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Tittle: Investigation of Conflicts Between Railway and Road Network Interaction and Their Impacts on the operation: The Case Addis Ababa Light Rail Transit

A Research Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfilment of the requirements for the Degree of Master of Science in Railway Engineering (Civil Infrastructure)

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Dedication

I dedicate this thesis to my mate, Civil Engineers, to our brothers during our period of studies, my wife Bayisenge Vestine, my sons Bruno and Bruce, My parents and the whole Family. I also dedicate this thesis to ARCE, who allowed me to further my studies. Above all, I dedicate this work to God, who gave me a purpose in life and the field of Engineering.

Declaration

I, SIBOMANA Aime Alphonse, declare that" **Investigation of Conflicts Between Railway and Road Network Interaction and Their Impacts on the Operation: The Case Addis Ababa Light Rail Transit**" is my original work, has not been presented for the award of degree or diploma in this or other universities. All sources of materials used in this work have been acknowledged and cited.

Name: SIBOMANA Aime Alphonse **Signature:** **Date:**

Acknowledgments

It has been a very long journey to get to this point in this Master of Science in Railway Engineering (Civil Infrastructure), and I could not have achieved a fraction of what I have without the help and support of my lovely wife, Bayisenge Vestine. My sons, Bruno, Bruce and my parents. They kept me focused and motivated throughout this whole journey. My sincerest gratitude goes to my academic advisor, Dr. Kahssay Girmay, for supporting me to my most tremendous potential and conducting relevant research that can impact people's lives in the City of Addis Ababa and the world. Constructive criticism was received from him, and where my knowledge was limited, he chipped in. I would also like to acknowledge the support of Nahu, a student from ARCE under Addis Ababa University, who aided me in data collection from various organisations, traffic count and questionnaire distribution within the transit environment. I also want to acknowledge Eliezel Niyitegeka, who helped me structure the study and questionnaire analysis using the SPSS Software. Completing this thesis was possible with their guidance, technical support and motivation. I would also like to acknowledge Mukamana Esperance, an established researcher in the field of transportation engineering; her research work made the development of this thesis easier. Special acknowledgement also goes to AALRT and ERC for the critical information necessary for this study to succeed. Special thanks also go to the ARCE Engineering Department and all the lecturers and facilitators who have created a positive learning environment for me.

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Abstract

Due to quick financial growth, Addis Ababa city has a high traffic issue, which affects the movement of pedestrians, goods, and tracks where business is also affected. Addis Ababa Light Rail Transit (AALRT)has been involved in solving the problem. This research aims to investigate economic, social, and traffic conflicts caused by the alignment of AALRT and road network**,** suggest solutions for each conflict investigated, and mitigate for the next LRT project to avoid conflicts. Scenario 1 considered railway and road networks combined, and scenario 2 considered roads without LRT. The parameters for social conflicts were: pedestrians waiting time to cross, pedestrians travelled distance to access the next crossing level, the walkway distance between the railway and road network, safety and security at the crossing level, waiting area before the crossing level, and peak hours effects. The economic conflict parameters were: business owners crossing for services, vehicle supplying goods access to shops, customers and business owners' vehicles access to shops and Railway alignment contribution on business around, interviews and questionnaires have been delivered, and statistical package for social science (SPSS) has been used to analyse the respondents' feedback in qualitative aspects and Excel for quantitative aspects.

After comparing the parameters of both scenarios, the following conflicts have been shown: long distance travelled to reach the crossing, long waiting time before crossing, insufficient walkway area between railway and road, insufficient security and safety signs at the crossing, difficulties of the vehicles to access shops and traffic congestion at turn bay. Solutions to the investigated conflicts are: to provide an inclusive pedestrian flyover bridge on every 150 m to 200 m of LRT and road network, to provide a walkway of 1.5 m width between railway and road, to install a signalling system at every crossing, to provide vehicles turn bay for freight vehicles and passengers' vehicles on every 350 m of the systems which will make business easy and feasible. The future project must do a clear investigation during the planning phase; using tunnels and bridges to avoid alignment conflicts is better. The most cost-effective solution is constructing a turn bay that can be used as a zebra crossing and providing a signalling system at every turn bay. The other research can be focused on the design of suitable flyover bridges and turn bays.

Keywords: Conflicts, traffic, economic impact, Business, Accessibility, Crossing, turn bay.

List of Acronyms

AALRT: Addis Ababa Light Rail Transit

PT: Public Transportation

LOS: Level of Service

LRT: Light Rail Transit

UN: United Nations

SDG: Sustainable Development Goal

HCM: Highway Capacity Manual

ERC: Ethiopian Railway Corporation

AACTAB: Addis Ababa City Transport Administration Bureau

ITH: Integrated Transport Hub

ADT: Average Daily Traffic

AADT: Average Annual Daily Traffic

BOT: Build, Operate, and Transfer

DF: Daily Traffic

TOSMDS: Transit-Oriented Shopping Malls Development

HST: High-Speed Trains

ICC: Inter City Coach

FHWA: Federal Highway Administration

VCD: Vehicle Class Distribution

AASHTO: American Association Highway Transportation Official

Table of Contents

List of Figures

List of Tables

Chapter 1: INTRODUCTION

1.1 Background

Due to quick financial growth, Addis Ababa city has a high traffic issue, which affects the movement of pedestrians, goods, and tracks where business is also affected. Light rail transit (LRT) of Addis Ababa has been involved in solving the problem; the migration of RLT plays a role in city development in mobility facilitation and travel efficiency by reducing the duration and cost used by the citizens. The migration of LRT is intended to reduce private cars that are creating congestion in the urban to the adaptation of the public transportation system. Light Rail Transit of Addis Ababa (AA-LRT) is intended to close the mentioned gaps, improve the escalating transportation issues, address urban sprawl, lessen traffic congestion, and provide a different form of public transit. However, throughout the early stages, since its operations in 2015, it has had difficulties that could eventually cause it to cease. Other factors have contributed to these difficulties, but the biggest is a lack of finance for ongoing operations, pedestrian crossing, and business access on the two sides of the LRT and the road. Since LRT offers consumers affordable transportation, it is only anticipated to be financially sustainable with assistance from the appropriate authorities. Even if the transit-oriented Development (TOD) concept has benefited numerous cities all over the world, thorough research should be conducted, and stockholders should possess the essential information before Oriented Development (TOD) design and implementation(1).

Given that city light rail infrastructure is essential to urban mobility in conurbations and offers advantages such as increased mass transit capacity, comfort, quick speeds, safety reliability, and better environmental conditions, Addis Ababa responded to the effects of congestion and mitigation by implementing an urban LRT running through the suburbs and the city. Due to its capacity for altering urban environments and the circumstances required in planning for their efficient integration, Light Rail Transit (LRT) facilities are widely recognised for advancing "sustainable urban mobility strategies" in and around numerous towns. It is also noteworthy that as transportation improves social, environmental, and economic conditions, it must be considered while discussing concerns relating to the modern economy. Urban rail transit positions itself as a significant level for the development of the urban economy by encouraging the growth of industries and easy accessibility, which raises living standards(2, 3, 4).

This is built on contextual elements that compete with the latest LRT advances. The organisational structure of the various participating firms, socio-economic and environmental factors, cultural differences, procedural discrepancies, travel demand gaps, city governance, and the technical capability gap are just a few examples of the situations or contingencies that this method requires a tailored process to address. The numerous contextualisation techniques employed to adjust Chinese LRT advances to Addis Ababa's qualities(5).

Due to its technological improvement, the best method for relieving traffic congestion, economic advantages, low environmental pollution, and high passenger capacity, the LRT system has become a preferred mode of transportation. Due to this, most industrialised nations have a large Construction in underdeveloped countries and along railway lines. Nevertheless, Addis Ababa's LRT has been built in two directions. Even though Addis Ababa's light rail transit route underwent extensive planning and construction, tearing down recently completed roads and highways has become expensive. This can result from a need for more strategic planning for the city's integration of rail and roads(3). Despite the business and social-focused conflicts after its completion, it may be due to planning and geometry placement. Figure 1 illustrates the Addis Ababa light rail transit lines.

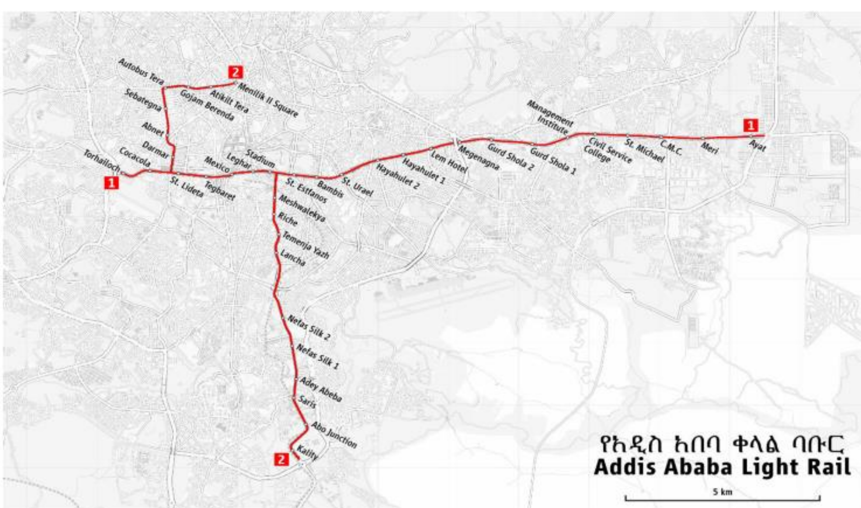

Figure 1: AALRT map

The construction of new significant infrastructures brings many conflicts due to decision-making processes where actors make decisions following a rigid and hierarchical framework, with the fact of high speed and low cost of the project where after conflicts occur which cannot be solved quickly, in any project during feasibility study phase it needs the involvement of Public interest (6). Despite the technological advancement in the railway sector, Conflicts based on traffic still exist and affect other sectors such as Social, Commercial, and health, so investigating and solving the conflicts is paramount(7).

Therefore, this proposal is based on investigating economic and Social conflict between Addis Ababa light rail transit and road network interaction in Addis Ababa City. The only corridor in the city for passengers has been built after the road network affected the customers to access the business activities on both sides of the road. Also, sellers have experienced delays in delivery and grocery buying. All those are caused by a lack of sufficient and safe crossing ways, contributing much to Traffic congestion. Researchers will investigate business and social conflicts and their ways of handling them.

1.2. Problem Statement

A problematic issue in most metropolitan settings is the integration of several transport modes, from construction planning to operation. With this approach, the ERC has built LRT routes within Addis Ababa that run along the current city streets in two directions: north to south and east to west. Even though combining road and rail transit is challenging in and of itself, building an LRT inside the constrained space of urban highways is challenging. The fact that the railroad is constructed between two road lanes affected the access on two sides of lanes, making it difficult for customers and business owners' vehicles to cross the road and railroad compared to the road network free from LRT. Rescue in case of an accident is difficult due to the lack of railroad and road crossing facilities, creating conflicts compared to roads free of LRT. This comes with the following challenges

1. Difficulties of Free movement for pedestrians to cross on both sides of transportation systems
2. The difficulties of vehicles crossing (Change in direction)
3. Business owners and their customers to access both sides

4. Traffic congestion at the vehicle turn bay.

This shows that during the planning phase, stakeholders have not been consulted. Research will investigate the conflict caused by this interaction and come up with solutions. Figure 2 shows the situation.

Figure 2: Alignment of the two-transportation systems

1.3. Research questions

This research is going to be based on the following questions

1. What are the traffic and social conflicts caused by the alignment of AA LRT around the area compared to a road network free from LRT?
2. What are the economic conflicts caused by the alignment of AA LRT in the area compared to the road network free from LRT?
3. What can be the solutions for the investigated conflicts?
4. What should the next planned LRT be considered to avoid conflicts between railway and road?

1.4. Objective of the research

This research focused on the following objectives.

1.4.1. Main objective

The main objective of this research on the business conflict between AA LRT and the road network is to identify and solve the conflict and advise to avoid them during the future project.

1.4.2. Specific objectives

The applicable objectives of this research are:

- To investigate customer/ Social conflicts caused by AA-LRT in the area around compared to the road free from LRT.
- To investigate transport and economic conflicts caused by AA-LRT in the area around compared to the road free from LRT.
- To suggest solutions for each conflict investigated.
- To mitigate for the next LRT project to avoid conflicts.

1.5. Research Method

The method used to achieve the objectives of the research included:

Literature review: Different studies were conducted on LRT in Ethiopia and rail-to-road conflict cases worldwide by reading documents, publications, and engineering codes.

Data: The collected data were done using questionnaires for pedestrians and business owners, interviews with AALRT staff, traffic counts for vehicles, and observations.

Data analysis and interpretation of results: The data collected have been analysed using SPSS and Excel; the study was done using the standards and publications, and a comparison of results found on railway and road users and road users only.

1.6. Significance of the research

The contributions of this research are

- To use the correct procedures to identify conflict and their resolutions separately for business-oriented and for customers, which has yet to be presented by other researchers.
- Provision of a crossway for cars supplying the products from wholesale to retail to avoid fuel consumption and traffic congestion.
- Placing the flyover bridges for the customers to access products on both sides of the two systems will improve business flexibility. Pedestrians will also use the flyover bridges to cross the systems safely. It will add value to the business done on both sides; it will also help balance the house rent price for both business and residential.
- The research is going to highlight the conflicts that are supposed to be avoided during the next LRT project

1.7. Limitation of the research

This research will cover the investigation of the business, customer, and pedestrian conflicts caused by interaction between AA LRT and the road network, mention the best solution for the investigated conflicts, and highlight points to avoid in the next LRT project in Addis Ababa city. In all, the research will not design the flyover bridges but will mention the correct position. The study will not design the crossways for cars, but it will mention their location on the AA LRT line. Therefore, the researcher will do validation referring to other related research.

