2	78.4	76.2	76.6	77.7	78.5	80.9	77.9	81.4	85.1	77.9	78.5	76.2	79.7	83.2	79.7	78.8	74.9	75.9	78.8	79.7	76.4	78.2	80.1	77.5	76.2	80.9	77.6	82.9	77.8	79.9	78.6	76.9	78.4
	Evening	82.5	79.6	82.9	84.4	81.4	85.8	75.1	80.0	76.9	80.1	78.2	85.5	75.8	81.3	85.2	83.3	77.0	78.6	85.1	83.7	84.3	80.8	74.6	85.6	83.3	84.7	79.9	81.4	81.9	84.9	81.0	85.1	77.1	83.5	83.2	80.4	82.8	84.7	75.2	74.1
Thursday	**Morning**	74.9	77.0	74.4	77.0	75.9	75.9	78.8	77.8	79.2	75.1	81.4	74.3	79.7	78.6	79.9	77.3	75.0	82.5	77.8	75.8	78.9	77.5	76.7	74.6	77.0	78.9	79.6	84.7	78.4	83.0	77.2	80.6	84.6	80.6	77.8	79.9	74.4	74.9	78.6	77.0
	Evening	83.1	78.9	80.2	82.1	83.6	85.3	83.2	84.7	84.5	77.2	78.3	82.3	74.1	79.0	77.5	83.9	75.4	81.0	84.7	84.7	82.4	83.5	82.3	87.4	84.4	85.5	83.9	79.6	78.9	74.4	85.4	81.6	82.9	82.5	84.5	75.1	79.6	84.7	84.3	77.0
Friday	**Morning**	76.2	79.7	77.7	77.5	76.8	80.2	87.1	85.5	80.6	78.9	78.3	80.5	82.4	76.4	80.2	74.9	80.6	81.9	77.0	79.0	76.2	78.2	84.9	78.9	79.9	82.8	79.0	76.2	79.2	77.5	85.6	82.4	80.3	79.9	78.5	82.5	77.8	80.5	77.4	85.1
	Evening	85.1	76.5	82.7	85.3	84.2	80.3	83.5	81.8	81.4	74.7	82.5	75.0	80.3	83.6	83.5	82.5	77.3	78.4	78.4	82.5	77.2	81.4	84.7	85.7	83.5	75.4	83.0	80.3	85.8	83.7	81.4	76.9	76.4	74.5	81.8	82.3	74.1	84.4	82.5	84.7
Saturday	**Morning**	77.5	78.9	74.3	78.8	76.3	78.6	76.2	82.7	83.1	83.5	81.0	75.4	76.2	75.0	76.2	79.0	75.1	78.9	80.0	80.9	76.0	75.5	74.0	77.5	81.4	80.1	85.8	80.6	77.8	81.3	76.5	79.9	78.9	81.2	77.8	77.4	77.2	79.7	79.9	79.6
	Evening	82.3	84.7	85.2	83.8	79.6	79.0	81.4	82.2	79.0	81.4	80.8	78.8	77.1	79.6	81.4	85.4	83.1	80.6	77.8	83.3	79.7	83.2	75.9	85.1	77.8	86.0	83.7	82.2	84.3	81.9	78.1	83.9	83.7	78.5	85.1	81.0	84.7	83.7	84.5	81.9
Sunday	**Morning**	80.1	75.1	80.6	80.0	74.0	76.4	77.0	74.4	76.2	81.4	75.8	82.3	76.4	76.3	79.7	85.3	76.6	82.5	84.7	77.0	80.6	79.6	77.2	84.6	81.0	82.6	80.6	76.2	74.9	77.8	78.5	86.0	84.0	78.9	83.2	81.9	78.4	75.8	80.2	75.1
	Evening	81.4	79.7	79.9	81.6	80.8	83.6	79.7	82.3	74.4	74.5	72.4	77.9	84.7	79.6	80.1	84.7	78.9	79.1	85.5	77.4	78.9	77.1	85.1	79.8	85.4	85.8	78.8	84.7	80.5	75.0	76.9	81.4	76.2	82.6	77.8	78.9	83.7	83.5	83.5	82.5
Morning and Evening	**Minimum**	74.9	75.1	74.3	77.0	74.0	75.9	75.1	74.4	74.4	74.5	72.4	74.3	74.1	75.0	76.2	74.9	74.3	76.4	75.1	75.8	76.0	75.5	74.0	74.6	75.9	75.4	75.1	76.2	74.9	74.4	76.5	74.9	75.0	74.5	76.2	75.1	74.1	74.9	75.2	74.1
	Maximum	87.4	84.7	85.2	85.9	85.6	86.0	87.1	85.5	84.7	84.6	84.7	87.4	85.3	85.8	85.2	85.4	83.1	82.5	85.5	84.7	85.3	84.7	85.1	87.4	85.4	86.0	85.8	87.4	85.8	84.9	85.6	86.0	85.3	84.5	85.1	82.5	84.7	84.7	84.8	85.1
	Mean	81.1	79.4	80.0	81.2	79.6	80.7	80.5	80.4	79.6	78.7	79.6	79.7	79.2	79.6	79.4	81.8	78.0	79.9	80.4	80.2	80.0	80.5	80.0	81.4	80.3	82.3	80.7	80.8	80.4	79.2	79.7	80.8	80.4	80.4	80.7	79.4	79.6	80.9	80.5	79.8
	Std Dev'n	3.5	2.7	3.0	3.0	3.8	3.3	3.8	3.2	3.2	3.2	3.1	4.1	3.4	2.9	2.8	3.7	2.9	2.1	3.9	3.1	3.4	2.9	3.8	4.4	3.1	3.6	3.1	3.4	3.5	3.5	3.0	3.6	3.4	2.8	3.1	2.1	3.2	3.7	3.1	3.6
Morning	**Minimum**	74.9	75.1	74.3	77.0	74.0	75.9	76.2	74.4	76.2	75.1	75.8	74.3	76.2	75.0	76.2	74.9	74.3	76.6	76.2	75.8	76.0	75.5	74.0	74.6	75.9	77.1	75.1	76.2	74.9	74.4	76.5	74.9	75.0	77.6	76.2	77.2	74.4	74.9	76.9	75.1
	Maximum	80.6	82.5	80.9	85.9	83.0	80.2	87.1	85.5	84.7	83.5	81.4	83.1	82.4	80.0	81.4	85.3	80.6	82.5	84.7	80.9	83.2	84.7	84.9	84.6	81.4	85.4	85.8	84.7	84.7	83.0	85.6	86.0	84.6	81.2	83.2	82.5	79.9	80.5	80.5	85.1
	Mean	78.3	78.4	78.1	79.4	77.7	78.4	79.3	79.2	79.6	79.0	79.4	78.4	78.7	77.6	78.8	80.9	76.6	80.2	79.0	78.0	78.3	79.1	79.2	78.9	78.4	80.8	79.7	79.2	79.4	79.1	78.7	80.4	80.4	79.4	79.1	79.4	77.9	77.7	78.7	78.9
	Std Dev'n	2.2	2.4	2.8	3	3.2	1.7	4.1	4	3.4	2.9	2.1	3.7	2.5	1.7	1.9	3.9	2.2	2.3	2.9	1.9	2.8	2.8	3.7	4.2	2.3	2.9	3.2	3.5	3.2	2.8	3.1	3.8	3.3	1.2	2.8	2.2	1.9	2.4	1.5	3.4
Evening	**Minimum**	81.4	76.5	79.9	81.3	75.6	79.0	75.1	79.0	74.4	74.5	72.4	75.0	74.1	79.0	76.2	75.1	75.4	76.4	75.1	77.4	77.2	77.1	74.6	79.3	77.8	75.4	77.9	79.6	75.0	74.4	76.9	75.6	76.2	74.5	77.8	75.1	74.1	83.5	75.2	74.1
	Maximum	87.4	84.7	85.2	85.3	85.6	86.0	84.7	84.7	84.5	84.6	84.7	87.4	85.3	85.8	85.2	85.4	83.1	82.3	85.5	84.7	85.3	83.5	85.1	87.4	85.4	86.0	84.5	87.4	85.8	84.9	85.4	85.1	85.3	84.5	85.1	82.3	84.7	84.7	84.8	84.7
	Mean	83.9	80.5	81.9	83.0	81.5	82.9	81.6	81.5	79.6	78.4	79.7	81.0	79.8	81.6	80.0	82.7	79.4	79.5	81.7	82.3	81.8	81.8	80.8	84.0	82.2	83.7	81.7	82.3	81.3	79.3	80.7	81.1	80.3	81.4	82.3	79.5	81.3	84.1	82.3	80.7
	Std Dev'n	2.1	2.7	1.9	1.5	3.4	3	3.3	1.9	3.3	3.7	4	4.4	4.3	2.5	3.6	3.5	3	2	4.4	2.6	3.2	2.3	4.1	3.1	2.7	3.8	2.7	2.8	3.6	4.3	2.8	3.6	3.8	3.6	2.5	2.3	3.6	0.5	3.4	3.8

In morning measurements an average of 80.9dB was recorded at location 16 and with a difference of 0.1 dB second highest average was at location 26. The lowest average measurement was recorded at location 17 with a reading of 76.6dB. In the evening a maximum average of 84.1dB was recorded at location 38 and a lowest average was recorded to be 78.4dB at location 10. Overall, considering both morning and evening the highest recorded average was 82.3dB at location 26. The lowest average was recorded at location 17 with 78.0 dB.

After analyzing the data collected it was seen that locations 23-29 have a higher noise measurement throughout the week with an average of more than 80 dB. With the highest location being 26 with a measurement of 82.3dB with an evening average of 83.7 dB. Other locations with high measurement levels were location 16 with 81.8dB, location 1 with 81.1dB, and location 4 with 81.2dB.

Some locations had also measured relatively low noise measurements as seen in locations 9-15 with average measurements less than 80dB with the lowest being location 10 being 78.7 dB. Other low-measurement locations were 30, 31, 36, and 37. With the minimum being at location 17 with a measurement of 78.0 dB average.

Locations with high noise measurements in the morning include location 16 with an average morning measurement of 80.9dB, location 26 with an average morning measurement of 80.8dB, locations 32 and 33 with an average morning measurement of 80.4dB, and location 18 with an average morning measurement of 80.2dB.

Locations with low morning measurements include location 5 with an average morning measurement of 77.7dB, location 14 with an average morning noise measurement of 77.6dB, location 17 with an average morning measurement of 76.6dB, location 37 with an average morning noise measurement of 77.9dB, and location 38 with average morning noise measurement of 77.7dB.

Locations with high evening measurements include location 1 with an average evening measurement of 83.9dB, location 4 with an average evening measurement of 83.0dB, location 6 with an average evening measurement of 82.9dB, location 24 with an average evening measurement of 84.0dB, location 26 with an average evening measurement of 83.7dB, and location 1 with average evening measurement of 84.1dB, Locations with low evening measurements include location 1 with an average evening measurement of 83.9dB, location 10 with an average evening measurement of 78.4dB, location 17 with an average evening measurement of 79.4dB, location 18 with an average evening measurement of 79.5dB, location 30 with an average evening measurement of 79.3dB, and location 36 with average evening measurement of 79.5dB.

Table 7 Day of Week Measurements

Day of Week	Time of Day	Min	Max	Mean	Day Mean	Std Dev'n
Monday	**Morning**	74.4	84.7	78.9	80.5	2.5
	Evening	75.0	87.4	82.1		3.0
Tuesday	**Morning**	74.3	85.4	79.1	80.3	2.9
	Evening	75.1	87.4	81.6		3.3
Wednesday	**Morning**	74.9	85.9	78.8	80.0	2.5
	Evening	74.1	85.8	81.3		3.5
Thursday	**Morning**	74.3	84.7	78.1	79.8	2.7
	Evening	74.1	87.4	81.6		3.4
Friday	**Morning**	74.9	87.1	79.9	80.4	2.9
	Evening	74.1	85.8	81.0		3.5
Saturday	**Morning**	74.0	85.8	78.6	80.2	2.7
	Evening	75.9	86.0	81.8		2.7
Sunday	**Morning**	74.0	86.0	79.2	79.8	3.3
	Evening	72.4	85.8	80.4		3.4

From Measurements throughout the week, the highest noise measurement is seen in the evenings. The highest measurement days include Monday evening with an average noise measurement of 82.1dB and Saturday evening with 81.8 dB. The highest noise measurements in the morning include Friday Morning with an average measurement of 79.9 dB and Sunday with an average morning measurement of 79.2dB. And in full-day averages, Monday and Friday are the highest with average measurements of 80.5dB and 80.4dB respectively.

Measurement days with low morning noise include Thursday with a measurement of 78.1 dB and Saturday with a measurement of 78.6 dB. The lowest measurement evenings include Monday evening with an average noise measurement of 82.1dB and Saturday evening with 81.8 dB. And in full-day averages, Thursday and Sunday are the lowest with an average measurement of Both at 79.8dB.

Table 8 Overall Measurements

	Morning	Evening	Overall
Min	74.0	72.4	72.4
Max	87.1	87.4	87.4
Mean	78.9	81.4	80.2
Std Dev'n	2.8	3.3	3.3

Throughout the measurements, morning noise measurements averaged at 78.9dB and Evenings averaged at 81.4 dB. With a Standard deviation of 2.8 in the morning and 3.3 in the evening. The highest noise measured throughout the study was 87.4dB on Tuesday Evening at location 1 and Measurement with the lowest measurement was 72.4dB on Sunday evening at location 11. The average noise measurement of the Megenagna area as a whole was 80.2dB with a Standard deviation of 3.3.

4.3 Survey Responses

4.3.1 Participants' Demographics

Participant demographics, including age and gender, were critical for accurate and representative study findings. Different age groups have varying behaviors, attitudes, and experiences that impacted the outcomes. For noise perception studies, age diversity was necessary to determine age-related noise effects. Gender differences also showed different impacts on health outcomes, so the inclusion of both sexes made it essential to the study. Taking participant demographics into account enhanced study validity, improved understanding of health outcomes, and increases the effectiveness of all measurements.

Age

The division of age was in a 10-year range. This division allowed for better comparison between different age groups. It was easier to see trends and differences in health outcomes between a group of people aged 11-20,21-30,31-40,41-50 and above 50 to compare people of different ages within the study. Grouping people in 10-year ranges allows for a manageable sample size which also aligns with commonly used definitions of life stages.

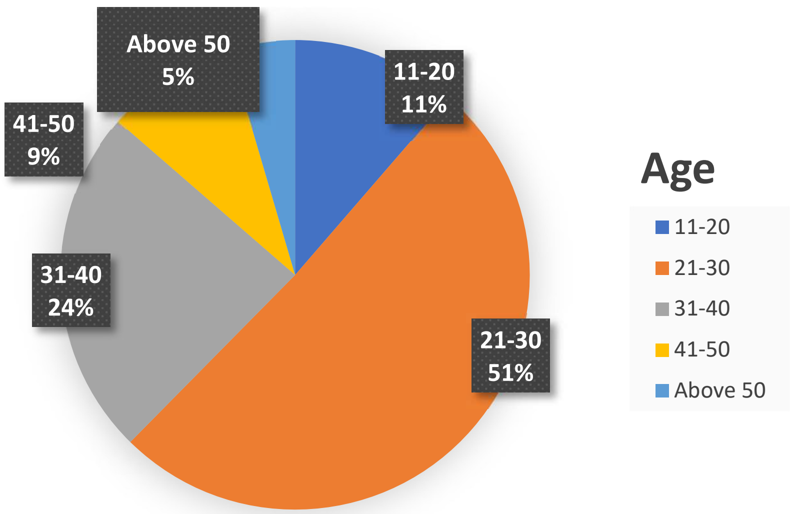


Figure 9 Age of Participants

Out of a total of 396 participants, 45 of them were aged between 11-20, this is 11% of the total participants, this section of kids and teenagers have a high hearing ability due to young ear and brain network. The next section is early adults which consists of 51 % of participants with a total of 202 people participating, this age group is highly active around Megenagna and contributed to the majority of collected data. The section aged 31-40 also contributed vastly with a percentage of 24, 95 people participating. The other was the age group of elderly adults with the age range 41-50 which 36 people participated and amounted to 9% of the total. The last section is the elderly with age above 50 collectively made up 5% of the total with 18 people participating.

Gender

Involving both genders was crucial for the study because men and women have different physiological and biological characteristics that affect their susceptibility to noise and its perception.

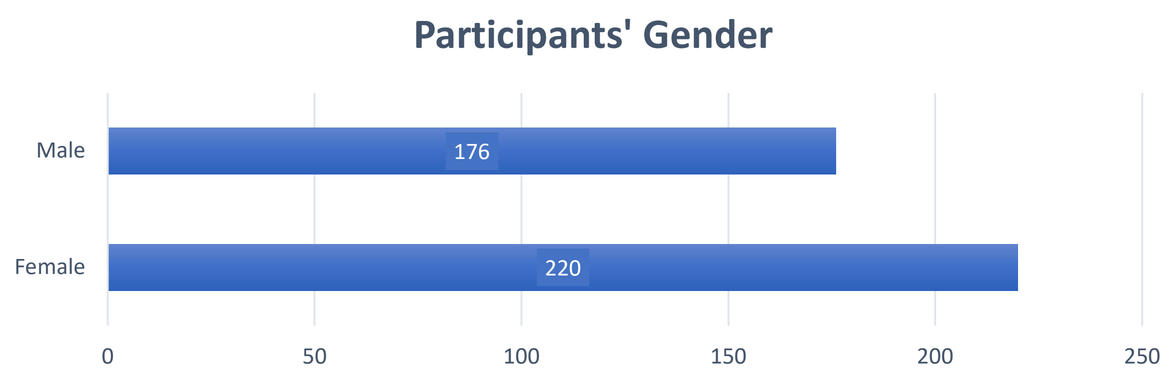


Figure 10 Participants' Gender

Both genders were vastly represented. Out of 396 participants, 176 were male and 220 were female which is 44.3% and 55.7% respectively.

4.3.2 General Information

Length of Residency

The length of time someone lived in a certain area had a significant impact on their perspective regarding the noise in Megenagna. Long-time residents had a more in-depth understanding of the changes that occurred throughout the time they lived. Newer residents, on the other hand, had a less in-depth understanding of changes in the city but have comparable perspectives to other cities they used to live.

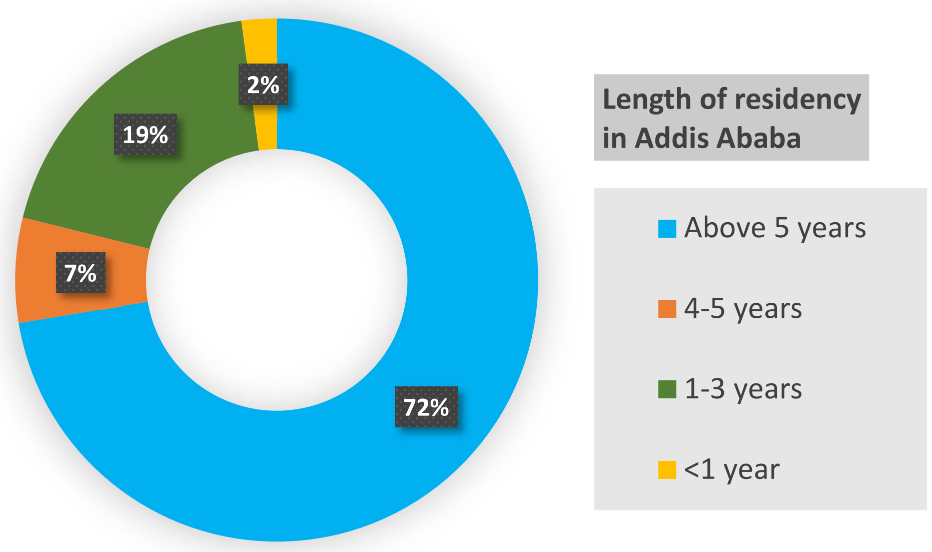


Figure 11 Length of residency in Addis Ababa

Residences that have lived and experienced Megenagna above 5 years are 72% of all participants. a total of 301 participants out of the 396 have lived for more than 5 years in the city. 7% of the participants have lived 4 to 5 years in the city also making them experienced to the changes in noise in Megenagna 27 participants are in this category. Newer residents that lived 1 up to 3 years were 79 participants, which make up 19% of the total participants. Residences with less than 1 year had insight into Megenagna's noisy environment compared to the previous residence city they make up 2% of participants in the study with a total of 9 people participating.

Working in the Location

Working and not working in an area can affect the perception of noise in that area. People who spent time in noisy environments for long periods like people who work in Megenagna had become desensitized to the noise, while those who are not accustomed to noise were more sensitive to even minimal sound and perceive the noise more accurately. Even though People working in the area had more insights into what goes on throughout the day and were highly at risk of health concerns, people not working area were in favor due to their accurate perception of the noise in the area.

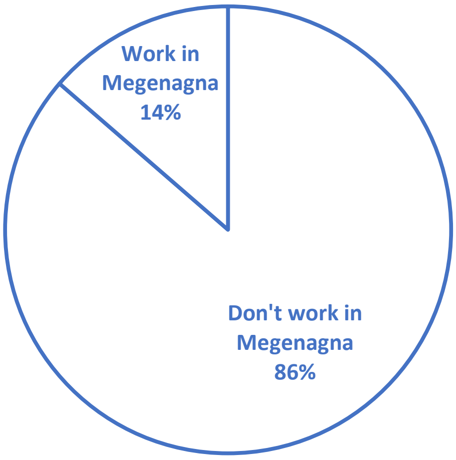


Figure 12 Working and not working in Megenagna

A total of 342 people that pass through Megenagna as a route, that went for shopping and business reasons participated in the study making up 86 percent of respondents. The remaining 14% were of people that stay a long period in Megenagna and work there. 54 people that work in Megenagna participated.

Frequency of Visit

The frequency of visits to a particular area can impact an individual's perception of noise. People that regularly visit Megenagna had gradual desensitization, while infrequent visitors had heightened sensitivity to noise. people who frequently visit Megenagna were more tolerant of the noise compared to those who only visit occasionally. An individual who rarely visits Megenagna perceives the noise as more disruptive and upsetting. So including a variety of frequencies of visits was essential.

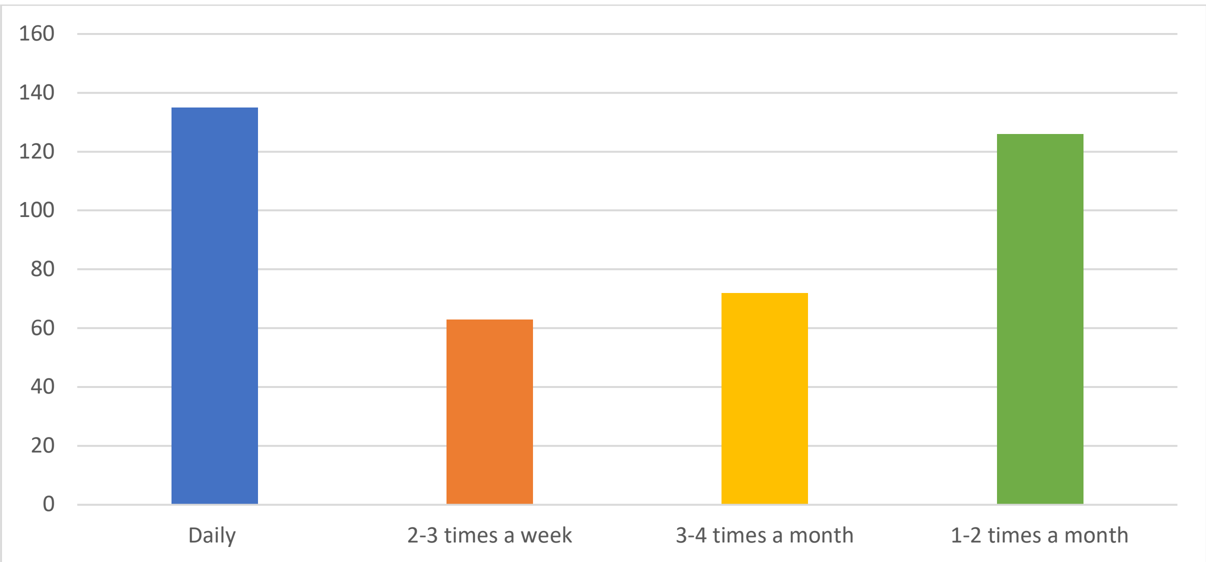


Figure 13 Frequency of Visit

Out of 396 participants, 135 of them daily visit Megenagna due to the working or learning area being in Megenagna or their route being through Megenagna. Also, participants that visited the area 2 to 3 times a week or 1 day after another were a total of 63. Participants that visited once a week or 3 to 4 times a month were 72. And participants that seldom visit the area up to once a month were 126. These seldom-visiting people gave insight into the disturbance of the area compared to other areas as they are sensitive to the loud noises present in Megenagna.