1.8. Organization of the research

This research was organised as follows:

Chapter One is an introduction part that shows the background of the research, states the problem, and mentions its source, the questions related to the study, the Achievable objectives of the research, the research's contribution, and the research's limitations.

Chapter Two will focus on a review of related research that can contribute to this research, which will be used to validate research results.

Chapter Three covers the research methods to be used, Data collection techniques, and data analysis techniques, including the use of SPSS and Excel software.

Chapter Four will display the results and their interpretation according to s the objectives at the end. Chapter Five will contain a conclusion, recommendations, and the points to be focused on in the following research. This will also be the Appendix to show the attachment needed to support the research.

Chapter 2. LITERATURE REVIEW

2.1 Introduction

This part provides the related research performed by other researchers and shows the logic of the common issue of transportation using all transport systems. It covered the impact of the railroad Interaction and the conflicts that happen and disturb the normal working conditions of LRT about SPSS Origin, which will be used in data analysis, and it ends by presenting the summary of all papers and books read.

2.2. Economic conflicts in a project.

Consider economic concerns, including how socio-economic growth primarily offers benefits at the macro level. Such huge facilities often benefit areas far from their site and hurt local activities. The final set of issues is financial: public costs are too expensive. A better financial investment would be made in projects that are more beneficial in other industries. If the current train line is adequately saturated, an analysis of the data would show that BBT is a worthwhile infrastructure. The Brenner HS/HC line is, without a doubt, the most important of the major infrastructure projects now under construction and should be the focus of European economic efforts.

Such frames of view are dissimilar. It does not imply that it is impossible to come up with a standard definition of the issue. Remembering the boundary objects, every point of view shares the idea of sustainability. We should reconsider the infrastructure development discussion in light of this idea and the various ways it might be interpreted. A similar strategy has been used for the Gronda di Ponente; a city roadway built in Genoa. Table 1 identifies the economic conflict point of view(6).

Table 1: Economic conflict point of view(6).

BOUNDARY OBJECT	PROBLEM	SCALE	SOLUTION	ACTORS
Sustainability	Lack of economic development and circulation right for citizens; transport externalities	Europe	HS/HC rail line	European Union, Italian and Austrian Government, some local public administrations, Alpine Convention
	Lack of accessibility = lack of economic development	Bolzano	HS/HC rail line, airport, A22 third lane	Chamber of Commerce Bolzano, Brenner Highway S.p.A., Airport Bolzano Dolomiti S.p.A.
	Pollution and lack of space for mountain regions	Alpine valleys	Improvement of existing railway lines discouraging road transport	Environmental and social associations, some local public administrations, South Tyrolean association of farmers
	Economic benefit	Brenner axis	HS/HC rail line	Economic evaluators

The conflicts highlighted are lack of transportation circulation for vehicles and pedestrians, lack of space and pollution of land and air; these conflicts reflect the second objective of this study.

2.3. Social and traffic conflicts in a project

Those players (primarily at the local level) who worry about the public's unnecessary costs and the loss of space and identity for the valley where the line will cross maintain a polar perspective. They contend that the alpine valleys will become little more than crossing areas that are less and less desirable to live in. Instead of building a new infrastructure, the idea is to rationalise and enhance existing ones. The "Brenner Action Plan," already approved and implemented, intends to increase the historical line's capacity to 244 trains per day, comparable to the HS/HC line. New regulations that encourage the use of the existing railway line and discourage the use of the road system.

The first group of problems is social; for instance, HS/HC lines reduce living space.

The second is environmental, such as losing numerous hectares of useful land. Aquifers might dry out, and uranium lodes might be discovered. Additionally, construction sites will be used for a considerable amount of time (at least 15 to 25 years), presenting long-term challenges for the locals (6). The social conflicts highlighted are lack of crossing area, access on both sides of the existing valley, reduction of living spaces and loss of agricultural land; these conflicts reflect the first objective of this study.

2.4. Accessibility perspective

The term "accessibility" is given many different definitions. There is no single accepted definition of accessibility, and the subject is approached from a wide range of scientific disciplines (such as urban planning, transportation planning, geography, and information technology, among others). Depending on the intended use and the context, the term has many definitions and interpretations. The phrase "accessibility'' is a slippery notion one of those commonplace expressions which everyone uses until faced with the challenge of defining and assessing it" is used to illustrate the term's adaptability and wide range of applications (8, 9).

Accessibility is substantially improved by a grid-shaped, sociable, interconnected network of streets with a high density of intersections and a wide range of destinations. However, transportation infrastructure, roads and interchanges, like highways, can facilitate and impede accessibility based on whether they were created to accommodate all types of road users or exclusive to cars. Activity is changed by a change in land use or transportation technology patterns that, therefore, have an impact on accessibility levels generally(4, 10).

A more accessible urban form is compact and served by a well-planned public transportation network. Elaborating on the idea of accessibility highlights the importance of accessibility in transportation planning and how it is connected to a variety of social and economic opportunities whose level of accessibility depends on the urban density, the distance to the destinations, the location of the transportation infrastructure as shown in *figure 3*(8, 10, 11).

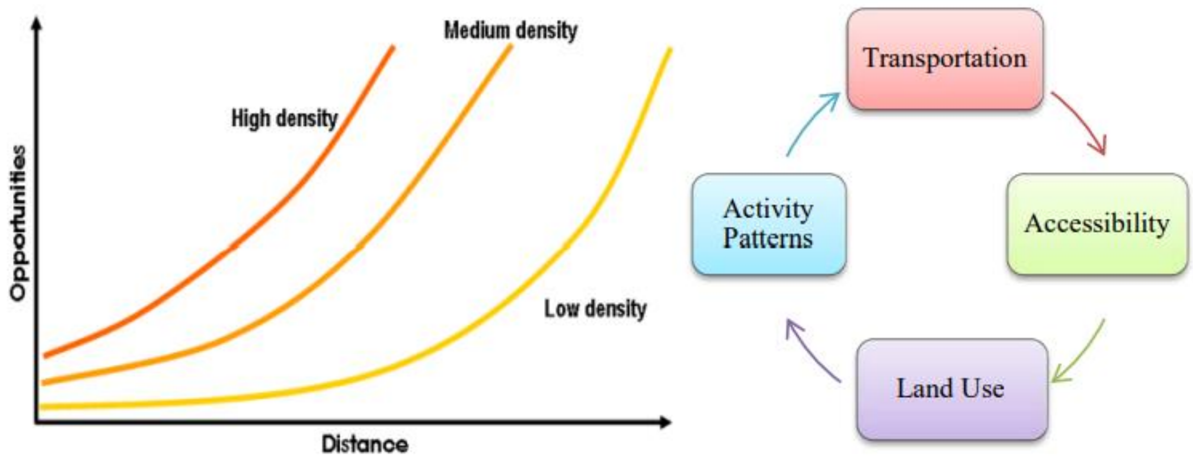

Figure 3: The relationship between distance and business opportunities (Rodrigue)

$$Accessibility\ i=\sum_j Opportunities * f(C_{ij})$$

Were

1. **I** = Index of origin zones
2. **J** = Index of destination zones
3. ***f(Cij)***= Function of generalized travel cost(4)

Accessibility facilitates the free movement of pedestrians and vehicles from one place to another; if accessibility is not respected, social and economic conflicts are raised. These reflect the two first objectives of this study.

2.5. Mobility

Mobility reflects both the potential for a movement and the actual movement, making it a multifaceted term. To begin with, it is a decision that can be made to be exercised or not based on economic and societal objectives(12, 13).

Regardless of its aim, mobility enables social, cultural, political, and economic activities to occur. Throughout history, changes in mobility have been the outcome of technological developments that improved operational characteristics such as speed, range, price, affordability, and comfort. These changes enhanced societies and the quality of life of populations. For instance, the diffusion of highways and the automobile profoundly impacted the mobility of contemporary societies and continues to do so.(12, 13).

It has been noted that mobility is moving in favour of motorised modes of transportation12, a phenomenon frequently associated with economic growth. Greater mobility is commonly associated with higher development opportunities than limited mobility. Greater mobility is a driver for development, whereas decreased mobility is a barrier. Therefore, mobility is a trustworthy sign of progress. An industry that sells services to its clients, hires people and pays wages, invests capital, produces income, and collects taxes is the provision of mobility. Therefore, mobility is the consistent factor where transportation has the most significant societal effects(12, 13).

Transportation facilitates access to a workforce and the capacity to contact suppliers and provide services to clients for economic activity. As transportation advances, interactions with labour become more efficient, and distribution costs often fall due to the increased competitive advantages. Since they utilise it frequently, most people have substantial expertise in transportation. Using transportation is frequently a social experience, occasionally unfavourable, and it is the method of accessing employment, commodities, services, leisure, and social networks (e.g., comfort, safety). As a result, a portion of society's consumption goes into addressing mobility demands. Inversely, greater income levels are typically correlated with a higher percentage of spending related to transportation, a tendency that is mainly linked to car ownership and air travel. Mobility represents social status; therefore, the bigger the income, the more it is spent on it(12, 13). Even if the research shows this in the case of Addis Ababa light rail transit and the road network, it is still a big challenge for the transportation system because mobility enables social, cultural, political, and economic activities to take place; if not respected, it creates social, economic and traffic conflicts in transportation, these reflect the two first objectives of this study.

2.6. Social conflicts dimensions in the Europe project

Roads and trains both offer mobility and have societal repercussions as a result. The ability to move about is viewed as a trait of late modernity, with advantages enhancing individual and societal well-being in the age of globalisation. The concept of the "mobility turn," which places a fresh emphasis on the spatial and social elements of transportation infrastructure, was inspired by the growing amount of social science research on railroads and, in particular, roads.

Speed is a significant social feature of connectedness and mobility made possible by transportation infrastructure. Through the "annihilation of space by time," it shortens distances and makes it easier to link distant locations and individuals. Highways represented the long-distance travel culture's acceleration in the post-World War II era. Social scientists are increasingly paying attention to the same consequences of high-speed train lines in the twenty-first century. For example, high-speed rail projects reduce travel time between major European cities and alpine areas and affect spatial relationships and development. Local objections over the associated social effects on nearby villages, such as dust and noise pollution, have led, for example, to the development of the "No TAV" high-speed rail resistance campaign in Italy's Susa Valley. There are many links between transport, beneficial social interaction, co-presence, well-being, and quality of life. In most cases, increased mobility and access to transport services lead to more frequent travel and interactions with others, as illustrated by the regular air services among Inuit villages in northern Canada that are isolated from one another.

Roads and railroads contribute to the social exclusion of disadvantaged or vulnerable populations because of their lack of availability and unequal access. New social relationships and identities formed while people are "on the move" are supported and made possible by travel and supporting and facilitating social networks between people who live in various places(14). The mentioned relationship between people living near the railroad and road network must be maintained for each project to avoid social conflicts; these reflect this study's first, third and fourth objectives.

2.7. Economic consequences of road and railroad

Individual roads rarely have an influence as significant as a railway line, but integrated road networks with national or international significance can. Examples include the American Interstate Highway system and the German Autobahn. Because they were a part of profound changes that profoundly impacted all facets of society, from new patterns of mobility and sociality to new forms and locations of consumption, such extensive road systems cannot be reduced to specific economic, ecological, social, or other consequences.

The economic effects of industrial infrastructure on local and Indigenous populations' traditional subsistence practices have frequently been seen through the lens of the dominant developmental paradigm and demand special consideration. Among the most prevalent but often disregarded negative effects of transportation infrastructure are pollution and the abandonment of pastures, hunting grounds, and fisheries. Indigenous peoples' traditional methods of life, particularly subsistence traditions, can be harmed by increased access to previously isolated resource-rich places and related infrastructural development(14). The economic conflicts highlighted are pollution of air and land, hunting grounds, and fisheries. These reflect the second objective of this research.

2.8. Economic conflicts between road and railroad in Russia

The Nenets, the local indigenous population in Russia, have benefited economically from the Bovanenkovo Railroad in several ways. Still, severe effects have also been on the environment and the cultural practices described below. The Russian Federation had significant unemployment in the early 1990s. People who lived on the tundra, distant from settlements and access to commodities and services, like child support programs and medical assistance, experienced very difficult living conditions. However, most Nenets people kept up their traditional fishing methods and reindeer herding to survive in the tundra. The Bovanenkovo Railroad has had a lot of positive economic consequences for the Nenets and the local Indigenous community. Still, it has also negatively affected the environment and the cultural traditions described here. Early in the 1990s, the Russian Federation had a sizable unemployment rate. People who lived on the tundra had highly challenging living conditions since they were far from settlements and had limited access to goods and services like child support programs and medical aid. To survive in the tundra, most Nenets people continued using their traditional fishing and reindeer-herding techniques(14). The mentioned conflicts reflect the second objective of the research.

2.9. Social conflicts between road and railroad in Russia

The social effects of the railway on the Indigenous residents have been a significant concern throughout this project's history. The railway crosses critical reindeer pastures and Nenets family migration routes, impeding the reindeer herders' seasonal movement across the Arctic. While some Nenets groups altered their migration routes, others stuck to their old tundra travel patterns, which resulted in several challenges and restrictions. The Nenets people did not isolate themselves from these developments; instead, they formed new companies to generate income and purchase items, including fuel and basic food supplies at the Tundra train stations and new communication networks with railway personnel.

Conflicts caused by the construction of the railway continue to significantly impact Indigenous culture, travel, the economy, and social activities. Many Nenets families consider losing their sacred sites a tragedy since they play a significant religious role. The Nenets Sacred Mountain Enzor Pe, a part of the Polar Ural Mountains, was demolished at the end of the 1990s so that stones could be removed and used to build a railroad embankment. It's not unexpected that this has turned into a touchy subject. The chief of a reindeer herding brigade working for the Yarsalinskii farm stated in a 2006 interview that railroad construction workers had damaged (14). The conflicts highlighted are based on people's movement and lack of communication between the transportation system users. These reflect the first objective of the research.