4.3.3 Perceived Location and Source of Noise

Location of Noise

Identifying the location of noise was crucial in studying the noise pollution in Megenagna because it helped understand the sources and causes of noise pollution in the area. Knowing where the noise was made it easier to identify the contributing factors and develop solutions to mitigate it. Megenagna was divided into 8 zones to identify locations with high levels of noise. These zones represented different sections of Megenagna. They were divided according to their similarity in the environment.

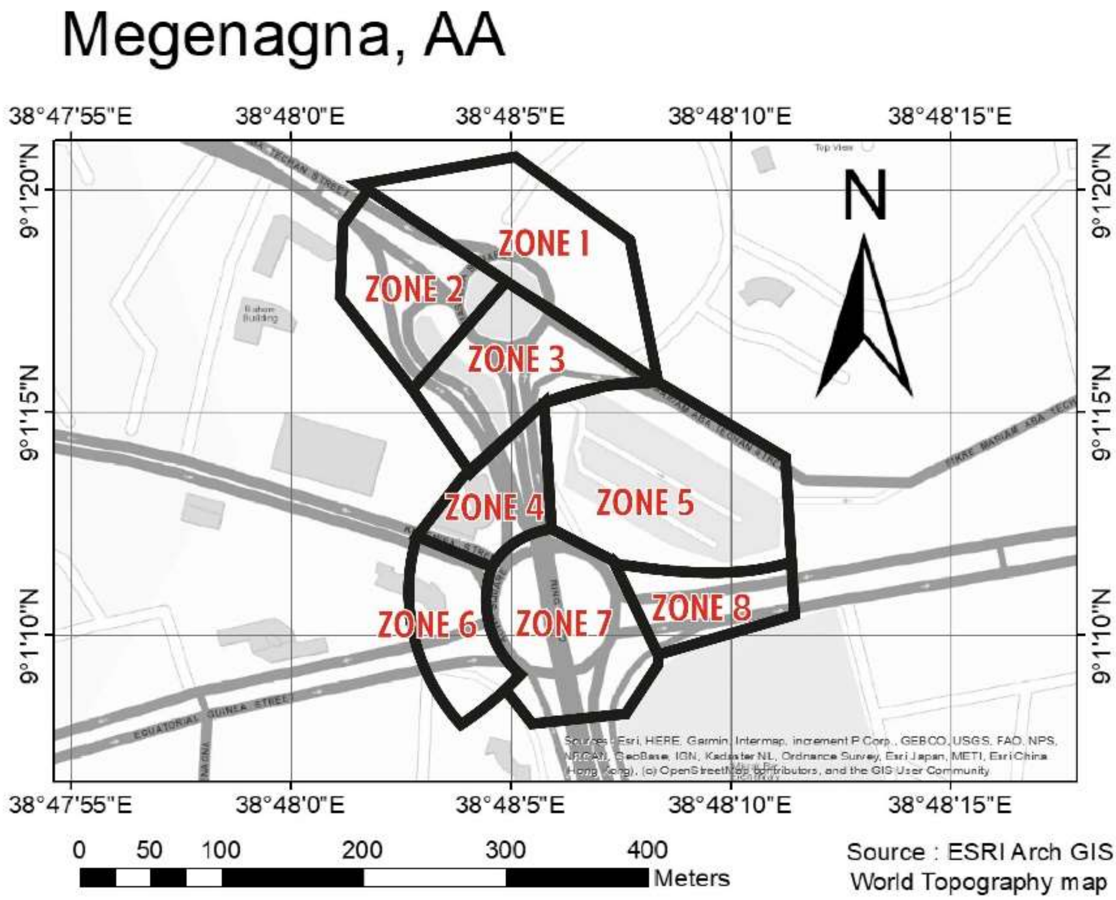


Figure 14 Zoned Location of Study

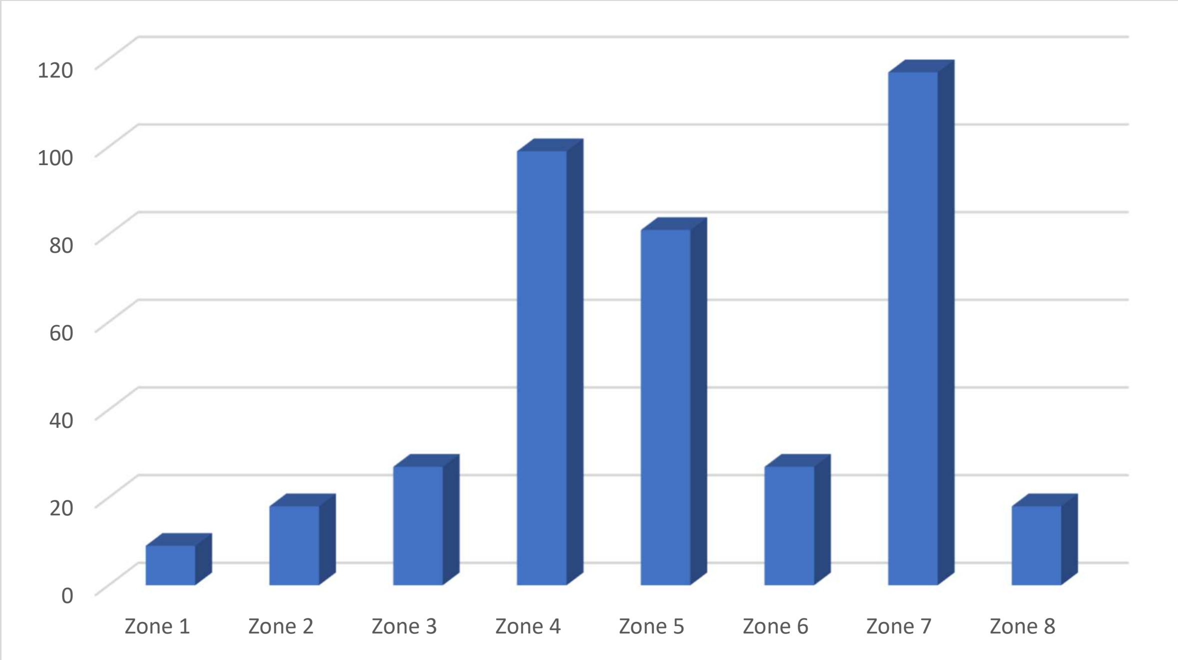


Figure 15 Participants selected zone of highest Noise

Areas designated as zone 4 and 5 are both selected as noisy by more than 80 participants each making them two of the noisest zones in the study area. Zone 5 consisted of Taxi and Bus terminal located in Megenagna and zone 4 consists of many outdoor markets as well as advertisement noises. But by being selected by 117 people participants zone 7 is considered the noisiest area of Megenagna. This Zone consists of Diaspora Square which is a noded to 5 radiating roads making it extremely busy, and highly used, it also has an underpass railway line making it very noisy compared to other zones. This zone also neighbours Zone 4 and 5 which are 2nd selected and 3rd selected respectively which makes the areas of Zone 4,5 and 7, which neighbour each other, even more noisy. Even though Zone 1,2,3,6 and 8 were selected for up to a maximum of 27 participants these zones were selected by few people considering the number of participants that selected zone 4,5 and 7.

Sources of Noise

Identifying the source of the noise was crucial in understanding noise pollution and developing effective solutions to manage it. This process was an essential step in protecting the health and well-being of people who go to noisy areas such as Megenagna

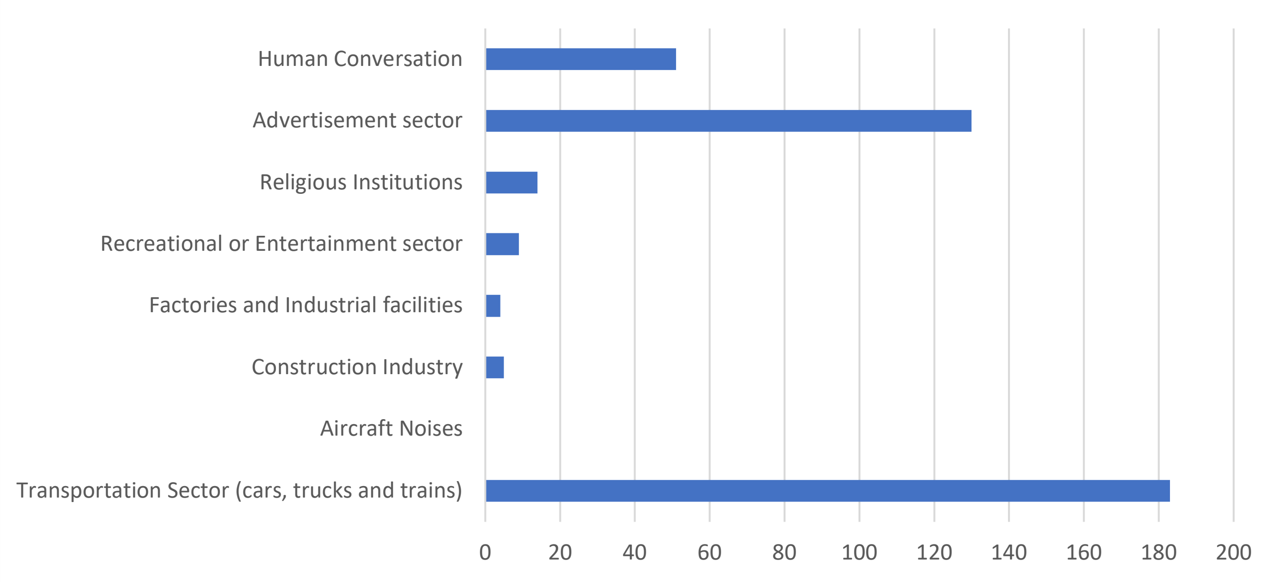


Figure 16 Sources of Noise

As reported by 183 participants the highest source of noise is the transportation sector which includes cars, trucks, and trains which pass through Megenagna every day. Even thou the source is highly chosen. Sources from advertisements and conversations with humans play a huge role in making the Megenagna area noisy. Advertisement sectors like loudspeakers and human calling for the advertisement of products are second favoured by participants as 130 of them chose it as being noisy. As a third noise pollutant human conversation on the streets and markets of Megenagna play a huge role in polluting Megenagna with noise. Religious sectors, Recreational sectors factories, and construction noises were also identified as noise-polluting sectors by 14,9,4,5 participants respectively.

4.3.4 Participants' Ability and Feeling

Comfort vs Disturbed in Megenagna

Living in an urban area, it is common to hear sounds such as traffic, sirens, chatter, and construction. While some individuals found the noise in Megenagna overwhelming and irritating, others can tune it out. Being disturbed by urban noise led participants to a more chaotic and distracted mindset and unappreciation of the city environment. Individuals in Megenagna were easily disrupted by loud sounds, as such they became stressed and anxious, which impacted their productivity and well-being.

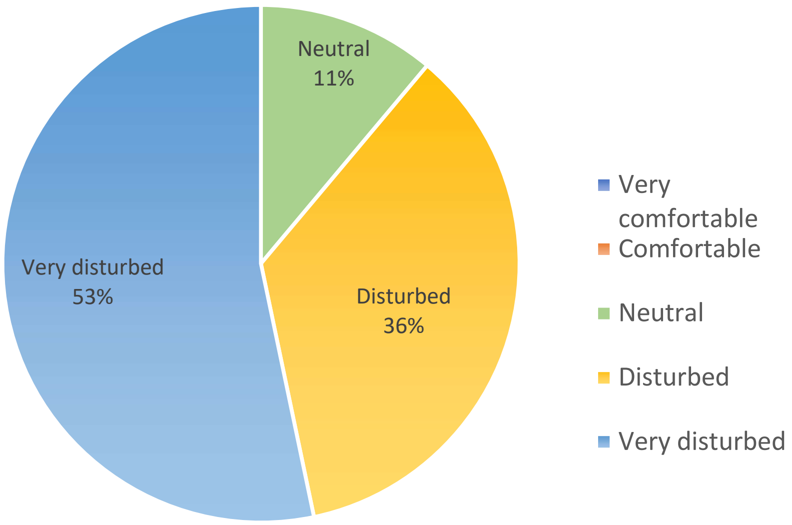


Figure 17 Comfort vs Disturbed

More than half of the participants were very disturbed the highest given on the scale of comfort to disturbed. Out of 396 participants 211 felt disturbed by the noise in Megenagna this is 53% of the total participants. Even though a lower level of being disturbed people were another 36% of participants even though these participants are not at the highest disturbance level these participants are still disturbed by the noise in Megenagna. The total number of participants in this section was 141. Which makes the total number of disturbed participant number to 352. So, 89% of participants felt disturbed by the noise present in Megenagna. The remaining 11 % of participants did not feel comfortable but had adopted to be not disturbed by the noise. These participants had desensitized to the noise, due to exposure to noise for a long period which causes long-term health and well-being concerns.

Emotion Change

Noise causes an emotional change by inducing a stress response in the body. Loud or persistent noise in Megenagna has caused the release of stress hormones such as cortisol and adrenaline in visitors to the area. This physiological response created feelings of anxiety or irritability in people around Megenagna, leading to a change in their emotional state.

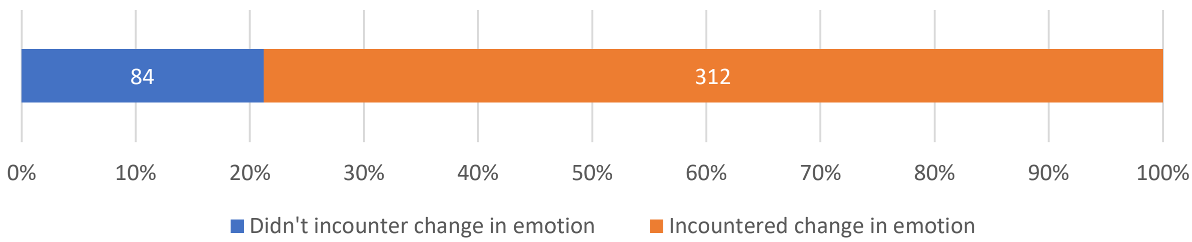


Figure 18 Change in Emotion

78.8% of participants had encountered a change in emotion due to noise in the area this shows how noise had affected their emotional state in their day-to-day life. There is a total of 312 participants. The remaining 21.2% reported they had not felt a change in emotion. Even though 84 participants did not feel a change in emotion, the fact that 312 participants felt a change in emotion shows the well-being concern by noise in the emotional state of visitors to Megenagna.

Annoyance

From traffic noise to Advertisements, noise had been a constant source of annoyance for many people in Megenagna. Noise also had been a source of irritation for people who are sensitive to it. Certain sounds, frequencies, or patterns triggered anxiety, discomfort, or even pain in some participants.

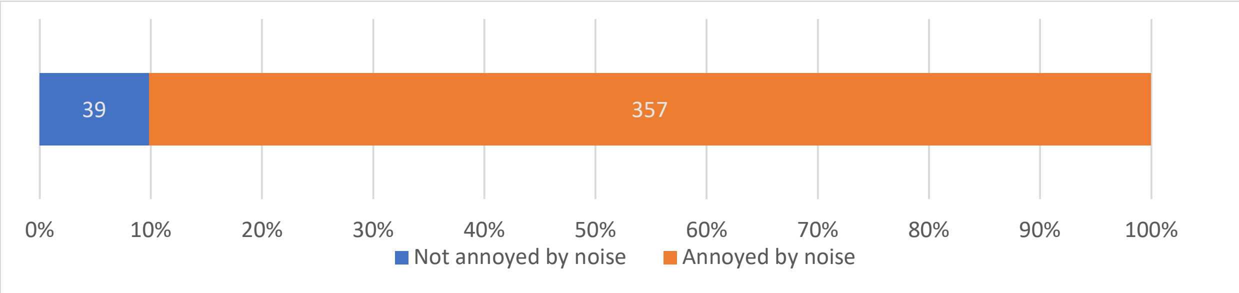


Figure 19 Annoyance

Around 9.9% of participants did not feel annoyance due to noise pollution in Megenagna which is 39 participants from a total of 396 participants. But 357 of the participants felt annoyed by the noise present in Megenagna the makes up about 90.1% of participants.

Focusing Ability

With the increasing levels of noise pollution in Megenagna, the ability to concentrate on a job, task, or day-to-day life without being distracted by external sounds is becoming more difficult in the area.

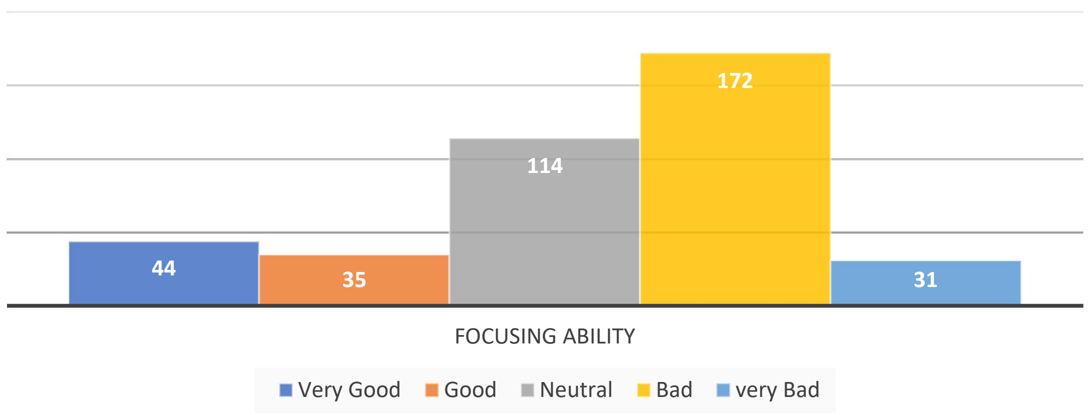


Figure 20 Focusing Ability

With varying levels of focusing ability by participants most participants reported their focusing ability is bad with 172 participants. Even though few, 31 other participants also reported their focusing ability was very bad. So a total of 203 participants had altered focusing ability due to noise which is around 51.3% of participants. 114 participants also stated that their focusing ability was neither bad nor good. A total of 79 participants reported their focusing ability was not altered by the noise from the area.

Hearing Ability

The factor that impacted hearing ability in Megenagna was the level of background noise such as traffic, advertisement, or construction, that overpowered speech and communication making it difficult to understand each other in the area.

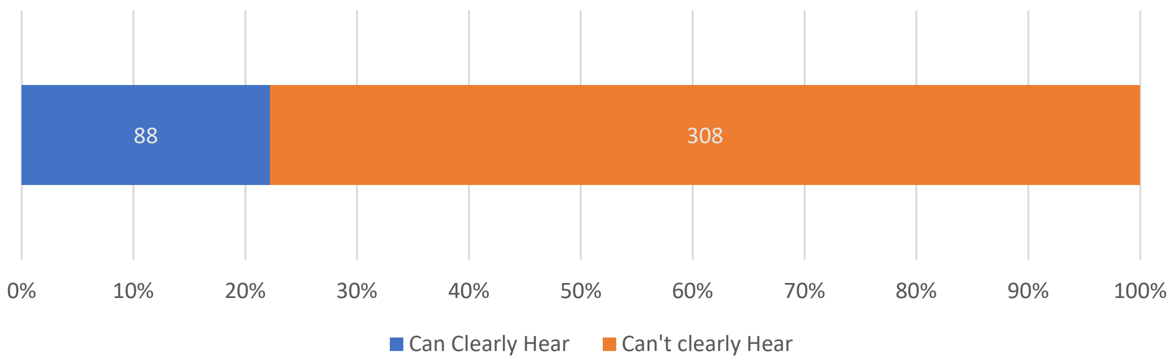


Figure 21 Hearing Clearly

Out of 396 participants 308, which is 77.8% of participants, found it difficult to hear what was being said or what specific communication was being relayed to them. Only 22.2% of participants reported they can hear around noisy environments of Megenagna these were 88 Participants in total.

Noise Endurance

Participants had different levels of endurance when it comes to noise. Some participants were able to tolerate loud noise for prolonged periods while many were not able to. Factors of these included genetics, background noise exposure, personal preferences, age, gender, stress levels, and hearing abilities.

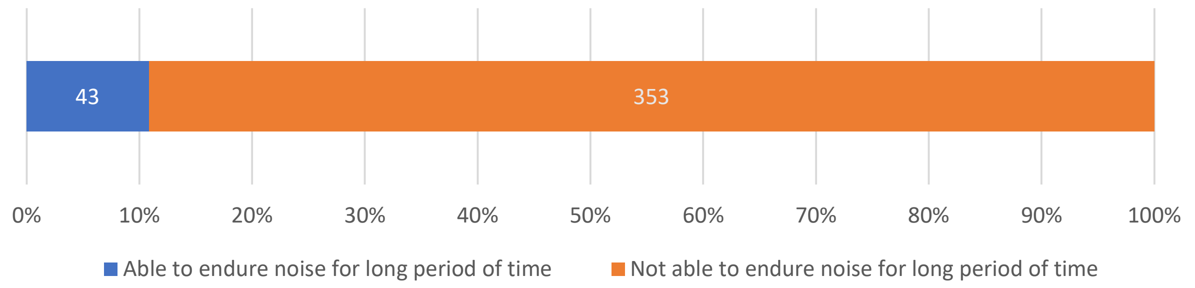


Figure 22 Noise Endurance

Even though the ability to endure noise varies from person to person about 353 out of 396 participants report they are not able to stay for long periods in noisy environments like Megenagna, which is 89.1% of participants. And about 10.9% of participants reported being able to stay in a noisy environment at noisy environments a total of 43 participants.

Discouragement to Visit

People visiting a particular place usually expect to find a peaceful and serene environment to relax and unwind. Noisy areas like Megenagna made them feel uncomfortable, unmotivated, and discouraged to visit again.

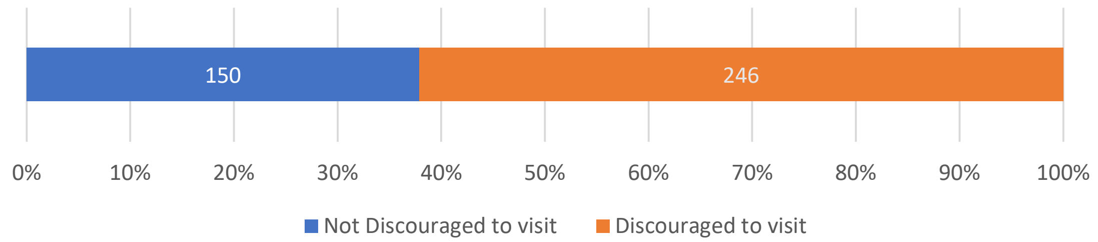


Figure 23 Discouragement to Visit

As for being discouraged from visiting Megenagna participants were divided on their feelings as 37.9% to 62.1%, not discouraged to discouraged participants in visiting Megenagna. 246 participants reported being discouraged from going to Megenagna due to its noisy environment. And 150 participants reported not being affected by the noise in Megenagna to visit the area.

4.3.5 Impact on Participants

Anger and Upset

Excessive noise pollution in Megenagna had negative effects on visitors, causing anger and upset. Continuous exposure to loud and disturbing noise had created a sense of discomfort and irritation, leading to frustration and annoyance in Megenagna to the majority of visitors.

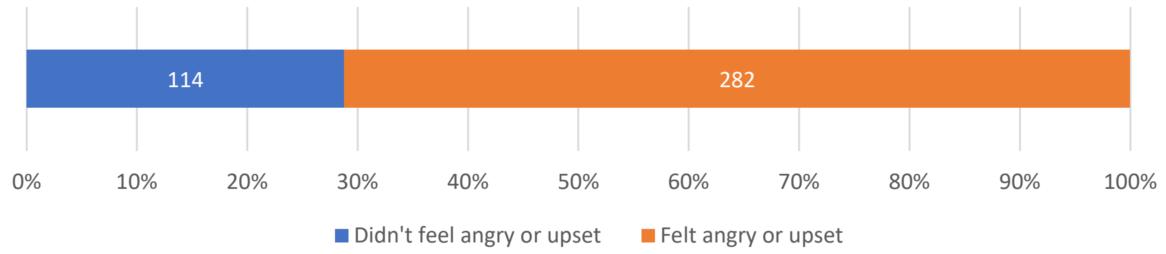


Figure 24 Anger and Upset

Even though noise disturbs everyone, tolerance for noise varies from person to person. 114 participants reported being not angry after passing through the noisy environment of Megenagna this is 28.8% of participants. The other 71.2% of participants reported feeling angry or upset after passing Megenagna which is a total of 282 participants.

Protection Against Noise

As noise pollution is a serious health hazard that must be taken seriously, Different measures were taken by participants to help them reduce the risks associated with noise pollution, thus safeguarding their mental and physical well-being. These measures were as follows.