2.10. Economic conflicts between transport and land use in Nigeria

Transportation is critical to economic development. It is a key in a country's progress measurement. Rural communities are linked to urban areas in Nigeria, and Nigeria's rail infrastructure has dramatically slowed down the economy. Rail infrastructure enhances land uses and encourages accessibility among land users to a significant extent. Due to its capacity to transport substantial quantities of freight and a large number of passengers at a low cost, rail transportation was crucial to the Nigerian economy's commercial and industrial activities. However, neglect has significantly reduced its contribution. With its beginnings in Lagos in 1898, rail transit is one of Nigeria's earliest forms of public transportation. Since then, as it has spread across the country, rail transportation has significantly contributed to the country's socio-economic growth. There needs to be more longitudinal analyses of train infrastructure in the literature, particularly concerning the expansion of towns and cities. The supreme body overseeing and regulating rail transportation is the Nigerian Railway Corporation (NRC), which leads, manages, and organises its operations. If taxpayers pay enough attention to them, Nigeria's railways will offer the most economical, accessible, energy-saving, and environmentally friendly means of transportation.

Rail transportation makes transporting raw materials, commodities, and produced items easier, providing chances for producers and consumers to interact. Suppose the government successfully continues to enhance its investment in the rail transportation subsector. In that case, a rise in the volume of passengers and freight can spur economic growth and employment in Nigeria. An increase in locomotives, coaches, and cargoes would improve travel for people and goods, support trade and business operations, boost productivity, open up direct and indirect opportunities, and boost tax revenue(15). The western and eastern flanks from the Lagos and Port Harcourt seaports, respectively, may save 44.2% and 93.7% of freight costs by combining railroad for hinterland-bound commodities. The student's t-test data also revealed that the matched differences in costs and times on both flanks were statistically significant(16). The use of rail infrastructure s in Nigeria slowed down the economy, but after its alignment, the economy has increased. These reflect the first and third objectives of this study.

2.11. Conflicts of rail to the road in South Africa

One of the most significant infrastructure investment projects in history, China's Belt and Road Initiative (BRI) has the potential to significantly boost regional economic growth in Asia, Europe, and Africa. The beneficial network effects of the transportation infrastructure cause the spillover effects. The BRI nations are further divided into five geographical zones. The findings demonstrate that improving transportation infrastructure (road and rail) considerably benefits economic growth in Central and Eastern Europe and South east Asia. In contrast, there is no appreciable association in other areas, and in South Asia, West Asia and North Africa, respectively, the rail infrastructure and regional economic growth are even inversely correlated. In addition, the development of transportation infrastructure in Central and Eastern Europe exhibits a favourable geographical spillover impact on regional economic growth due to the region's highly developed transportation infrastructure. The diffusion effect is displayed via the spatial effect. The BRI can be very beneficial by supplying the capital required for infrastructure development in the BRI countries. Therefore, we advise the BRI participating nations to drop their political and ideological justifications and seize the chance presented by Chinese government-funded initiatives to upgrade their transportation systems(17). Some countries are gaining from railways; others are losing due to the plans and infrastructure alignment. These reflect the third and fourth objectives of this research.

2.12. Economic conflicts of light rail transit in the USA

For the urban transportation planning industry, the notion that perception trumps reality regarding the economic development potential of fixed-route transit systems raises the obvious question of how to prevent or offset these drops in new company activity. Making new transit systems fully competitive with existing modes from the perspective of transportation service is one approach given by the example of Phoenix, where the system only serves a small percentage of regional travel. The system's utility as a mode of transportation, which necessitates a high level of service, dependability, speed, affordability, and a wide range of potential destinations, ultimately determines any economic benefits.

Results demonstrate that while new company development impacts are still considered for all three analysed kinds at one mile (network distance) from stations, they are decreasing with increasing distance from the stations. Additionally, distance from light rail stations differently affects the three types of businesses differently. Although knowledge (12%) and service (0%) firms do not see a rapid decline in benefits with distance, retail businesses experience a rapid decline (21%). These findings collectively imply that TOD programs may be most successful in encouraging the establishment of businesses in the knowledge sector and that the more closely a program is targeted to a station, the more beneficial it will be(18). The gap remaining is to be assessed by considering zoning and construction of transit service on business formation**.**

2.13. Conflicts in China-Mongolia- Russia Rail line

The "Prairie Road Program" planned by Mongolia and the "Eurasian Economic Union" proposed by Russia both fall inside the China-Mongolia-Russia Economic Corridor. China, Mongolia, and Russia are all committed to expanding this corridor because it is a crucial strategic area. "Promoting the development and inter-connectivity of transportation infrastructure" is prioritised as a key area of cooperation among the three countries in the "Plan for Construction of the China-Mongolia-Russia Economic Corridor," which was signed in 2016 by the governments of the three countries. The plan explicitly states to "increase the potentiality of railway and road transportation capacity and establish and develop international land transportation corridor." High-speed trains are regarded as one of our most significant scientific and technological achievements. They offer quick transportation, high capacity, high economic efficiency, low energy consumption, and reduced environmental contamination. This study developed the integrated risk evaluation model (IREM) to quantitatively and spatially assess the economic, social, and ecological hazards of developing the China-Mongolia-Russia high-speed railway. Based on this study, we suggest designs for the east and west high-speed railways between China, Mongolia, and Russia, as well as policy recommendations to reduce construction risks. Establishing cooperative prevention and control systems is recommended to lessen the three main ecological chances in the China, Mongolia, and Russia trans-border areas, strengthen communication and technology dissemination, and apply innovative engineering techniques and set buffers. It is also suggested to promote economic integration by enhancing strategic coordination(2018)(19).

2.14. Railroad conflicts

A study was conducted on railroad conflicts with the following objectives: Update the road-rail conflict database, develop a corridor-based project prioritisation process and identify recommendations for a statewide list of projects using the quantitative method. The results have found 1. Projects are at varying phases of development around the state, and MPO awareness of project progress differs across the state.

2. Due to the high costs and lack of finance, planners and project sponsors find it challenging to identify, design, and complete plans and projects to manage road-rail issues.
3. WSDOT, UTC, FMSIB, and other state programs provide funding for safety and mobility enhancements at road-rail conflicts, but there is still a critical need.
4. The Freight and Passenger Transportation System (FGTS) 2017 Update is the only significant change to the Phase 1 database's other data pieces(20)

2.15. Conflict in transport infrastructure construction

An approach for managing conflicts in the construction of new transport infrastructures with the objective of conflict of polarised positions occurs challenging to be managed by using the concept of framing and boundary object, the results where the decision-making process must be inclusive by providing maximum publicity of the various project phases and the stakeholders ' involvement should be included as early as possible, to avoid radicalised positions. Integrating different points of view from the beginning of the process develops common ground and shared decisions and improves the backing of results. It contributes to quality assurance and easier implementation of the projects. From an economic perspective, this reduces the final costs and has significant timesaving effects on the involvement of stakeholders in the construction of new infrastructure(6).

2.16. Conflict in transport planning

Conflicts occur due to metropolitan transportation planning to assess the potential occurrence of urban conflicts generated by the transportation network design using a quantitative approach based on a set of new proposed indexes; more quantitative data that can be spatially represented will aid in creating effective and sustainable transportation networks. Applying quantitative approaches will assist in taking action, from identifying an issue to estimating its size and identifying the negative effects and those affected by them. Overall, the results showing the projected likelihood of conflict within the chosen metropolitan zones show that regional Romanian urban planning was quickly and unintentionally adopted after being artificially supported through legislation. As a result, the development of the metropolitan areas was done without a thorough knowledge of the fundamental goals of these territorial establishment methods. In this regard, the mobility networks inside the urban areas can lead to long-term disputes depending on planning as they cannot guarantee constant and even flows of resources, information, and knowledge to all urban residents. The suggested methodological approach and the conclusions could offer comprehensive supervision of the remaining unsolved problem, Establishing the potential conflict occurrence and providing exciting insights(21).

2.17. Effects of Walking Distance on Conflicts

There needs to be more established literature on how far pedestrians walk and the variables that affect their route choice than on mode choice, which has received more attention in transport planning research than availability to various modes. The environment in which one walks significantly impacts how far they walks and what kind of transportation they use. The appropriate walking distance depends on the situation, the intended purpose of the trip, the amount of time available, and the walking environment. As significant as shortening pedestrian walking distances and times may be changes to the built environment that lessen harmful psychological elements. The purpose of the overall trip, demographic factors, especially age and gender, and the location of the access trip in terms of the built environment and natural environment, although the impacts are variable, suggests that walk distance and time to public transport may be influenced. Because access distances and service availability are interdependent, it is challenging to separate the built environment's impact on pedestrian access to public transportation. There should be between 160 and 200 meters between pedestrian crossings. Adherence to LOS B could be mandated in locations where pedestrian traffic is more important(22). These reflect the first and fourth objectives of this research.

2.18. Use of Statistical package for social science (SPSS)

In 1968, Morman H. Nie, c.Hadlai Hull & Dale H. Bent, three young from disparate professional backgrounds, created a software program that employs statistics to transform unprocessed data into knowledge required for decision-making. These three trailblazers were visionaries who understood early on that data and how it is analysed is the engine that drives sound decision-making, the genetic code of intelligence. They were pioneers in their respective fields. The Statistical Package for the Social Sciences, or SPSS, was the name of this ground-breaking statistical software program. Nie, Hull, and Bent created SPSS in response to the requirement to quickly analyse large amounts of social science data amassed using various research techniques. The initial development of SPSS took place at Stanford University to keep it available just for domestic use rather than for global release.

Bent, an operations research doctoral candidate at Stanford, provided the analysis skills and created the SPSS system file structure. Hull, a recent Stanford MBA graduate, programmed. The calibre and accessibility of the software's accompanying documentation were crucial factors in SPSS's early success. The original SPSS user's guide was released by McGraw-Hill in 1970. The program quickly became in high demanded once the handbook was available in campus bookstores. Nie, Bent, and Hull received a royalty from manual sales but nothing from software distribution. Nie described it as similar to Gillette selling razors at cost and making money off the blades.

SPSS Inc. has grown over its 50 years of existence into a multinational enterprise that offers analytical tools and solutions to businesses worldwide. Customers have a shared desire to gain insight from data analysis, even though their sectors and customers vary. Since its inception, the Company's analytical technology has helped organisations learn from the past, comprehend the present, and foresee the future to manage it efficiently(23, 24, 25).

2.19.1. Use of SPSS

The following are among the uses of SPSS:

View: Gives the option to choose which toolbars to display, the font size, whether or not to display your raw data or the data labels, and whether or not to add or remove the gridlines that divide each data item.

Data: This can be chosen from various options, from displaying data sorted according to a specific variable to choosing particular cases for further analysis.

Transform: There are numerous options in the transform command to modify the variables that are now in effect. Can convert scores into rank scores, convert continuous variables to categorical variables, add a constant to variables, etc.

Analyse: The command set for performing statistical analyses and calculating descriptive statistics is all contained in the analyse command. Using the commands in this menu will be a big part of this.

Graphs: Box plots, histograms, line graphs, and bar charts are just a few of the many diagrams that may be created using the commands in the graphics package(26).

2.19. Intersection

The primary goal of intersection design is to make crossing the intersection comfortable, convenient, and easy to use while allowing for the smooth circulation of bicycles, pedestrians, buses, trucks, and passenger cars. The design should closely match the users' natural transitional routes and operating styles.

Design considerations for intersections include four fundamental components:

- Human elements
- Considerations for traffic
- Physical components
- Economic variables

Even though intersections have a lot of characteristics, they cannot be categorised and must instead be handled as distinct issues (27).

The physical intersection area often extends from the point of return perpendicular across the roadway, as shown in Figure 4. Intersections are characterised by both the function and physical areas. The functional area of an intersection includes the speed change lanes and their tapers, as well as the regions upstream and downstream of the actual intersection area. The intersection facilitates the transportation system to enter another to reduce traffic congestion in the intersection or turning bay; these reflect the second objective of this research.

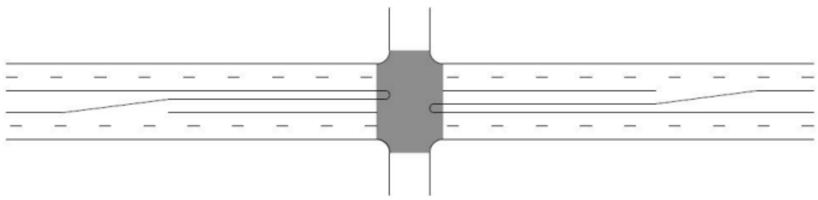

Figure 4: Intersection area

2.20. Literature review summary

The literature reviewed shows the rail-to-road interaction focused on traffic congestion and transportation planning; in AA-LRT, all research conducted showed the problem of facilities at the railway stations and the impact of private vehicles on traffic volume on the side that the railway is aligned. Otherworld researchers showed that the conflict between rail roads on new business, environmental, agriculture, social, and cultural conflicts in their respective countries was caused by the alignment of the railway. However, no research focused on the economic, traffic and social conflicts between AALRT and the Road network, where pedestrians, business owners and Customers face challenges accessing commercial services on both sides of the transportation system. The walking distance between the two cross levels is long, and customers' and freight vehicles to the business owners' shop take a long distance to cross the systems and reach the shop. Statistical Package for Social Science (SPSS) and Excel have been used in this research to analyse data and present results.