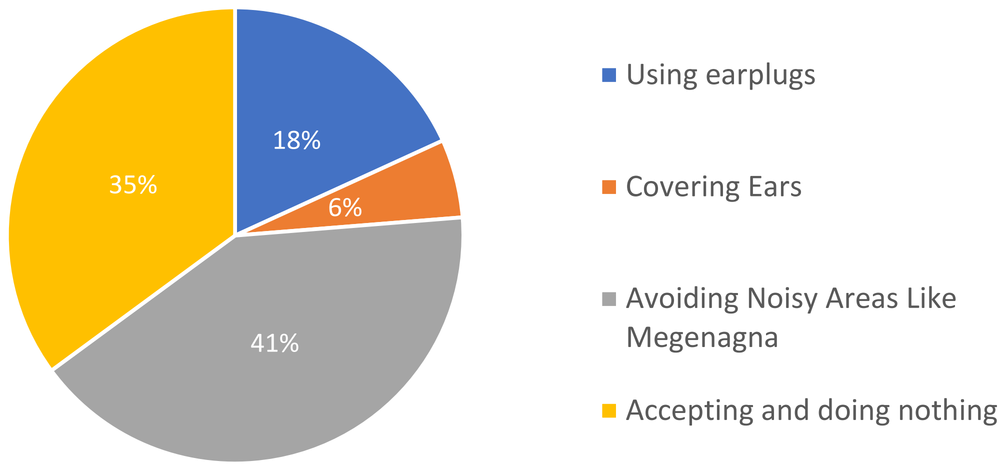


Figure 25 Protection Against Noise

18% of participants reported using some kind of earplugs including tissue paper to protect themselves from noise these were a total of 72 participants. Another 22 participants cover their ears when passing through the noisy environments of Megenagna, which is 6% of participants. The most popular solution by participants was avoiding areas like Megenagna due to its noisy environment, with a total of 163 participants favoring this solution, which makes up 41% of the total participants. Another popular alternative being chosen by 35% of participants was accepting the noise and doing nothing to protect oneself with a total of 139 participants.

4.3.6 Suggestions by Participants

Importance of Studying Noise Pollution

The majority of participants reported that studying noise pollution is an important issue as it impacts human health, communication, and the environment. Participants also figured that to better our environment studies must be done to understand, mitigate and prevent noise pollution.

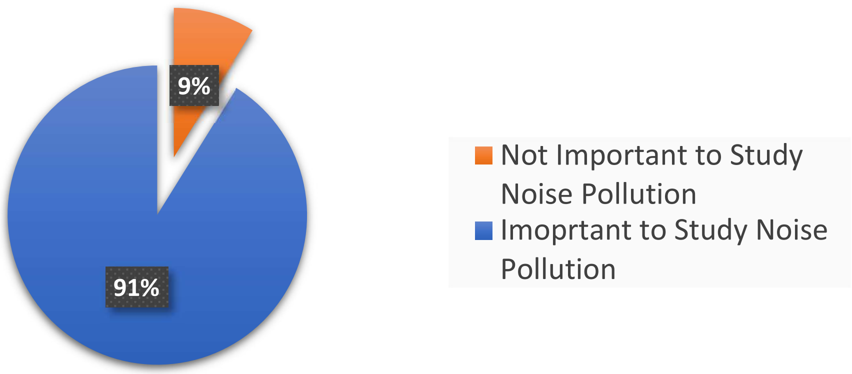


Figure 26 Importance of studying Noise pollution

91% of participants agree that it is important to study noise pollution in Megenagna with a total of 361 participants out of 396. Another 35 participants disagree with this and reported that it is not important to study noise pollution.

Suggested ways to Reduce Noise Pollution

Participants also stated measures to prevent and minimize noise pollution, both for personal and societal benefits must be taken. Measures like formulation of noise regulation and law, redesigning the area for better noise management, creating awareness in people's perception, and promoting planting trees to act as natural sound barriers were the suggested measures.

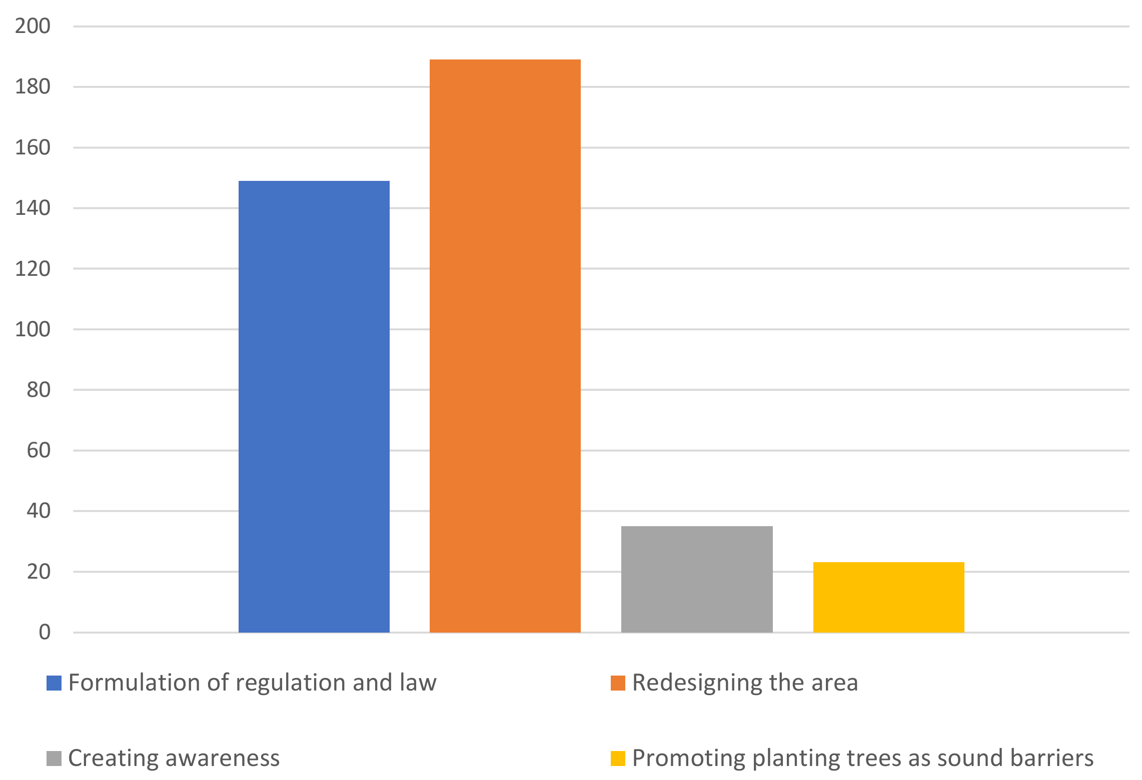


Figure 27 Suggested Ways of Reduction

Even though promoting planting trees was the least suggested it was suggested by a total of 23 participants. Another measure that was also suggested by a few people was creating awareness in people's perceptions, being suggested by only 35 participants. Formulating noise regulations and laws was suggested by a total of 149 participants as the best measure to combat noise pollution. Another measure suggested by the majority of participants was redesigning the area for better noise management, which was suggested by a total of 189 participants making it the most suggested measure of noise in Megenagna.

4.4 Major Trends, Patterns, and Differences

4.4.1 Location and Source of Noise

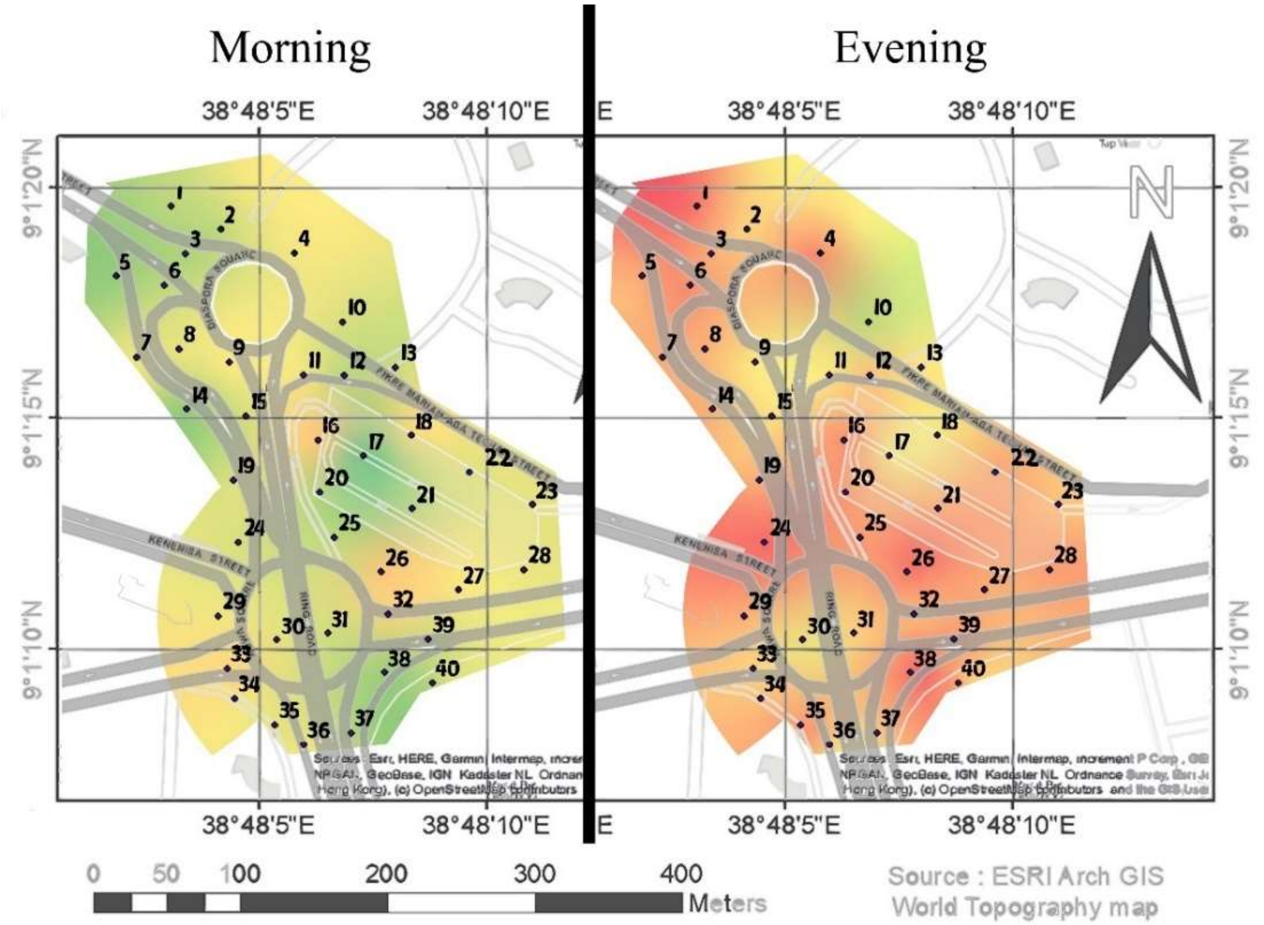


Figure 28 Morning/Evening noise map

In general, it is easily identifiable that morning measurements show a lower noise measurement compared to evening measurements. Throughout the day the road radiating to Fikre Mariam Aba Techan Street from Diaspora Square has a low morning measurement but a high noise measurement in the evening. The road leading from Adwa Square to Kenenisa Street gradually increases from morning to evening. Parking located between the 2 squares also gradually increases in noise from morning to evening. Also, areas southeast of Adwa Square has very low morning noise measurement but high noise measurement in the evening. Compared to other areas of Megenagna

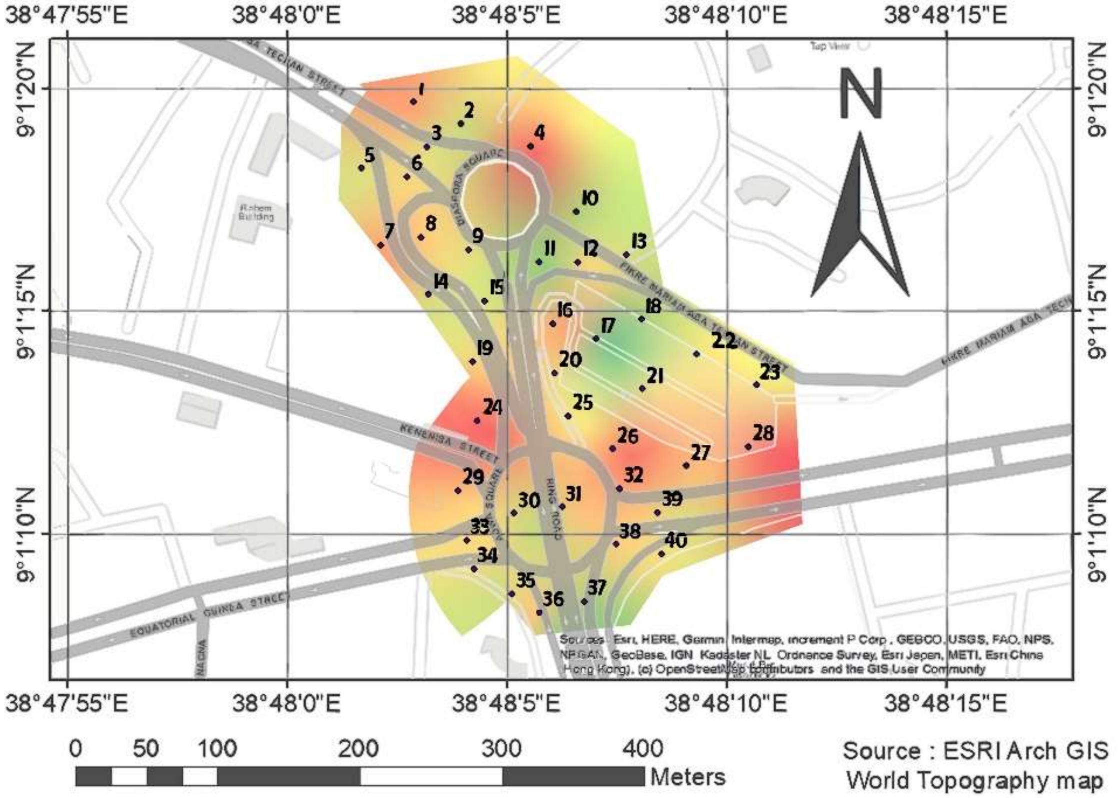


Figure 29 Average Noise Map

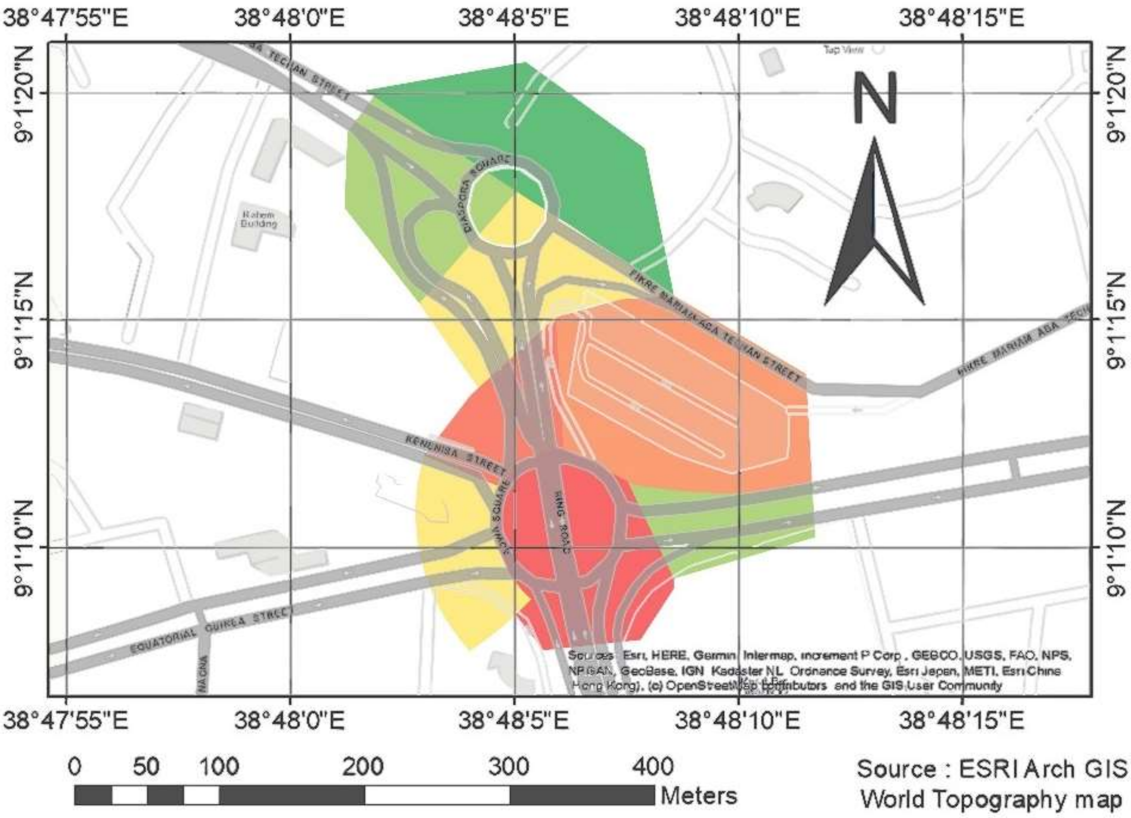


Figure 30 Perception Noise Map

As the average noise measured indicated noise was concentrated around Diaspora Square, Kenenisa Street, and the border of the parking and the street heading eastward from Adwa Square this area had a high noise measurement compared to other areas of Megenagna. But to the noise map from participants, the noise was high around Diaspora Square, followed by the parking and road connecting Adwa and Diaspora Squares. Even though some areas were not high in their noise measurements people perceive them to be high due to their evening congestion with a high number of people as well as a high number of vehicles having high noise measurements only in the evenings.

As indicated by participants sources of noise that are more disturbing than other sectors were the transportation and advertisement sectors. Even though the level and locations of sound highly vary, Sources of noise like human conversations, vehicles, and outdoor advertisements were common sources of noise in Megenagna. Congestion of people, vehicles, and advertisements had a high level of noise compared to other areas of Megenagna. Making the Transportation and advertisement sector one of the nosiest Sources of noise in Megenagna.

4.4.2 Ability of Visitors

Visitors of Megenagna needed to cope with a range of challenges related to their ability to communicate, concentrate, and relax. Depending on the intensity, duration, and nature of the noise, people experience physical discomfort, hearing damage, stress, or annoyance. However, individuals vary in their ability to adapt to and manage these noises in Megenagna. Some people had better hearing, cognitive skills, emotional regulation, or coping strategies that enable them to tolerate the noisy environments of Megenagna. Others were more sensitive, vulnerable, or distracted by noise, which can affect their overall experience and well-being.

Visitors were often sensitive to noise disturbances when visiting Megenagna, which hindered their overall experience and enjoyment of the area. Visitors often desired a comfortable, peaceful environment when visiting Megenagna, but this was difficult when faced with a noisy area of Megenagna. However, many visitors can remain undisturbed by ambient noise. Some may block out unwanted sounds using hand or earplugs, while others focus their attention on something else rather than their surroundings. the ability to remain undisturbed by noise is a valuable skill for anyone.

Megenagna had a dramatic impact on the emotions of visitors. When subjected to the loud and chaotic areas of Megenagna, visitors experienced a change of emotions from normal to anger and upset. However, the ability of these visitors to resist change in emotions in a noisy area is influenced by several factors, including their perception of the noise and their coping mechanisms. Visitors to Megenagna experience annoyance due to the continuous loud and intrusive sounds, making it difficult for them to converse or concentrate. The inability to concentrate or hear clearly can cause frustration and stress, leading to an unpleasant experience.

Visitors to Megenagna face difficulties in hearing and understanding the conversations between them. The excessive noise interferes with their ability to perceive sound accurately, making it harder to understand the words being spoken. Visitors of Megenagna rely on lip-reading, body language, and visual cues to communicate effectively in the noisy environments of Megenagna.

Noise enduring ability of visitors in Megenagna varies based on individual tolerance levels. While some visitors were able to endure prolonged exposure to loud noises, others were irritable by the noise and experienced discomfort after a short period. The ability to endure noise also depended on individual factors such as genetics, age, gender, and overall health. Some individuals were naturally more tolerant of noise due to genetic factors and past experiences, while others were more sensitive to noise due to underlying medical conditions. The ability to endure noise in Megenagna was influenced by a variety of biological, environmental, and psychological factors.

People's discouragement to go to Megenagna due to its noisy environment had been high due to the various negative impacts noise pollution has on human health and well-being. The constant exposure to noisy environments had led few people to hearing impairment, sleep disturbance, and stress-related disorders. so, people are opting to avoid places with advertisement noise, traffic noise, and industrial sounds, opting instead for more peaceful and serene areas. This trend emphasizes the need for society to recognize the importance of preserving quiet spaces and promoting sustainable development that minimizes noise pollution.

4.4.3 Impact on Visitors

When visitors were subjected to the noisy environments of Megenagna, it led them to feelings of anger and upset, making it difficult for them to enjoy the experience. The overwhelming and disruptive noise of Megenagna had a negative impact on their overall feeling and well-being.

Due to the distractions and disturbances created by the noise present in Megenagna, visitors were experiencing a decrease in productivity. The noise frequently interrupted their focus, reduce their attention span, and disrupt their thought processes, consequently resulting in a decline in their overall efficiency. Visitors of Megenagna had also experienced increased stress, irritability, and anxiety, leading to mood swings and a negative overall experience.

4.4.4 Measures to take

Noise in Megenagna had been one of the major problems that were caused by excessive noise levels beyond tolerable limits. To combat this issue, further research needs to be conducted to develop effective measures to address noise pollution in Megenagna. Further research should focus on the development and use of quieter and more efficient technologies in transportation and industry. It is important to consider the long-term sustainability of these measures to ensure their effectiveness. Collaboration with stakeholders such as local communities, policymakers, businesses, and industries can help to develop comprehensive strategies aimed at reducing noise pollution. It is vital to take appropriate and immediate action to ensure that noise pollution is controlled and minimized.

Governments can establish strict laws towards transportation and advertisement sectors that are causing noise pollution. This can include controls on the level and timing of loud activities. Zoning laws can be implemented to separate residential areas and commercial areas. so that each can have noise limits of its own. This can limit noise interference caused by businesses and markets. A noise reduction policy can be created and implemented in public spaces such as congested urban areas and squares. Strict enforcement measures can be taken to penalize individuals or companies that exceed the noise limit. These measures can facilitate a cleaner and more serene environment and reduce the negative societal impact of noise pollution in Megenagna as well as the rest of the city.

Another solution to mitigate noise is to redesign areas to mitigate noise pollution. Some measures that could be taken include incorporating more green spaces or landscaping, which has been shown to reduce noise levels by absorbing sound. Additionally, the use of sound-absorbing materials in the construction of buildings, such as thicker walls or insulated windows, could also be effective in reducing noise pollution in urban areas like Megenagna. By implementing these measures, developers and city planners could help create quieter, more livable urban areas for their residents.

Creating more public spaces in Megenagna limits congestion and in turn minimize the noise from human conversations and traffic congestion. Implementing smart traffic management systems throughout the city to reduce idling vehicles would be effective. Encouraging public transportation reduces the number of cars on the roads, thereby reducing traffic and the associated noise levels.

Noise pollution is increasingly becoming a major problem that affects the quality of life. Therefore, awareness campaigns need to be conducted to educate people about the measures they can undertake to reduce noise pollution. People need to understand the negative impacts of noise pollution on their health, and social, and economic well-being; this can be done through seminars, workshops, and mass media campaigns. People need to take individual responsibility to reduce noise levels in their communities, by not playing loud music and constructing buildings close to residential areas. By raising awareness, people can take action to reduce noise emissions and ultimately help enhance their quality of life.

4.5 Mitigation Approaches

4.5.1 Transportation Noises

These noises mainly concentrate around Adwa Square which has a high vehicular traffic. Mitigating the noises present in Adwa Square requires redesigning Adwa Square to accommodate more vehicles would significantly decrease the traffic congestion present. The roads leading away from Adwa Square have 2 lanes each as seen in Figure 31 as such not accommodating the level of traffic in the area. Increasing lanes on radiating roads is one of the approaches to mitigating noise in the area. The capacity of the square should be increased by adding more lanes for vehicles to enter, use and exit the square inefficiently.

Expanding Adwa square is a process that involves increasing its area and size by adding additional land and extending its boundaries. This expansion can be beneficial in mitigating noise pollution in several ways. by increasing the number of vehicles and pedestrians. Expanding the square can have a significant impact on mitigating noise pollution. The first step in expanding the square is by acquiring additional land around adwa square which are mostly government owned. This can be done by negotiations with private landowners and by government intervention. Once the land is secured, the square can be expanded by increasing its size and creating more open spaces and green areas. This expansion allows for the redistribution of noise sources and the creation of buffer zones between the square and surrounding noisy areas.