Chapter 3. Methodology

This chapter will outline the steps that were considered in the research and design of the way to the crossing and road interchange for two scenarios in the study area (Stadium station to Kaliy depot, from the stadium to Ayat). This means the East-west line and North-South railway lines combined with the road network are the scenario, and the road network is free from the railway line from Stadium to Bole. The research was done based on interviews, Questionnaires and traffic count to confirm the existence of conflicts caused by the railroad's presence. Through qualitative and quantitative research involved the railway and road network end-users. In this concept, several methods have been used to collect data and analysis to produce results confirming the conflicts' facts. The problem consists of the following sections:

a. Pedestrians and business owners' aspect on the accessibility of the railway and road network
b. Monitoring the vehicles crossing the railway at the Lancha station
c. Watching the vehicles crossing the railway at the Guard Shola2 station
d. Analyse and confirm the conflicts caused by the alignment of AALRT.
e. Pedestrians' perceptions of the road network before LRT.
f. Results comparison of the two scenarios for each parameter.

All those elements permitted to confirm the availability of conflict between railway and road networks and the mitigations to solve the problem and for the future planning for the new project to facilitate the safe operation of both systems.

3.1. Study Area

The research covers the Addis Ababa Light rail transit alignment that takes from Stadium to Kality and Ayat, where questionnaires were distributed for each station and by counting vehicles that are crossing the Lancha crossing level and crossing level between Guard Shola 1 and Shola 2, this is to measure and compare the number of vehicles crossing the two turn bays and consider this as results from a distance travelled without crossing which creates congestion as one of source the conflicts between railway and road network to come with trustable results. The same investigation on the road network has been conducted to confirm the railway alignment contribution to the conflicts. The research area has been selected after checking the distance between the crossway to another and considering the long distance travelled by pedestrians to reach a zebra crossing, the distance travelled by vehicles to the next turn bay, and the distance travelled by business owners and their customers to cross for services.

3.2. Research Design

Since this research aims to investigate the conflict between railway and road network and their impacts on operation, descriptive, qualitative, and quantitative research methods were employed. Descriptive research mainly focuses on describing the characteristics of individual groups of respondents. Visual observation was used to identify the conflicts by observing the difficulties pedestrians and business owners meet with caused by the alignment of the railway.

3.2.1. Research scenarios

This research has been conducted based on two scenarios, and results from both scenarios have been compared to confirm the conflicts from one parameter to another.

Scenario 1: Considered the railway combined with the road where the investigation was conducted to determine the pedestrians' perception of the alignment of LRT. The considered lines were Stadium to Kality depot and from Stadium to Ayat depot.

Scenario 2: considered the road free from the LRT by investigating the pedestrians' perception of the road access. The considered line is the line from Stadium bus parking up to the Bole bus stopping area because the chosen line has the same starting as the lines in scenario 2; it has shops around and bus and taxi stops which facilitated the data collection and good comparison .

3.2.2. Social conflict parameters

The social conflicts caused by railway alignment have been investigated using the following parameters.

1) Pedestrians waiting time to cross
2) Pedestrians travelled a distance to access the next crossing level
3) The walkway distance between the railway and road network
4) Safety and security at the crossing level
5) Waiting area before crossing level
6) Peak hours Effects

These indicators have been compared to similar parameters in road networks without railways to confirm social conflicts caused by the alignment of railways.

3.2.3. Economic conflicts parameters

The economic conflicts caused by the railway alignment have been investigated and confirmed using the following indicators for railway and road networks compared to similar indicators for roads separated from the railway.

1) Business owners crossing for services seeking
2) Vehicle supplying goods access to shops
3) Customers and business owners' vehicles access to shops
4) Railway alignment contribution to business around
5) Contribution of peak hours on economic conflict parameters

The research findings from the indicators were produced so that they would be open for further research improvement and for the problems' solutions; the following structure in **Figure 7** was adhered to to conceptualise and analyse**.**

3.3. Comparison between conflict parameters

The parameters for economic conflicts and social conflicts were compared for scenario 1 and scenario 2 to analyse and confirm that the railway alignment causes the conflicts; therefore, the users of the road and the railway were interviewed on the same parameters for comparison reasons.

3.4. Field Observation

Before developing an appropriate survey, one of the first steps was to identify the crossing difficulties that make the system not accessible on both sides, either for passengers, cars or business owners. This investigation aimed to get the aspect of the transportation system end users on the location of the railway and road network if it does allow them to cross easily, Customer interchangeability and the sociability between surrounding people. The observation shows that the problem is dangerous for the railway from the stadium to Kality and from the stadium to Ayat. The Questionnaires were distributed to stations on railway lines from North to South, East to West, starting with Stadium station. During this activity, the following documents were required:

- Camera

- Blank Questionnaires
- Notebook
- Pens/Pencils and Clipboard
- Station Map
- Badges and Authorisation letter

By observation, it has been shown that the railway stations are used as Zebra crossings for the two sides of the road network, which creates congestion and confusion at railway stations. Also, it can come with a high probability of accidents occurring on the road network caused by the crowd created by railway passengers and road network crossing pedestrians.

3.5. Simple size

As a result, the sample size for proportions was utilised to determine the sample size required to calculate a confidence interval for a proportion.

Table 2: Value of Za/2 to different confidence

Confidence	Za/2
90%	1.645
95%	1.960
99%	2.576
99.9%	3.291

Where n = sample size, p = sample proportion affected by LRT, q = sample proportion not affected by LRT, $Z_{a/2}$ = z value, = significance level, and E = margin of error or maximum error of the estimate, one can calculate the minimal sample size required for the interval estimate of a population proportion. To calculate the sample size, you must estimate the percentage of people impacted by LRT with a 99% confidence level and strive for accuracy within 10% of the actual percentage(28).

By application the sample size formular using p= 0.5, q= 0.5 and Za/2 = 2.576

$$n = \mathrm{p} * q * \left(\frac{Z\alpha/2}{E}\right)^2 = n = 0.5 * 0.5 \left(\frac{2.576}{0.1}\right)^2 = 166$$

The minimum sample calculated is 166, and as the sample size, there is a chance of getting the correct answer.

So, reference made to the above minimum sample size, Questionnaires were distributed at the railway stations; 300 transportation systems users were interviewed, where 221 were passengers who use the railway and road network daily, and 79 were business owners having shops near the research area.

For comparison, 300 questionnaires have been distributed to pedestrians using the stadium to Bole Road, where 79 business owners have shops near the road, and 221 pedestrians use the road.

3.6. Data collection

Most data available for this thesis were collected from primary data through questionnaires, interviews, traffic count and secondary sources through documents. Random sampling procedures were used to obtain the data, as mentioned earlier.

1. Questionnaires Distribution

Questionnaires have been prepared for pedestrians and business owners near the two transportation systems combined and the road network only to collect data. The intention is to investigate the pedestrians' perception of the distance they walk from one station to another, the waiting time to cross the transportation systems, the waiting area between the road and railway, the waiting time for a road crossing, business owners perception on the vehicles access to the shops, Customers access for service both sides of the transportation systems and good supplying vehicles access to the shops. (Appendix A & B: Questionnaire).

Figure 5: Questionnaire distributed to pedestrians at railway stations

Figure 6: Questionnaires distributed to road user pedestrians

Figure 5 shows the pedestrians filling out the questionnaires at the railway stations. Most of them were passengers waiting for the train. Figure 6 shows road users from the stadium to Bole filling out the questionnaires at the bus and taxi stop. The Thethe two conducted investigations helped me to come up with an actual image of the source of conflict caused by the railway alignment.

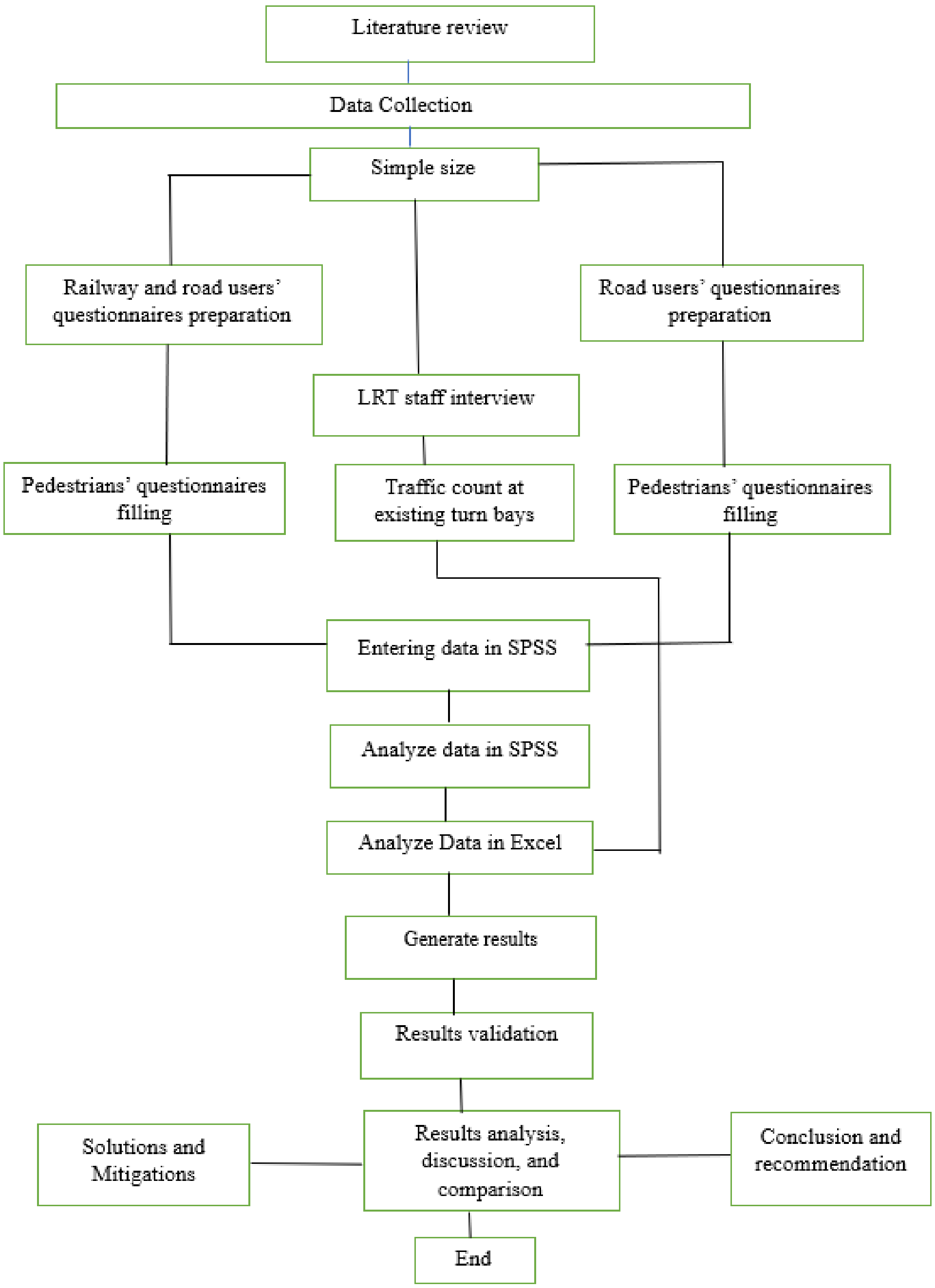

Figure 7: Flowchart of the research methods

Note: Data analysed in Excel are for traffic count (Daily traffic volume, Average daily traffic, daily adjustment factors, graphs of daily traffic volume per hour, all for traffic conflicts identification) and survey sample characteristics. SPSS has been used to analyse the facts of social and economic conflicts caused by railway alignment and variables correlation.

3.7.Traffic Counts

Traffic counts were conducted to gain an insight into the disturbance created by the long distance travelled by vehicles to reach the crossways from the stadium to Lancha station and the crossway between Guard Shola 1 and 2. This has been done by counting vehicle by vehicle crossing by considering one way of the road measured from 6:00 AM to 9:00 PM without considering the peak hours in 7 days using the manual counting method. This helped to estimate and confirm the challenge of a few crossways on the railway line. The congestion can be demonstrated by counting the vehicles delayed by missing the crossover. The entire traffic count form is attached to the appendices at the end of this research. Figure 8 shows traffic count activity at two turn bays.

Figure 8: Traffic count at turn bay

3.7.1. Average Daily Traffic (ADT)

The ADT, also known as mean daily traffic, is the typical number of cars that pass through a particular location on a road over a brief period (typically seven days or less). It is calculated by dividing the total daily volumes during a time range by the total number of days.

$$ADT = \frac{1}{n}\sum_{i=1}^{n} VOL_i$$

Where:

Vol_i = Daily volume in the day

n = the number of whole days

The most fundamental tool for tracking and predicting traffic is ADT. It offers a totalised measurement of traffic volume. It is used to determine the size or purpose of proposed roadways, especially those with low and moderate traffic levels, in conjunction with other traffic data elements.

3.7.2. Annual Average Daily Track Traffic (AADTT)

The year average of a road segment's daily truck traffic volume; in the FHWA's 13-category vehicle classification system, trucks are categorised as being in classes 4 through 13. AADTT is calculated similarly to AADT, with the exception that only truck volumes are taken into account. AADTT can be calculated using the basic average approach or the AASHTO method.