Expanding Adwa square mitigates noise pollution in several ways. the increased size of the square provides more space for people to spread out, reducing crowding and congestion. When people are not crammed together, they are less likely to generate excessive noise. Additionally, with more open spaces and green areas, the square can incorporate noise-absorbing features such as trees, shrubs, and grass, which act as sound barriers and help absorb sound waves. These natural elements break up sound waves and reduce their intensity, dampening the noise pollution around the square.

Expanding the square allows for the implementation of better urban planning practices. With more available space, new infrastructure can be built with noise reduction in mind. For example, soundproof barriers can be erected along busy roads near the square, preventing the intrusion of traffic noise into the expanded area. Additionally, expanded squares can incorporate design features, such as elevated walkways or underground passages, to redirect noise away from the central square, protecting it from nearby noisy streets. These planned interventions contribute to a quieter, more peaceful atmosphere, creating an inviting and pleasant environment within the square while minimizing the impact of noise pollution.

Another Mitigation Approach is the use of smart traffic lights around the square as well as throughout Megenagna as these lights would manage, direct and control the flow of traffic. And minimize congestion in the area. Also making the area pedestrian crossing friendly as well, as one reason for the congestion is untimed and uncontrolled pedestrian crossings blocking the flow of vehicular traffic as well as vehicular traffic blocking the flow of pedestrian crossings.

Figure 31 Traffic Flow

Mitigation approaches for vehicular maintenance to reduce noise pollution throughout the city can begin with regular maintenance of vehicles. Proper maintenance practices can reduce the noise generated by the vehicle. Regular engine tune-ups, repairing leaking exhaust pipes, and replacing worn-out suspension systems can significantly decrease the noise emanating from the vehicle. Restricting the use of loud horns as well as limiting the sound level of horns to reduce the noise generated by vehicles and encouraging people to use electric vehicles is also effective in mitigating vehicular noise pollution in Megenagna as well as the city.

Promoting public transportation serves as an effective way to decrease congestion on roads and highways of the city, which ultimately reduces noise pollution. The more people use public transportation, like buses, trains, and minibusses, the fewer cars on the road, which leads to less traffic. When traffic is reduced, vehicles do not have to honk their horns frequently, especially during peak hours, which helps to decrease noise pollution in Megenagna and the city. Public transportation that is powered by electric or hybrid engines, produce less noise than gas-powered cars and trucks. By reducing traffic and the use of individual cars, people can mitigate noise pollution in their communities and reduce the overall carbon footprint and lead to a cleaner and quieter environment. Adopting green transportation options is beneficial for the well-being of everyone as it has the potential to decrease noise pollution, and traffic-related issues, and create a better quality of life.

One effective mitigation approach to decrease noise pollution in Megenagna is to encourage sound-absorbent material use practices in buildings. This can involve installing acoustic panels and insulation in walls, and facades to absorb or block sounds. Another approach is to promote the use of double-glazed windows to reduce the transmission of outside noise to the insides of the buildings present. Government incentives and regulations should help encourage the adoption of these soundproofing practices in both existing and new buildings.

4.5.2 Advertisement Noises

Several approaches could be taken to mitigate the level of sound from advertising noises in Megenagna. One approach would be to establish laws and regulations that limit the volume and frequency of advertising noises in public spaces. Another approach is to use alternative methods of advertising, such as visual displays or digital media as Megenagna is rich in display walls on buildings and infrastructures. Encouraging advertisers to use non-intrusive marketing methods such as handing out flyers and brochures instead of loudspeakers and megaphones can also help limit advertisement noise in urban centers.

To mitigate the effects of advertisement noises in urban areas, several approaches can be implemented within the regulatory framework. Firstly, the permissible decibel levels of advertisements should be strictly enforced as well as limit the hours during which advertisements can be played. Advertisements at commercial buildings should be regulated to reduce the number of loudspeakers around the building. Penalties should be imposed for non-compliance with the regulations. Establishing a hotline or a complaint mechanism to receive reports from residents can also be useful in mitigating excess advertisement noise. By implementing these approaches, the regulatory framework can help to manage the advertisement noise levels and reduce the negative impact on those living in urban areas.

Another mitigation approach that can be implemented in Megenagna is designating separate market areas for businesses that want to advertise using loudspeakers or other noisy methods. This can be achieved by zoning the marketplace into different areas based on the type of business being operated. Businesses that utilize loudspeakers for advertisements can be allocated a section that is set far enough from streets, roads, and public areas. In this way, the area where businesses use loudspeakers can be isolated, minimizing the impact of the noise on other areas of Megenagna.

4.5.3 Human Conversations

Planting trees in Megenagna can serve as an effective mitigation approach from human conversation noises. Trees provide a natural barrier that can absorb and deflect sounds, reducing the amount of noise present in Megenagna. Additionally, the rustling of leaves and the soothing sounds of nature can help to lessen the impact of background noise and create a more calming atmosphere. By strategically planting trees in areas that experience high levels of human conversation noises, cities can improve the quality of life for residents, reduce stress levels, and create a more pleasant environment for everyone.

One approach to mitigate human conversation noises in urban areas is to reduce other noise sources that contribute to the overall noise level. Naturally, human conversations rise because of the inability to communicate at lower volumes due to the noise present from other noise sources, mitigating other sources of noise, in turn, mitigate noises coming from human conversations in Megenagna.

One approach to mitigate human conversation noises in Megenagna would be to create awareness among the residents. This could be done through community campaigns, social media, and educational programs. People could be encouraged to use polite tones while speaking in Megenagna and other public places, avoid shouting or screaming, and keep a check on their volume level. There should also be discussions on the impact of excessive noise on health and well-being. This would help in fostering a sense of responsibility among the visitors of Megenagna towards maintaining a peaceful and quiet environment in urban areas.

4.5.4 Creating Awareness

Noise pollution is a major problem in Megenagna, one way to mitigate the impact of noise pollution is by increasing awareness among visitors about its effects on their health and environment. This can be achieved by organizing awareness campaigns, seminars, and workshops on the harmful effects of noise pollution and ways to reduce it.

The first step in creating awareness about noise pollution is to educate people about its sources. Many people are unaware that common activities, such as construction work, traffic, and loud music, can cause noise pollution. Once people understand the sources of noise pollution, they can take steps to reduce it. By use of headphones, avoid loud activities during peak hours.

4.6 Objective Target Reached

4.6.1 Studying the levels of sound in noise hotspots

The objective of studying the levels of sound in noise hotspots of Megenagna and the problems it creates was reached through a systematic and thorough process. Initially, a list of potential noise hotspots in Megenagna was compiled based on previous data, community input, and site visits. Then, each hotspot where measured their sound levels using calibrated decibel meters. These measurements were taken during peak hours of the morning and the evening when noise levels were expected to be at their highest.

The data collected from these measurements were then analyzed to identify which hotspots had the highest sound levels and which types of noise sources were contributing the most to the problem. This information was used to create a noise map of the area, highlighting the hotspots and sources of noise that are causing the most problems for visitors of Megenagna.

4.6.2 Investigate the perception of noise by people exposed

The objective to investigate the perception of noise by people exposed to noise pollution was reached by conducting a survey. The survey was designed with a set of questions that aimed to gauge the participants' perceptions and attitudes toward noise pollution. The survey was conducted in several locations where the problem of noise pollution was prevalent. Participants were selected randomly, and their consent was obtained before the survey commenced. The questionnaire was administered to the participants to obtain their responses.

The set of questions in the survey included queries about the source of noise pollution, the severity of the noise, the hours of exposure, and the tolerance level of the participants. The participants were also asked about any health issues that arose due to noise pollution. Responses were collected anonymously and analyzed to obtain the perception of noise by people exposed to noise pollution. The results of the survey were used to draw conclusions and recommendations for managing noise pollution.

Conducting a survey was an effective way to meet the objective of investigating the perception of noise by people exposed to noise pollution. The survey responses provided valuable insights into the level of perception, the attitude of people towards noise pollution, and the impact of noise pollution on health and well-being.

4.6.3 Identifying mitigating approaches to reduce and eliminate noise pollution

The objective of identifying mitigating approaches to reduce and eliminate noise pollution in Megenagna was reached through a collaborative and multi-faceted approach that involved research, noise measurements, public consultation, and evaluation of options. The resulting action plan helps to improve the quality of life for visitors of Megenagna and promote a healthier and more sustainable environment.

The action plan includes a variety of approaches, such as implementing tree noise barriers along major roads and highways to reduce the transmission of noise, implementing noise-reducing materials in construction, such as sound-absorbing insulation and double-pane windows, encouraging the use of electric and hybrid vehicles to reduce noise levels from transportation. implementing noise ordinances and regulations to control noise emissions from businesses and outdoor activities. Redesigning for better accommodation of both vehicles and pedestrians in highly congested areas. educating people about the effects of noise pollution and guiding how to reduce noise levels in their homes and workplaces.

Conducting regular monitoring of noise levels in the area to evaluate the effectiveness of the mitigation approaches and make necessary adjustments. Overall, the action plan provides a comprehensive and integrated approach to reducing noise pollution in Megenagna. By working together, residents, businesses, and government can make a positive difference in the quality of life for everyone in the community.

4.7 Result in Relation to Research Questions and Literature

1. What are the levels, and major locations of noise in the area?

The research conducted on noise levels in Megenagna revealed that the average noise levels during morning and afternoon rush hour exceeded the recommended maximum limit set by the World Health Organization. On average, noise levels reached 78.9 dB in the morning and 81.4 dB in the afternoon. Which averages 80.2dB overall. This increase can be attributed to various sources such as shops, markets, and traffic congestion; however, human conversations also had an impact on the level of noise pollution experienced by visitors of Megenagna as well. Location of high noise was seen mainly around Adwa Square and Public Transport hub areas.

2. What is the perception of noise by people exposed to noise pollution?

Participants exposed to noise in Megenagna had various perceptions and reactions. Some individuals perceived noise as annoying or disturbing or both, while others experience stress, anxiety, or headache. Exposure to high levels of noise pollution also affects physical health and causes hearing damage, sleep disturbances, and other health issues in a few participants. The perception of noise can also depend on individual factors such as age, gender, culture, and personal attitudes toward noise.

Participants visiting the area of Megenagna areas with high levels of noise pollution also experienced a decrease in their overall quality of life. Noise pollution interfered with their daily activities of work, study, and relaxation, negatively impacting social interactions.

3. What are the mitigating approaches that can be identified to reduce and eliminate noise pollution in the area?

Implementing noise-reduction technologies like mufflers, sound barriers, and acoustically-engineered materials can all be used to reduce the amount of noise generated. Regular maintenance and servicing of equipment like cars, generators, and HVAC systems can help prevent noise pollution.

Proper placement of machinery and equipment which is away from residential areas can help reduce noise levels. The use of low-noise equipment like electric mowers and leaf blowers can help reduce noise pollution.

Landscaping practices can help absorb sound waves and minimize noise levels. Implementation of noise ordinances can help regulate the amount of noise emitted by industrial, commercial, and residential activities. Education and awareness campaigns: Educating the public on the negative effects of noise pollution and how to reduce it can help mitigate noise pollution levels. Proper urban planning, such as land use planning and zoning regulations, can help prevent noise pollution.

Soundproofing buildings and walls can help prevent sound transmission and reduce noise levels. Encouraging the use of eco-friendly infrastructure like electric vehicles and solar power can help reduce noise pollution from combustion engines.

4.8 Implications and Limitations

Noise pollution refers to any excessive or disruptive sound that interferes with normal activities or causes discomfort. Noise pollution has serious implications for human health, as it causes stress, hypertension, sleep disturbance, and hearing loss, among other health problems. The limitations of noise pollution control are also significant as they show how we can provide the best mitigating strategies for noise control in Megenagna. Public education, awareness campaigns, and government regulations can help reduce noise pollution, but a collaborative effort from all stakeholders is necessary to ensure that noise levels remain within safe limits.

4.8.1 Implications of the Study

Noise is a ubiquitous environmental pollutant that poses considerable health risks to individuals. It has been linked to various illnesses. This analysis sought to examine the effects of noise pollution on individuals' mental well-being, physiological responses, and performance. In conducting this study, data were collected from participants exposed to varying noise levels. Results showed that individuals exposed to high levels of noise had significantly higher levels of stress, anxiety, and depression compared to those exposed to low levels of noise. Additionally, the study found that prolonged exposure to noise pollution led to physiological responses such as increased heart rate and blood pressure.