Table 3: Traffic volume formulas

Simple average method	$\text{AADTT} = \frac{1}{n}\sum_{k=1}^{n} (\text{ Truck VOL })_k$
AASHTO method	$\text{AADTT} = \frac{1}{12}\sum_{m=1}^{12} \left[\frac{1}{7}\sum_{j=1}^{7} \left(\frac{1}{n_{jm}}\sum_{i=1}^{n_{jm}} (\text{ Truck VOL })_{ijm}\right)\right]$

Where:

Truck Vol_k = Daily truck volume on the k^{th} day of the year

n = number of days in a year (365 to 366)

Truck VOL_{ijm} Daily truck volume for the first day of the week within the month.

i = Occurrences of day j in month m for which truck traffic data are available

j = day of week (1 to 7)

m = month of year (1 to 12)

n_{jm} = number of occurrences of day j in month m for which truck traffic data are available

For the design and analysis of pavements, freight, air quality, crash data, highway planning, and performance evaluation, AADTT offers essential information on truck movements. The percentage distribution of AADTT in the population of FHWA vehicles of classes 4 through 13 is known as the "vehicle class distribution" or "VCD." The distribution of AADTT is also discussed to truck hourly distribution factors(29).

3.8. Interview

Interviews were critical in gathering data related to the planning and implementation of the railway project. The interview questions were used to obtain information addressed to the AALRT staff as part of experts following the project from ideas to a preliminary survey, finding stage-up to its realisation. Here, the focus was to check if they had been involved in the project. 20 Staff were interviewed: 10 interviewers from the Department of Transportation, ten from the Department of Safety and Security aged above 30 years old, and seven of them had academic qualifications of Master's in railway engineering, where 13 have a Bachelor in Transportation engineering. They have been asked the following questions:

a. Their position during the LRT project construction

b. Their consultancy during the implementation of LRT

c. Their views on the location of the railway between two roadsides.

d. If they have been involved in the preliminary studies before the project starts.

e. Stakeholders have been involved in the project

3.9. Data Analysis

While investigating the conflicts between railway and road networks, the concepts involving the cross-level for pedestrians, vehicles and business owners around the transport system, the tools used to analyse the collected data are IBM SPSS for qualitative data analysis and Excel to analyse the quantitative data.

CHAPTER 4. RESULTS ANALYSIS AND DISCUSSIONS

4.1. Introduction

Analysis was based on collected data using the methodology outlined in **Chapter 3**. From the reviewed literature, it was noted that early efforts involved in designing transit lines based on the comfort of end users and considering the easy way of crossing the railway and road network (Scenario1) compared to the road users separately (Scenario 2), the business feasibility around the railway and road consider the alignment.

This phase assessed the effectiveness of the railway and road network compared to the road free from railways. Evaluation of pedestrians' perception, flow, space utilization, and crucial linkages among the chosen parameters were the process's main areas of attention. The analysis of the road and railway network accessibility was the main goal of the project, where respondents were found at the station platform after crossing the zebra crossing and another in their shops.

Pedestrians were classified as male, female and disabled people. From field observations, sample characteristics for the scenario are summarized in Figure 9 (a). From this figure, males occupied 45.7%, females occupied 53.3%, and most respondents had ages ranging between 26 to 35 years old, with 182 representing 60.7% of the total sample of 300 respondents. People with disabilities during the survey 12 among the sample size present 4% where eight passengers with temporary disability equal 2.7 % and four passengers equal 1.3%**.** In scenario 2, females were 60%, males 40%, 70% with an age range of 15 to 25 years, and 10% people with disabilities. The summary is in Figure 9(b).

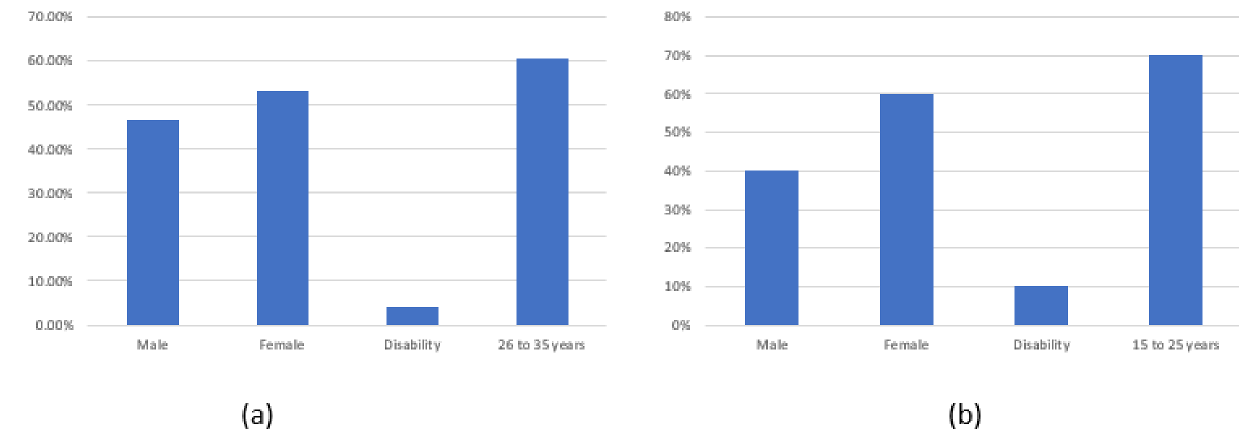

Figure 9: Sample characteristics for both scenarios

4.2. Scenario 1: Railway combined with road network

The questionnaires were distributed to the pedestrians using railway and road networks combined. The following results have been generated from different social and economic parameters.

4.2.1. Pedestrians' Perceptions of Crossing

On this parameter, respondents answered that they cross the systems at a percentage of 98% of the total sample size. Most of the pedestrians, about 83%, cross the railway combined with the road network 4 to 10 times per day; this shows that 15% of them cross less than four times per day due to fear. Table 4 shows details. While 100% of pedestrians for scenario 2 cross the road more than ten times per day, the results show that the crossing for scenario 1 is less compared to scenario 2, so there is a crossing conflict caused by the railway alignment; more details are in Table 4.

Table 4:Transportation systems Crossing times per day (scenario 1)

Times per day	Frequency	Per cent
2	48	16.0
4 to 6	77	25.7
8 to 10	172	57.3
Above 10	3	1.0
Total	300	100.0

4.2.2. Distance from one crossing to another

The distance pedestrians travel from crossing to crossing: 25.7% walk from 300 to 350 m, and 62.3 % walk more than 350 m from one crossing to another. A considerable percentage of the pedestrians travel a long distance to access the next crossing; more details are in Table 5.

Table 5: Distance from one crossing to another (scenario 1).

Traveled distance range	Frequency	Percentage
10 m	13	4.3
10 to 50 m	3	1.0
60 to 100 m	7	2.3
100 t0 150 m	7	2.3
200 to 250 m	6	2.0
300 to 350 m	77	25.7
Above 350 m	187	62.3
Total	300	100.0

4.2.3. Waiting time to cross

The time used by pedestrians to wait before crossing the railway combined with the road network results show that 82.6% of the pedestrians stay from 2 to 5 minutes to cross the systems; the waiting time is too much where the remaining 17.4% wait more than 5 minutes to cross the system, table 6 gives details.

Table 6: Waiting time before crossing (scenario 1)

Waiting time		Frequency	Percentage
Valid	20 Sec	0	0
	30 to 40 sec	0	0
	1 min	0	0
	2 to 5 min	247	82.3
	5 to 10 min	15	5
	10 to 15 min	9	3
	Above	5	1.7
	Total	276	92.0
Missing		24	8
G. Total		300	100.0

4.2.4. Effect of Peak hours on pedestrians

Pedestrians at different railway stations have shown difficulties crossing the transportation system; 43.1% of pedestrians fear crossing at 6 to 9 AM, and 41.5% fear crossing the system from 12 to 2 PM. This is because the congestion and trains are much on the railroad and nearby road network due to peak hours congestion. Table 7 shows details.

Table 7:Effects of peak time to cross (scenario 1)

Peak hours		Frequency	Percentage
Valid	6 to 9 AM	129	43.0
	12 to 2 PM	124	41.3
	4 to 8 PM	42	14.0
	Other	4	1.3
	Total	299	99.7
Missing		1	.3
G. Total		300	100.0

4.2.5. Walkway area at crossing

The access to LRT and road network combined with the help of walkways, after the construction of the two systems, there is no sidewalks distance separating one system to another, contributing to the inaccessibility. 82.3% of the pedestrians responded that the waiting area at the crossing level could be better. This means that before accessing the railway system, there is no walkway where the pedestrians stand waiting for the departure of the trains. Figure 10 shows the situation.

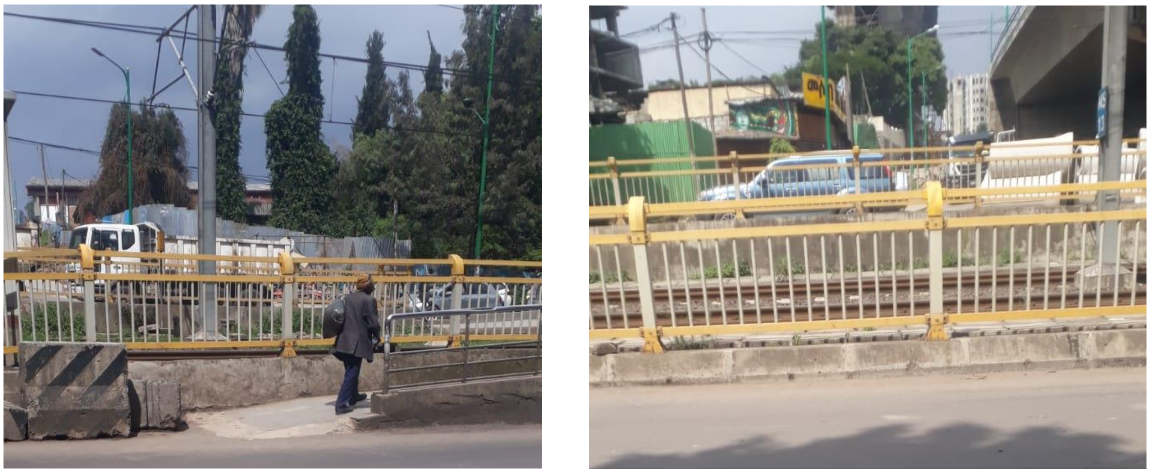

Figure 10: Lack of sidewalks between systems

4.2.6. Safety at crossing level

Safety is a core issue in railway operation, and in terms of rail transport safety, crossing has created severe conflicts between rail and road transport. The transportation system has the most complicated safety concern due to the lack of security indicators and an operational signalling system at the crossing level; 83.3% (poor, very poor response) of the pedestrians confirmed that the safety indicators at the crossing level for security reasons are not satisfactory on the railway and road network combined users details are in Table 8.

Table 8: Signaling at crossing (scenario 1)

Safety level		Frequency	Percentage
Valid	Very Poor	173	57.7
	Poor	86	28.7
	Neutral	27	9.0
	Good	13	4.3
	Very Good	1	.3
	Total	300	100.0

4.2.7. Correlation of distance on social conflicts

Considering the impact of the distance between two crossing levels for pedestrians as an independent variable on the waiting area before crossing, security at the crossing level, waiting time before crossing and the impact of the peak hours as dependent variables, by analysis, the variable correlation is 62.1% with a significance value greater than 0.05 which means that the distance between two crossings affects all other social activities around railway combined with road network Table 9 shows details.

Table 9: Correlation between distance and social conflicts (scenario 1)

Model	R	R Square
1	.788[a]	.621

4.2.8. Supply of Goods to shops

Vehicles supplying goods to shop accessibility: 84.9% of the business owners confirmed that the crossing is poor in facilitating vehicles providing their goods to shops of the business owners around railway and road combined, so they use a lot of fuel to reach the shops. Table 10 shows details.

Table 10: Business owners' vehicles supplying crossing (scenario 1)

Indicators		Frequency for scenario 1	Percentage for scenario 1
Valid	Very Poor	54	68.4
	Poor	13	16.4
	Neutral	10	12.7
	Good	2	2.5
	Total	79	100.0
Missing		221	0
Total		300	100.0

4.2.9. railway's alignment contribution to business

Of the business owners with shops around the railway and road combined, 86.1% of the business owners near the road with railway alignment confirmed that the railway alignment doesn't contribute to their businesses. Still, it affects their business in negative ways. Table 11 shows details.

Table 11:System location facilitates business (scenario 1)

Indicators		Frequency	Percentage
Valid	Very Poor	53	68.09
	Poor	15	18.99
	Neutral	10	12.6
	Good	1	1.3
	Total	79	
Missing		221	0
Total		300	100.0

4.2.10. Traffic based conflicts

Except for the long distance travelled by business owners supplying vehicles and their customers' vehicles with other kinds of vehicles of different utilities that are taking a long distance to get to the crossing level, which can be the source of congestion in the road network, the study conducted showed that from the crossing level near to the Stadium station to the next crossing which is Lancha is 2.2 Km and from Magenagna to the nearest crossing between Guard shola 1 and 2 there is 2.3 Km due to the mentioned distances vehicles are many at the turn bays mainly at the turn bay between Guard Shola 1 and 2. The research conducted traffic count focusing on the turning vehicles only for one side of the road.

4.2.10.1. Traffic data at Lancha

During the data collection at this crossing level, I conducted a manual traffic count for 13 hours per day for seven successive days a week. The following data have been found by considering only one side of the road network; the details are in Table 12.

Table 12:Traffic count at Lancha crossing level

Day	Motorized Vehicles	Non-Motorized Vehicles	Total/Day
1	2729	14	2743
2	2907	8	2915
3	2989	17	3006
4	3020	9	3029
5	3103	15	3118
6	2967	7	2974
7	2897	10	2907
Total			**20,692**

From the above data, I calculated the Average Daily Traffic (ADT)

$$ADT = \frac{1}{n}\sum_{i=1}^{n} VOL_i = \frac{1}{7} 20{,}692 = 2{,}956$$

By validating the obtained data, I calculated the daily adjustment factor (DF) by dividing the daily traffic volume by ADT. More details are in Table 32.

Table 13: Values of daily adjustment factors at Lancha

Day	Motorized Vehicles	Non-Motorized Vehicles	Total/Day	DF
1	2729	14	2743	0.927943
2	2907	8	2915	0.98613
3	2989	17	3006	1.016915
4	3020	9	3029	1.024696
5	3103	15	3118	1.054804
6	2967	7	2974	1.006089
7	2897	10	2907	0.983424
TOTAL			**20,692**	
ADT			**2,956**	

DF controls the fluctuation between the daily data volume and the Average daily traffic. When DF is more significant than one, it confirms that the ADT is less than the daily traffic volume, and if it is less than one, it is proof that ADT is greater than the daily traffic volume. Refers to Table 25, it is visible that there are four successive days with DF greater than 1. This means there was a daily traffic volume from day 3 to day 6. The peak day at the Lancha Crossing level is Friday. Figures

11 and 12 show the traffic volume increment where the highest traffic was from 12 AM to 2 PM, with a traffic volume of 315 to 325 vehicles per peak hour.

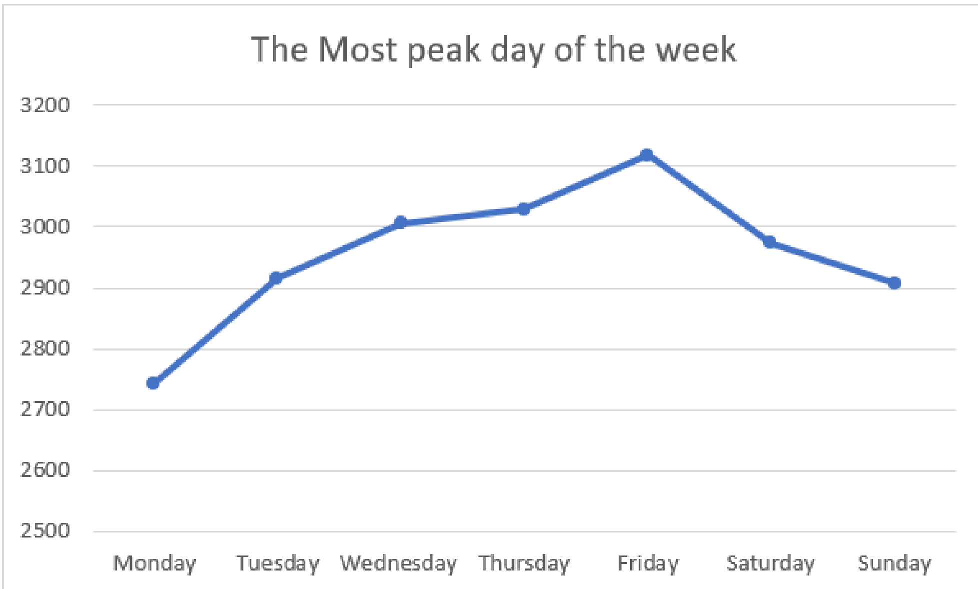

Figure 11: Peak day of the week

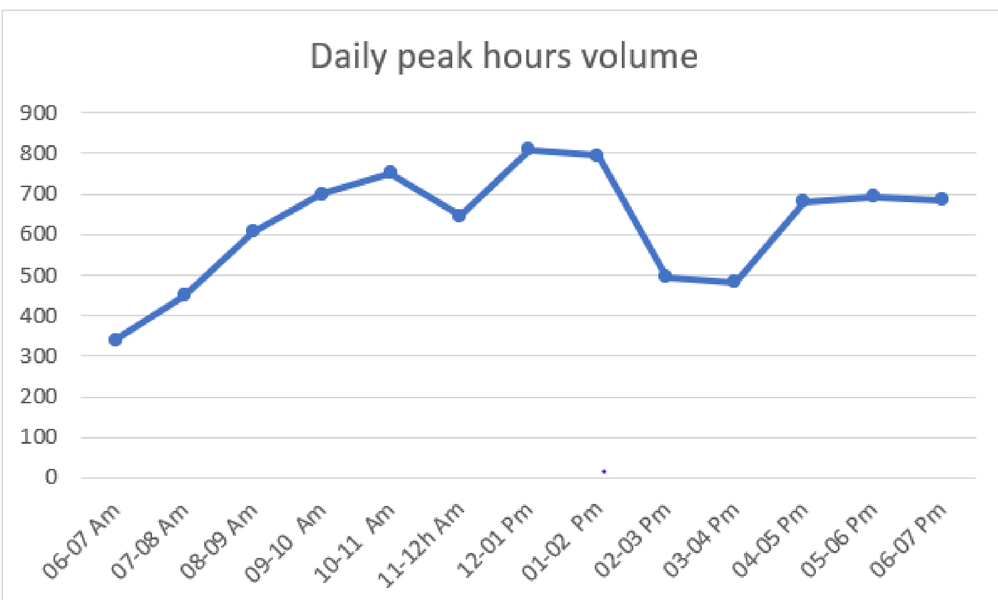

Figure 12: The most peak day traffic volume

4.2.10.2. Traffic Data at Guard Shola 1 and 2

During the data collection at this crossing level, I have collected using a manual traffic count method duration of 13 hours per day for seven successive days of a week. The following data have been found by considering only one side of the road network; the details are in Table 14.

Table 14:Traffic data at Guard Shola crossing level

Day	Motorized Vehicles	Non-Motorized Vehicles	Total/Day
1	6221	89	6310
2	7078	107	7185
3	7689	95	7784
4	7345	114	7459
5	8019	125	8134
6	7106	78	7184
7	6923	58	6981
Grand Total			**51,037**

From the above table with collected data, I calculated the Average Daily Traffic (ADT)

$$ADT = \frac{1}{n}\sum_{i=1}^{n} VOL_i = \frac{1}{7} 51{,}037 = 7{,}291$$

By conducting the validation (Fluctuation) of the obtained data, I calculated the daily adjustment factor (DF) by dividing the daily traffic volume by ADT. More details are in Table 15.

Table 15:Values of daily adjustment factors at Guard shola 1 and 2

Day	Motorized Vehicles	Non-Motorized Vehicles	Total/Day	DF
1	6221	89	6310	0.865451
2	7078	107	7185	0.985462
3	7689	95	7784	1.067618
4	7345	114	7459	1.023042
5	8019	125	8134	1.115622
6	7106	78	7184	0.985324
7	6923	58	6981	0.957482
Total			**51,037**	
ADT			**7,291**	

DF controls the fluctuation between the daily data volume and the Average daily traffic. When DF is more significant than one, it confirms that the ADT is less than the daily traffic volume, and if it is less than one, it is proof that ADT is greater than the daily traffic volume. Refers to Table 27, it is visible that there are three successive days with DF greater than 1. This means there was daily traffic volume from day 3 to day 5. The peak day at Guard Shola crossing level is Friday, as shown in Figures 13 and 14, which show the traffic volume increment where the highest traffic was from 12 AM to 2 PM with a traffic volume of 810 to 795 vehicles per peak hour.

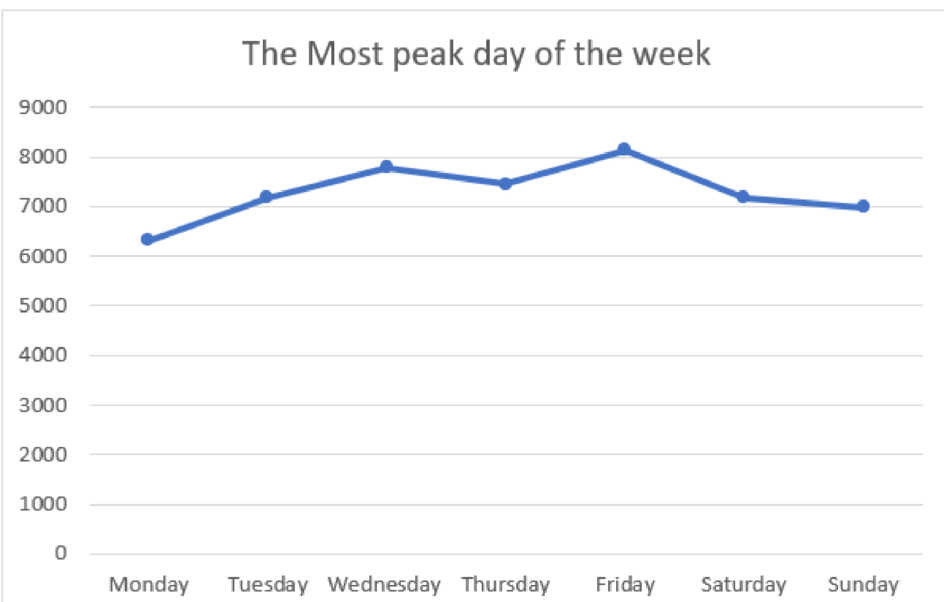

Figure 13: The peak day

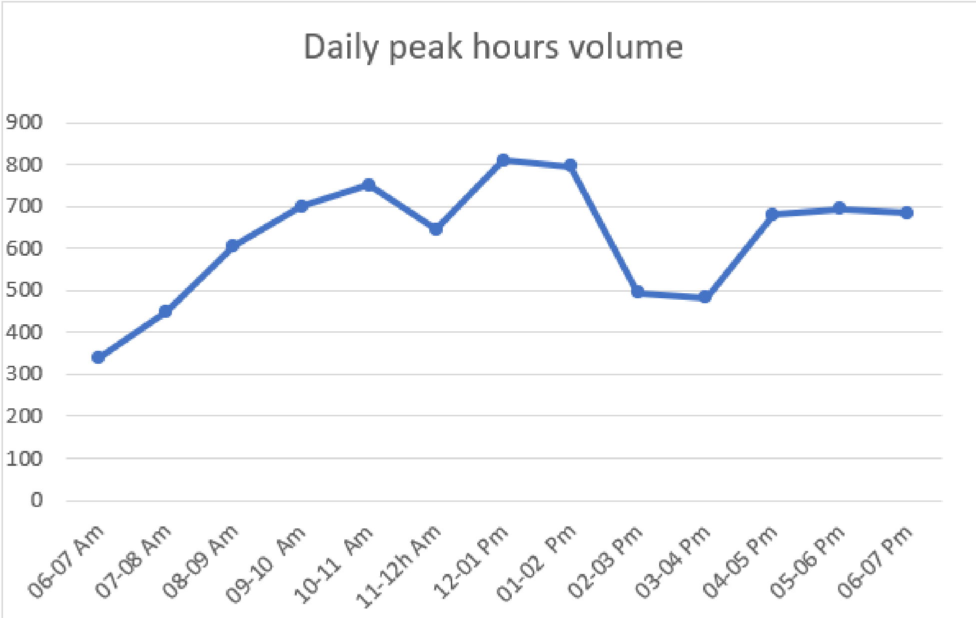

Figure 14:The most Daily traffic volume at Guard Shola

Conclusion: Considering the data obtained from the vehicle crossing levels on both lines, it has been shown that the average daily traffic is more significant at the Guard Shola crossing level than at Lancha, but at all levels, it has shown that there are some days where traffic was increasing except the considerable number of vehicles one side. This is proof of missing more crossing levels at the transportation lines, so the conflicts are caused by traffic congestion; more information on vehicle classification and the details are available in the appendices.

4.2.12. Correlation of system alignment on economic conflicts

In the analysis of the impact of alignment of the transportation systems as independent variable access on both sides of the transportation systems, customer's vehicles crossing the systems to access the shop, service availability on both sides, business owners and their customers' vehicles access to turn bay and customers increase time. The results show that the significance value is more significant than 0.05, with a correlation of 81.5%, detailed on railway and road combined. Table 16 gives the details.

Table 16: Correlation value on a railway alignment (scenario 1)

Model	R	R Square
1	.846[a]	.815

4.3. Scenario 2: The road free from the LRT

The questionnaires were distributed to the pedestrians using road networks free from LRT. The following results have been generated from social and economic conflict parameters.

4.3.1. Pedestrians' Perceptions of Crossing Road

On this parameter, the feedback collected shows that 100% of pedestrians cross the road more than 10 times per day for different purposes, and the results show that the pedestrians using the road portion are crossing without fear. Road users respect the free movement of pedestrians; details are in Table 17.

Table 17:Transportation systems Crossing times per day (scenario 2)

Times per day	Frequency	Percentage
2	0	0
4 to 6	0	0
8 to 10	153	51.0
Above 10	147	49.0
Total	300	100.0

4.3.2. Distance from one crossing to another

The results show that 60% of the pedestrians walk from 10 to 50 m, and 80% walk from 60 to 100 m to access the next crossing. This shows free access of the road users from one crossing to another by travelling short distances. Table 18 gives details on the percentage and frequency.

Table 18: Distance from one crossing to another (scenario 2)

Traveled distance range	Frequency	Percentage
10 m	0	0
10 to 50 m	60	20
60 to 100 m	240	80
100 t0 150 m	0	0
200 to 250 m	0	0
300 to 350 m	0	0
Above 350 m	0	0
Total	300	100.0

4.3.3. Waiting time to cross

The waiting time for pedestrians using the road free from the railway results show that 30% of them wait for 20 seconds, and 70 % wait from 30 to 40 seconds before crossing the road; the time looks reasonable for pedestrians. Table 19 highlights the waiting range and the percentage of respondents.

Table 19:Waiting time before crossing (scenario 2)

Waiting time		Frequency	Percentage
Valid	20 Sec 30 to 40 sec 1 min	100 200 **0**	30.0 70 0
	2 to 5 min	**0**	0
	5 to 10 min	**0**	0
	10 to 15 min	**0**	0
	Above	**0**	100.0
	Total	300	
Missing			
G. Total			

4.3.4. Effect of Peak hours on pedestrians

Pedestrians at different railway stations have shown difficulties in crossing the road; 35% of the pedestrians were challenged to cross from 6 to 9 AM, 36% of them were challenged to cross from 12 to 2 PM and 29% were challenged to cross from 4 to 8 PM, the results generated above show the freedom to cross during peak hours table 20 shows the details on peak hour, frequency and percentage.