The results of this analysis have important implications for noise pollution research. the first implication is that it highlights the need for effective noise pollution control measures in Megenagna. Authorities should focus on regulating the levels of noise in residential and commercial areas of Megenagna to minimize exposure and consequential health effects. The second implication is that the study underscores the importance of Urban planners' interventions by designing and developing cities that are environmentally sustainable, socially inclusive, and livable of noise pollution. Urban planners can do this by designing and implementing noise barriers, ensuring the right design of buildings, influencing the use of transportation, and implementing noise ordinances to mitigate the impact of noise pollution on their health. The last implication of the study is the need for further research to better understand the long-term effects of noise pollution on individuals' health. Researchers should examine the impact of noise pollution on vulnerable populations such as children, pregnant women, and individuals with pre-existing health conditions.

This analysis highlights the detrimental effects of noise pollution on individuals' health and well-being. Authorities should prioritize noise pollution control measures, and urban planners can adopt interventions to mitigate the impact of noise pollution. Continued research is needed to further understand the long-term effects of noise pollution on individuals' health.

4.8.2 Limitations of the Study

It is challenging to control noise pollution, as it can come from a variety of sources such as transportation, Advertisement activities, construction sites, and recreational activities. Noise reduction techniques such as soundproofing, insulation, and the use of barriers can be expensive and may not be feasible in every situation. Furthermore, public awareness campaigns, regulations, and enforcement may not be effective in reducing noise pollution, as people may not always be willing to comply with regulations or change their behavior.

Another limitation of noise pollution control is the lack of consensus on safe noise levels. The World Health Organization recommends that the average noise level in residential areas should not exceed 55 decibels during the day and 45 decibels at night, yet many countries have different noise standards. Moreover, there is no clear threshold for noise exposure that can cause health problems, as people may respond differently to noise depending on their sensitivity, age, gender, and overall health status. While there are various methods to control noise pollution, the limitations of such controls need to be considered.

4.9 Unexpected Findings

An unexpected finding in the study of noise pollution study was the relationship between noise pollution and crime. Areas of Megenagna with high levels of noise have higher instances of crime compared to quieter areas of Megenagna. another finding was also how noise pollution amplifies aggression levels in humans, increasing the likelihood of confrontations and crime.

Another unexpected finding in this study reveals the impact of noise pollution on education. Noise in Megenagna areas disturb student going to and returning to school impacting their learning ability at school. the noise around classrooms also impacts students' learning abilities. Students in noisy classrooms show lower levels of academic performance. As such exploring new solutions in designing educational spaces as well as student school routes that prioritize quiet environments that promote learning such be made.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Noise pollution has become a significant problem in Megenagna, affecting the physical and psychological health of people as well as effects on the cognitive and psychological well-being of visitors. This study focused on the impact of noise pollution in different areas of Megenagna on the visitors of areas. This study found that transportation, advertisement, and human noises exceeded the permissible limit of 65 decibels for commercial areas, creating various health implications such as sleep deprivation, headache, and cardiovascular diseases. The study recommends that Megenagna should be redesigned to accommodate more vehicles and pedestrians at a time, minimizing the level of congestion. Megenagna should also have regulatory frameworks on noise pollution to avoid loud noises from advertisement noises as well as planting more trees to combat noise from human conversations.

5.2 Contribution to the Field

Urban planning plays a crucial role in creating healthier cities, and one aspect that has gained attention in this field is noise pollution. Noise pollution is unwanted or excessive sounds that affect the environment and society's well-being. This study on noise pollution will contribute significantly to urban planning as it identifies the sources of noise, as it assesses the adverse effects of noise on the health and life quality of people, and suggests mitigation measures.

This study will help urban planners to understand the relationship between noise levels and land use patterns. Urban commercial areas like Megenagna are vulnerable to high levels of noise pollution from transportation, advertisement, and construction sites. Urban planners will use this study to allocate land uses appropriately, separating public areas from noisy loudspeakers using markets to reduce noise complaints and mitigate health risks associated with noise pollution. This study also plays a vital role in promoting sustainable urban development as it promotes the planting of trees to combat noise in the area. By understanding how noise pollution impacts ecological and social sustainability, urban planners will ensure that new developments consider the impacts of noise pollution on future residents and visitors.

This study will also contribute to legislation and policy development in urban planning. With the increasing concern about noise pollution, many areas around the city as well as other cities in the country will develop noise ordinances and guidelines to regulate noise sources. These laws limit noise pollution from transportation, advertisements, and Construction activities in urban areas. By enforcing these policies, policymakers and urban planners have ensured that noise pollution is controlled and minimized to enhance urban quality of life. Overall, the contribution of this study to urban planning will be significant, making cities healthier and more livable.

5.3 Suggestions

One suggestion to address noise pollution is to establish and enforce noise regulations in residential and commercial areas. This can be done by conducting regular sound level measurements and setting thresholds for acceptable noise levels. Local authorities should also ensure that new construction projects adhere to noise reduction measures and encourage noise mitigation techniques such as planting trees to reduce the impact of noise on residents.

Another suggestion is to promote public education and awareness about noise pollution. This can be done through community get together, informational campaigns and outreach programs aimed at informing citizens about the harmful effects of noise pollution on their health and well-being. Public education can also help individuals understand the different types of noise pollution and provide tips on how to reduce their exposure to excessive noise. By increasing public awareness, individuals are be more likely to adopt measures that can help reduce noise levels in their immediate environment.

It is also important to encourage the development and use of technology to mitigate noise pollution. Innovations such as electric cars, quieter engines for motor vehicles, and low-noise power tools can significantly reduce noise levels in urban environments. There is also a need to develop new building materials and techniques that can absorb or reduce noise levels. By supporting research and development of such technologies, we can progress towards a more peaceful and sustainable environment.

5.4 Benefits and drawbacks

5.4.1 Benefits

The benefits of studying noise pollution are many and far-reaching. One major advantage of studying noise pollution is that it can help to identify the sources of noise pollution in a community or region. This is essential to develop an effective plan for reducing exposure to excessive noise and ultimately preventing hearing loss and other adverse health effects.

Another benefit of studying noise pollution is that it can lead to the development of new technologies and techniques for reducing noise levels. The study of noise pollution has helped to create quieter engines for cars and airplanes, as well as more effective soundproofing techniques for buildings.

Studying noise pollution can help to raise awareness about the importance of noise reduction in our daily lives. By educating people about the risks of excessive noise exposure and providing them with tools and resources to reduce their exposure, we can help to create a healthier and more peaceful society.

5.4.1 Drawbacks

There are also some potential drawbacks to studying noise pollution. One of the main concerns is that it can be expensive and time-consuming to conduct comprehensive noise pollution studies. This can be a barrier for smaller communities or organizations that may not have the resources or expertise to conduct their studies.

Another drawback is that noise pollution studies can be complex and difficult to interpret. Noise levels can vary widely depending on the time of day, season, and location, and it can be challenging to determine the exact sources of noise pollution in a given area. This can make it difficult to develop effective strategies for reducing noise levels.

Finally, there is the potential for backlash or resistance from those who may be impacted by noise reduction efforts. Businesses that rely on noisy equipment or loudspeakers may be reluctant to invest in measures to reduce their noise levels, even if it would benefit public health. Noise pollution researchers need to consider these potential challenges and develop strategies for addressing them.

5.5 Recommendation for future research

It would be valuable to conduct further research to understand the impacts of long-term exposure to noise pollution. While this research has shown that excessive noise can lead to short-term health risks such as elevated blood pressure, hearing damage, and sleep disturbances, it remains unclear whether exposure to noise pollution over a longer period can have a cumulative effect on an individual's health. Future studies could investigate the effects of long-term noise exposure on a range of health outcomes, including cardiovascular disease, cognitive functioning, and mental health.

Future research could explore the role of urban design and city planning in reducing noise pollution. This research and previous research have suggested that urban planning measures such as placing green spaces and noise barriers between buildings, implementing traffic calming measures, and encouraging public transportation can help reduce noise pollution levels in urban areas. Further research could investigate the effectiveness of these measures and identify additional strategies for mitigating noise pollution in urban environments, to improve community health and well-being.

It would be valuable to explore the impact of noise pollution on different populations, particularly those who are most vulnerable to its effects. For example, elderly individuals, children, and people with pre-existing health conditions may be particularly susceptible to the harmful effects of noise pollution. Future research could investigate how these vulnerable populations are affected by noise pollution and identify strategies for mitigating its impact on their health and well-being. By focusing on the needs of these at-risk groups, noise pollution research could help inform public health policy and improve public health outcomes for some of the most vulnerable members of our communities.

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APPENDIX

Questionaire used

Dear participants,

Thank you for taking the time to complete this questionnaire. This survey aims to gauge how noise pollution affects people in Megenagna, Addis Ababa. It is part of the research I am conducting in partial fulfillment of a Master's Degree (MSC) in Urban Planning and Design from Adama Science and Technology University. I value honesty and accuracy in your responses, as these are for academic purposes only and will not be used for any other purpose. Your feedback is important to me
– thank you for helping and contributing to this research!

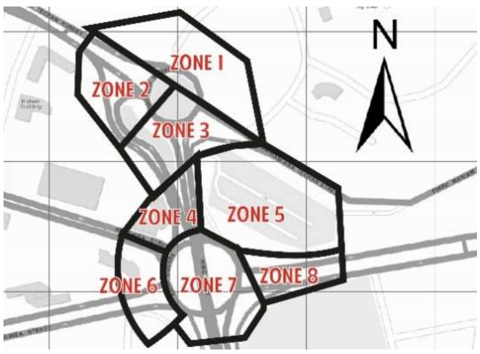
Please circle your answer for the following questions

Demography

1. What is your gender?
   a. Male
   b. Female
2. How old are you?
   a. 0-10   d. 31-40
   b. 11-20   e. 41-50
   c. 21-30   f. Above 50

General Information

3. How long have you been living in Addis Ababa?
   a. < 1 year   c. 4-5 years
   b. 1-3 years   d. Above 5 years
4. Do you work in Megnagna?
   a. Yes   b. No
5. How frequently do you go to or pass through Megenagna?
   a. Daily   c. 3-4 times a month
   b. 2-3 times a week   d. 1-2 times a month



6. In which parts of Megenagna do you often hear loud noises?
   a. Zone 1   e. Zone 5
   b. Zone 2   f. Zone 6
   c. Zone 3   g. Zone 7
   d. Zone 4   h. Zone 8
7. what sources of noise have you noticed more than other sources?
   a. Transportation Sector (cars, trucks, and trains)   e. Recreational or Entertainment sector
   b. Aircraft Noises   f. Religious Institutions
   c. Construction Industry   g. Advertisement sector
   d. Factories and Industrial facilities   h. Human Conversation

Feeling and Ability

8. What do you feel when you pass the Noisy environments of Megenagna?
   a. Very disturbed   d. comfortable
   b. disturbing   e. very comfortable
   c. neutral
9. Do you encounter a change in emotion when you are in a highly noisy area?
   a. Yes
   b. No

10. Do you think highly noisy areas annoy you?
    a. Yes b. No
11. How much is your focusing ability in a highly noisy area?
    a. Very good
    b. Good
    c. Neutral
    d. Bad
    e. Worse
12. Can you hear clearly around the Megenagna area?
    a. Yes b. No
13. Can you stay in a highly noisy area for a long period?
    a. Yes b. No
14. Are you discouraged from going to Megenagna due to its noise pollution?
    a. Yes b. No

Impact Assessment

15. Did you notice any health impact because of experiencing a noisy environment?
    a. Yes b. No
16. Have you noticed an ear problem related to noise pollution?
    a. Yes b. No
17. Did you encounter any sleeping difficulties?
    a. Yes b. No
18. Do you feel well after passing through noisy environments?
    a. Yes b. No
19. Do you feel angry or upset after passing through noisy environments?
    a. Yes b. No
20. How intensely have you encountered the following problems due to noise in the range of 1-5

Sleeping disorder	1	2	3	4	5
Hearing problem	1	2	3	4	5
Annoyance	1	2	3	4	5
Lack of focus	1	2	3	4	5
Mood swings	1	2	3	4	5
Stress	1	2	3	4	5
Cardiovascular problems	1	2	3	4	5

21. How do you protect yourself from noise pollution
    a. Using earplugs
    b. Covering Ears
    c. Avoiding noisy areas like Megenagna
    d. Accept and do nothing

Suggestion

22. Do you think it's important to study noise pollution?
    a. Yes
    b. No
23. In your opinion what are the ways to reduce noise pollution in Megenagna?
    a. Formulation of noise regulation and law
    b. Redesign the area for better noise management
    c. Create awareness in people's perception
    d. Promoting Planting trees to act as natural sound barriers