Table 20: Effects of peak time to cross (scenario 2)

Peak hours		Frequency	Percentage
Valid	6 to 9 AM	105	35.0
	12 to 2 PM	108	36.0
	4 to 8 PM	87	29
	other	0	
	Total		
Missing			
G. Total		300	100.0

4.3.5. Walkway area at crossing

The access to the road network free from LRT is helped by the walkway and the construction of the road systems, and there is a sidewalk distance separating one side to another, contributing to accessibility. 100% of the pedestrians responded that the road users use enough walkway area to wait before crossing. Figure 15 illustrates the situation.

Figure 15: Walkway between two road lanes

4.3.6. Safety at the crossing level

Safety is a core issue in road operation, and in terms of transport safety, crossing has created severe challenges for road transport. The transportation system has the most complicated safety concerns due to the lack of security indicators and an operational signalling system at the crossing level. Therefore, 90% of pedestrians using the road uncombined with the railway justified that at the crossing ways, security is ensured; compare the two situations, security is high on the road uncombined with the railway; Table 21 shows details.

Table 21: Signaling at crossing (scenario 2)

Safety level		Frequency	Percentage
Valid	Very Poor	0	0
	Poor	0	0
	Neutral	0	0
	Good	30	10
	Very Good	270	90.0
	Total	300	100.0

4.3.7. Correlation of distance on social conflicts

Considering the impact of the distance between two crossing levels for pedestrians as an independent variable on the waiting area before crossing, security at the crossing level, waiting time to cross and the impact of the peak hours as dependent variables, by analysis, the variables correlation is 10.7% means that distance between two crossings have no effects on social conflicts so the road users are not affected by the distance between crossing table 22 gives details on the values of R and R square.

Table 22: Correlation between distance and social conflicts (scenario 2)

Model	R	R Square
1	.327[a]	.107

4.3.8. Supply of Goods to shops

Vehicles supplying goods to shop accessibility: 70.9% of the business owners around the road confirmed that it is easy for vehicles to cross the road to access their shop. Table 23 shows details on the business owner's perception of the ways the road is aligned to facilitate vehicles supplying to reach the shops.

Table 23: Business owners' vehicles supplying crossing (scenario 2)

Indicators		Frequency	Percentage
Valid	Very Poor	0	0
	Poor	0	0
	Neutral	23	29.1
	Good	56	70.9
	Total	79	100.0
Missing		221	
Total		300.0	100.0

4.3.9. road's alignment contribution to business

The business owners with shops around the road from LRT feedback, 70.9% of the business owners near the road uncombined with the railway appreciate the alignment of the road, and it's a positive contribution to their business. The fact that some business owners are profiting from the alignment of the road near their business Table 24 shows the details of the business owners' perception of road alignment.

Table 24: System location contribution on business (scenario 2)

Indicators		Frequency	Percentage
Valid	Very Poor	0	0
	Poor	0	0
	Neutral	23	29.1
	Good	56	70.9
	Total	79	100
Missing		221	0
Total		300	100.0

4.3.10. Correlation of system alignment on economic conflicts

In the analysis of the impact of alignment of the transportation systems as independent variable access on both sides of the transportation systems, customer's vehicles crossing the systems to access the shop, service availability on both sides, business owners and their customers' vehicles access to turn bay and customers increase time. The results show that the 34% correlation of the road alignment does not affect the business around it. Table 25 gives details on roads free from LRT.

Table 25: Correlation value on road alignment (scenario 2)

Model	R	R Square
1	.436	.340

4.4. Comparison of two scenarios

The parameters for economic and social conflicts were compared for scenario 1 and scenario 2 to confirm that the railway alignment causes the conflicts.

4.4.1. Pedestrians' perceptions of Crossing railway and road

For scenario 1, 83% of the pedestrians cross the railway combined with the road network 4 to 10 times per day, where 15% of them cross less than four times per day due to fear, while 100% of pedestrians for scenario 2 cross the road above ten times per day because they do not fear, by comparison the results show that the crossing for scenario 1 is less compare to scenario 2, so there is a crossing conflict caused by the railway alignment, more details are on table 26.

Table 26: Transportation systems Crossing times per day (scenario 1&2)

Times per day	Frequency for scenario 1	Percentage for (scenario 1)	Frequency for scenario 2	Percentage for (scenario 2)
2	48	16.0	0	0
4 to 6	77	25.7	0	0
8 to 10	172	57.3	153	51.0
Above 10	3	1.0	147	49.0
Total	300	100.0	300	100.0

4.4.2. Distance from one crossing to another

For scenario 1, 25.7% of the pedestrians walk from 300 to 350 m, and 62.3 % of them walk more than 350 m from one crossing to another, while for scenario 2, 60% of the pedestrians walk from 10 to 50 m, and 80% of the pedestrians walk from 60 to 100 m to access the next crossing, by comparison, the results from the two scenarios show that the scenario1 users travel a long distance to reach the crossing than scenario2 users these confirms social conflicts caused by LRT alignment based on the distance between crossing to crossing details are given in table 27.

Table 27: Distance from one crossing to another (scenario 1&2).

Traveled distance range	Frequency for scenario 1	Percentage for scenario 1	Frequency for scenario 2	Percentage for scenario 2
10 m	13	4.3	0	0
10 to 50 m	3	1.0	60	20
60 to 100 m	7	2.3	240	80
100 t0 150 m	7	2.3	0	0
200 to 250 m	6	2.0	0	0
300 to 350 m	77	25.7	0	0
Above 350 m	187	62.3	0	0
Total	300	100.0	300	100.0

4.4.3. Waiting time to cross

For scenario 1, the time used by pedestrians to wait before crossing the railway combined with the road network, the results show that 82.6% of the pedestrians stay from 2 to 5 minutes to cross the systems; the waiting time is too much, where the remaining 17.4% wait more than 5 minutes to cross the system, for scenario two pedestrians using road uncombined with railway 30% showed they wait for 20 seconds and 70 % of them wait from 30 to 40 seconds by these results show that there is a social conflict based on the waiting time caused by the alignment of LRT table 28 shows comparison on both scenarios.

Table 28: Waiting time before crossing (scenario 1&2)

Waiting time		Frequency for scenario 1	Percentage for scenario 1	Frequency for scenario 2	Percentage for scenario 2
Valid	20 Sec	0	0	100	30.0
	30 to 40 sec	0	0	200	70
	1 min	0	0	**0**	0
	2 to 5 min	247	82.3	**0**	0
	5 to 10 min	15	5	**0**	0
	10 to 15 min	9	3	**0**	0
	Above	5	1.7	**0**	100.0
	Total	276	92.0	300	
Missing		24	8		
G. Total		300	100.0		

4.4.4. Effect of Peak hours on pedestrians

For scenario 1, 43.1% of the pedestrians feared crossing at 6 to 9 AM, and 41.5% feared crossing the system from 12 to 2 PM. This was because of the congestion, whereas for scenario 2, 35 % of the pedestrians got challenged to cross from 6 to 9 AM, 36% of them got challenged to cross from

12 to 2 PM and 29% got challenged to cross from 4 to 8 PM, the results generated above show the freedom to cross during peak hours for scenario 2 is higher than for scenario 1. This confirms the social conflict based on peak hours caused by railway alignment after comparison. Details are in Table 29.

Table 29: Effects of peak time to cross (scenario 1&2)

Peak hours		Frequency for scenario 1	Percentage for scenario 1	Frequency for scenario 2	Percentage for scenario 2
Valid	6 to 9 AM	129	43.0	105	35.0
	12 to 2 PM	124	41.3	108	36.0
	4 to 8 PM	42	14.0	87	29
	other	4	1.3	0	
	Total	299	99.7		
Missing		1	0.3		
G. Total		300	100.0	300	100.0

4.4.5. Walkway area at crossing

For scenario 1, 82.3% of the pedestrians responded that the waiting area at the crossing level could be better. This means that the railway system is not accessible, and there is no walkway where the pedestrians stand waiting for the trains to pass. In scenario 2, 100% of the pedestrians responded that the road users use enough walkway area to wait before crossing; this justifies the social conflict based on the walkway distance between the railway and road network. Figure 10 shows the situation.

4.4.6. Safety at the crossing level

For scenario 1, 83.3% of the pedestrians confirmed that the safety indicators at the crossing level for security reasons are poor on the railway and road network combined. For scenario 2, 90% of pedestrians use the road free from LRT. This justifies that at the crossways, security is ensured; comparing the two scenarios, security is higher at the road uncombined with the railway than at the railway combined with the road network, meaning the conflict is based on safety caused by LRT alignment. Table 30 shows details of the two scenarios comparison.

Table 30: Signaling at the crossing (scenario 1&2)

Safety level		Frequency for scenario 1	Percentage for scenario 1	Frequency for scenario 2	Percentage for scenario 2
Valid	Very Poor	173	57.7	0	0
	Poor	86	28.7	0	0
	Neutral	27	9.0	0	0
	Good	13	4.3	30	10
	Very Good	1	.3	270	90.0
	Total	300	100.0	300	100.0

4.4.7. Correlation of distance on social conflicts

Considering the impact of the distance between two crossing levels for pedestrians as an independent variable on the waiting area before crossing, security at the crossing level, waiting time before crossing, and the impact of the peak hours as dependent variables, by analysis, the variable correlation is 62.1% means that the distance between two crossing affects negatively for all other social activities around railway combined with road network. In scenario 2, a correlation of 10.7% means that the distance between two crossings affects social conflicts. By comparison, 62.1% is more significant than 10.7%, so the road users are not affected by the distance between crossing as the railway and road network combined users. After that, the alignment of the railway causes social conflicts. More details are in Table 31.

Table 31: Correlation between distance and social conflicts (scenarios 1&2)

Model	R for scenario 1	R Square for scenario 1	R for scenario 2	R Square for scenario 2
1	.788[a]	.621	.327[a]	.107

4.4.8. Supply of Goods to shops

In scenario 1, 84.9% of the business owners confirmed that the crossing is poor in facilitating vehicles supplying goods to shops of the business owners around railway and road combined, so they use a lot of fuel to reach the shops, compared to scenario 2 where 70.9% of the business owners around the road confirmed that it is easy for vehicles supplying goods to cross the road to access their shops this ensures the economic conflict between railway and road network caused by LRT alignment due to the long distance travelled by vehicles supplying good to reach shop table 32 shows details.

Table 32: Business owners' vehicles supplying crossing (scenario 1&2)

Indicators		Frequency for scenario 1	Percentage for scenario 1	Frequency for scenario 2	Percentage for scenario 2
Valid	Very Poor	54	68.4	0	0
	Poor	13	16.4	0	0
	Neutral	10	12.7	23	29.1
	Good	2	2.5	56	70.9
	Total	79	100.0	79	100.0
Missing		221	0	221	
Total		300	100.0	300.0	100.0

4.4.9. railway's alignment contribution to business

In scenario 1, 86.1% of the business owners near the road with a railway alignment confirmed that it doesn't contribute to their businesses. Still, it affects their businesses. For scenario 2, 70.9% of the business owners near the road uncombined with the railway appreciate the alignment of the road. It's a positive contribution to their business, the fact that some business owners are profiting from the alignment of the road near their business. Others are affected by the alignment of the railway between two roads, which justifies the economic conflict. Table 33 shows the details.

Table 33: System location contribution on business (1&2)

Indicators		Frequency for scenario 1	Percentage for scenario 1	Frequency for scenario 2	Percentage for scenario 2
Valid	Very Poor	53	68.09	0	0
	Poor	15	18.99	0	0
	Neutral	10	12.6	23	29.1
	Good	1	1.3	56	70.9
	Total	79		79	100
Missing		221	0	221	0
Total		300	100.0	300	100.0

4.4.10. Correlation of system alignment on economic conflicts

In the analysis of the impact of alignment of the transportation systems as independent variable access on both sides of the transportation systems, customer's vehicles crossing the systems to access the shop, service availability on both sides, business owners and their customers' vehicles access to turn bay and customers increase time. A correlation of 81.5% detailed on railway and road combined, so the railway alignment affects all other variables. Compared to the 34% correlation of the road alignment effects on business around, there is no adverse effect on the business around the road. Table 34 gives the details.

Table 34: Correlation value on a railway and road alignment

Model	R for scenario 1	R Square for scenario 1	R for scenario 2	R Square for scenario 2
1	.846[a]	.815	.436	.340

4.5. Project Consultancy

Before starting any project, it is mandatory to do the preliminary survey as one of the project phases. AALRT has been designed and constructed by a Chinese company. Most of the phases have been done by themselves on a contract of build, operation and transfer (BOT); my research has been conducted by considering the ERC staff and asking them about their contribution to the planning of the AALRT project; the twenty staff interviewed, most confirmed that they have not been consulted at any phase and they do not appreciate the railway location the table 35 is giving the summary of their feedback.

Table 35: Interview Feedback from Staff

ID	Age	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5	Answer 6
1	35	Yes, but not involved	Not consulted before	Yes, they were existing	No, the location is not appreciated	Not included all end-users	No, stakeholders have not been consulted
2	40	Yes, but not involved	Not consulted before	Yes, they were existing	No, the location is not appreciated	Not included all end-users	No, stakeholders have been consulted
3	32	Yes, but not involved	Not consulted before	Yes, they were existing	No, the location is not appreciated	Not included all end-users	No, stakeholders have not been consulted
4	42	Yes, and involved	Not consulted before	Yes, they were existing	No, I do not appreciate the location	Not included all end-users	No stakeholder has been consulted
5	31	Yes, but not involved	Not consulted before	Yes, they were existing	No, the location is not appreciated	Not included all end-users	No, stakeholders have not been consulted
6	32	Yes, but not involved	Not consulted before	Yes, they were existing	No, the location is not appreciated	Not included all end-users	No, stakeholders have not been consulted

7	40	Yes, and involved	Not consulted before	Yes, they were existing	No, I do not appreciate the location	Not included all end-users	No, stakeholders have not been consulted
8	31	Yes, but not involved	Not consulted before	Yes, they were existing	No, the location is not appreciated	Not included all end-users	No, stakeholders have not been consulted
9	33	Yes, but not involved	Not consulted before	Yes, they were existing	No, the location is not appreciated	Not included all end-users	No, stakeholders have not been consulted
10	39	Yes, and involved	Not consulted before	Yes, they were existing	No, I do not appreciate the location	Not included all end-users	No, stakeholders have not been consulted
11	33	Yes, but not involved	Not consulted before	Yes, they were existing	No, the location is not appreciated	Not included all end-users	No, stakeholders have not been consulted
12	41	Yes, and involved	Not consulted before	Yes, they were existing	No, I do not appreciate the location	Not included all end-users	No, stakeholders have not been consulted
13	32	Yes, but not involved	Not consulted before	Yes, they were existing	No, the location is not appreciated	Not included all end-users	No, stakeholders have not been consulted

14	33	Yes, but not involved	Not consulted before	Yes, they were existing	No, the location is not appreciated	Not included all end-users	No, stakeholders have not been consulted
15	40	Yes, and involved	Not consulted before	Yes, they were existing	No, I do not appreciate the location	Not included all end-users	No, stakeholders have not been consulted
16	32	Yes, but not involved	Not consulted before	Yes, they were existing	No, the location is not appreciated	Not included all end-users	No, stakeholders have not been consulted
17	30	Yes, but not involved	Not consulted before	Yes, they were existing	No, the location is not appreciated	Not included all end-users	No, stakeholders have not been consulted
18	39	Yes, and involved	Not consulted before	Yes, they were existing	No, I do not appreciate the location	Not included all end-users	No, stakeholders have not been consulted
19	31	Yes, but not involved	Not consulted before	Yes, they were existing	No, the location is not appreciated	Not included all end-users	No, stakeholders have not been consulted
20	34	Yes, but not involved	Not consulted before	Yes, they were existing	No, the location is not appreciated	Not included all end-users	No, stakeholders have not been consulted

Table 35 above presents the feedback from the ERC/LRT staff; 7 staff said that they had been there during the construction works of AALRT, but they did not appreciate the location of the railway, and they had yet to be consulted before the project. There are no citizens or end-users consulted in the planning phase. Unfortunately, they confirmed that the road network was there before the railway project implementation, and 13 other staff have yet to be involved. Still, they need to appreciate the location of the railway, and they confirmed that the project did not include the end-users; no special investigations have been done to approve the source of conflict between the railway and road network. Conducted research on planning a railway project with those findings; the need for a project can be determined in various ways, including ideas from staff members in charge of operations and maintenance, engineers, planners, local elected officials, developers, and the general public. The assessment should lead to documentation that includes factual evidence of the present and future situations and the justification for the project's pursuit. Numerous studies discuss potential solutions, such as location, technology, funding sources, contracting approach, etc. These discoveries will prevent irrational spending on preliminary engineering and associated costs. They usually take the shape of feasibility/route studies or significant investment studies and will also confirm the viability of moving forward with the chosen option(30).

4.6. Results Interpretation and Validation

The results from the two scenarios have been analyzed and agreed with the existing literature, leading to conclusions about each conflict parameter.

4.6.1. Pedestrians' perceptions of Crossing railway and road

For scenario 1, 83% of pedestrians cross the roads and railways between four and ten times daily, while 15% do so less frequently out of fear. In contrast, all pedestrians in scenario 2 cross the road more than ten times daily because they are fearless. Consequently, the railway alignment brings a crossing conflict because pedestrians feel more comfortable crossing the road when combined with the railway than when it is free of LRT.

4.6.2. Distance from one crossing to another

For scenario 1, 25.7% of pedestrians walk between 300 and 350 m, and 62.3% walk more than 350 m from one crossing to another. In scenario 2, 60% of pedestrians walk from 10 to 50 meters, and 80% walk from 60 to 100 meters to reach the next crossing. Pedestrians travel more than 350 meters to the next crossing for the railway combined with the road. In contrast, for the road free of the LRT, pedestrians cross only 100 meters, indicating that the LRT alignment creates a conflict.

However, a minimum distance of 20 meters is recommended for a signalled crossing, and for a zebra crossing, a minimum length of 5 meters is required in all cases (31). According to the studies, between 160 and 200 meters should be between pedestrian crossings. In areas where pedestrian traffic is more important, adherence to LOS B could be required. Then, there should be 120 to 160 meters between each pedestrian crossing (22).

4.6.3. Waiting time to cross

The results show that 82.6% of the pedestrians wait from 2 to 5 minutes to cross the railway and road combined system, 17.4% wait more than 5 minutes to cross the system, for scenario 2, pedestrians using road uncombined with the railway, 30% showed they wait for 20 seconds and 70 % of them wait from 30 to 40 seconds. The waiting time to cross two systems is from 2 to 5 minutes. According to the literature, this time is too long. Researchers' results indicate that pedestrians at the crossings wanted to wait at most 20 seconds. As a result, signal phasing should be planned so that pedestrians do not have to wait for longer than 20 to 30 seconds(31).

4.6.4. Effect of Peak hours on pedestrians

Because of the congestion, 43.1% of pedestrians fear crossing the system between 6 and 9 AM, and 41.5% fear crossing between 12 and 2 PM. In Scenario 2, 35% of pedestrians were challenged to cross between 6 and 9 AM, 36% between 12 and 2 PM, and 29% between 4 and 8 PM. Pedestrians crossing the railway and road networks during peak hours are influenced by peak hours.

4.6.5. Walkway area at crossing

82.3% of the pedestrians using railway and road combined responded that the waiting area at the crossing level could be better. This means that the railway system is not accessible and there is no walkway; 100% of the pedestrians responded that the road users use enough walkway area to wait before crossing. The walkway is required to facilitate pedestrians to stand in a safe zone before crossing the transportation system for railway and road combined. There are no walkways. Research on sidewalk distance shows that the walkway must have a minimum width of 1.53 m (5 feet) for its entire length. All utility poles, traffic signal poles, café railings, benches, newspaper boxes, and other structures that could intrude on the sidewalk space must be kept at a distance of 1.53 meters. For a sidewalk to be barrier-free, it must include intersecting curb ramps. Hence, this measure also considers their presence(32).

4.6.6. Safety at crossing level

For scenario 1, 83.3% of the pedestrians confirmed that the safety indicators at the crossing level for security reasons are poor on the railway and road network combined. For scenario 2, 90% of pedestrians use the road free from LRT. Security in the transportation systems is a key to consider for all cases, but in both scenarios, the road users are safer than the railway and road networks combined. Research conducted on safety and risks analysis at a railway crossing showed the issues raised included whether or not there were automatic barriers, mechanical barriers, warning signals, magneto phones, a flagman present at the crossing at all times, stop signs available at the crossing on both tracks and the availability of a safe board in both the local language and other languages. With respect to percentages, it is demonstrated that the RLC lacks magneto phones, mechanized barriers, and flagmen. Automatic barrier provision, only 12%, needs to be addressed. To reduce train-road user collisions at RLCs, gates are considered more effective than "other traffic control devices at crossings such as flashing lights, bells, and signs(33).

4.6.7. Correlation of distance on social conflicts

A correlation of 62.1% means that the distance between two crossings affects all other social activities around the railway combined with the road network; a correlation of 10.7% means that the distance between two crossings does not affect social conflicts on the road free from the LRT. So, the road users are unaffected by the distance between crossing as the combined railway and road network users researched correlation coefficient's value in statistics ranging from +1 to -1. A perfect degree of relationship between the two variables is considered to exist when the correlation coefficient value is close to 1. The two variables' association will weaken as the correlation coefficient value approaches zero(34).

4.6.8. Supply of Goods to shops

84.9% of the business owners confirmed that the crossing is poor in facilitating vehicles supplying goods to shops of the business owners around railway and road combined, so they use a lot of fuel to reach the shops, 70.9% of the business owners around the road confirmed that it is easy for vehicles supplying goods to cross the road free from LRT to the alignment of railway affect the vehicles providing goods to shops of business owners around railway combined with road network, the conflict is not supposed to appear in the transportation system. Conducted research on the impact of transit-oriented shopping found that the predicted ridership impact of TOSMDs on surrounding transit network stations in the form of increased shopper passenger traffic flowing into stations near TOSMDs is details knowledge is seen to be helpful for effective TOD approaches to rail network and shopping mall patterns of growth, as well as for economic sustainability in the form of directing private or public investment as to where the best outcomes would be reached when creating metro stations(35).

4.6.9. System alignment contribution to business

86.1% of the business owners near the road with railway alignment confirmed that the alignment of the railway doesn't contribute to their businesses. Still, it negatively affects their business; 70.9% of the business owners near the road uncombined with the railway appreciate the alignment of the road, and it's a positive contribution to their business. The transportation systems must negatively affect the business activities around it as it is on the AALRT. Conducted research on the socio-economic impacts of AALRT, and they found that the cost of transportation before and after the LRT was examined, and it was discovered that after the LRT began operating, the cost of transportation had decreased. In addition, the LRT has reduced travel times for 63% of the residential areas close to the LRT stations; on the other hand, the LRT's adverse effects were noted as separating the nearby residential areas and requiring a significant walking distance to reach the opposite side of the LRT (36).

4.6.10. Correlation of system alignment on economic conflicts

A correlation of 81.5% detailed on railway and road combined, so the alignment of the railway affects all other economic variables, and a correlation of 34% on the road alignment affects business around, so there is no adverse effect on the business around the road. The correlation clearly shows the impact caused by the railway alignment refers to the road network free from LRT. The research on the correlation coefficient's value statistically ranges from +1 to -1. A perfect degree of relationship between the two variables is considered to exist when the correlation coefficient value is close to 1. The two variables' association will weaken as the correlation coefficient value approaches zero(34).

4.6.11. Validation of conflicts

4.6.11.1. Economic conflicts validation

The alignment of the railway has divided the business owners near the system into two parts due to the lack of easy business interchange on both sides of the roads; business owners themselves fear crossing for goods in another shop with similar service on another side of the transportation system, this makes their business only for one side, not only the business owners also people living near the two transportation systems are separated economically when one service is missed one side of the system it is difficult to cross for it on the other side. Conducted research on transportation and the economy, their findings show an improvement in how quickly businesses may access their respective clients, raw materials, and parts. As a result, transportation increases the availability of a wide range of commodities required for industrial and manufacturing systems, improves access to labour, and lowers the cost of access, primarily through better commuting (on a local scale) or the employment of lower-cost labour (on a global scale). By connecting producers and customers, transportation creates market accessibility and allows for transactions (37). In the case of AALRT and the Road network, it is not respected, which creates economic conflicts.

4.6.11.2. Social conflicts validation

The social conflicts investigated are primarily based on crossing ability, the distance pedestrians travel from one crossing to another, waiting time to cross and walkways between roads and railways. All these conflicts affect the mobility of pedestrians compared to what the literature shows.

Although the tram broadened the range of transport alternatives, enabling greater urban mobility, the car continues to be the preferred mode of transportation for most respondents. While some earlier research indicated that the LRT had significantly altered people's travel habits, the project is probably responsible for the city's promotion and for helping it develop a favorable reputation, an analysis of the Olsztyn tram project's effects on alterations in travel patterns and increases in housing costs leads to the conclusion that light rail might be a workable option for promoting sustainable mobility in mid-sized cities(38). Compared to the AALRT situation, the social conflicts investigated in this research are valid.

4.6.11.3. Traffic conflict validation

The traffic conflicts investigated in the research are based on the long-distance travelled by vehicles to reach the turn bay caused by the alignment of LRT; this research investigated that the distance from one bay to another is greater than 2 km, whereas research conducted previously shows the distance between adjacent auxiliary lanes and through lanes is known as the bay taper length. Although 100 feet is a usual minimum, bay taper lengths vary depending on vehicle speeds and the width of the auxiliary lane. For a typical 12-foot wide left-turn lane, the bay taper length is 100 feet for speeds up to 30 mph and 180 feet for speeds of 35 mph and higher. To calculate the necessary bay taper length, utilize the module's Bay Taper Length Calculator(39).

4.7. Solutions to social and economic investigated conflicts

4.7.1. Solutions for social conflicts

After conducting research on the alignment of railway impact in social-economic aspects, two scenarios were considered, and a comparison was made to confirm social and economic conflicts. The social conflicts observed during this research are: 1. Railway crossing times per day were caused by the alignment of the railway, and it can be solved by provisional zebra crossing; 2. distance between two successive crossings where distance is more significant than 350 m; 3. Waiting time before crossing the railway The conflict shows that the waiting time is between 2 to 4 minutes, 4. Peak hours effects on pedestrians where pedestrians are challenged by peak hours in crossing, 5. Walkway area at the crossing between the railway and road network; 6. Security and safety at the crossing level are not sufficiently caused by railway alignment. The solutions to the conflicts as mentioned earlier are:

a) To construct an inclusive flyover bridge on each 150 m that facilitates pedestrians to cross the transportation systems; this bridge will also help moto bike and bike crossing. The proposed flyover bridge is going to solve the problem of sun and rain at the crossing level by providing a well-roofed bridge. The research conducted by the U.S. Department of Transportation found that The traffic control signal shall be pedestrian-activated and situated at a non-intersection crossing at least 100 feet away from any side streets or driveways that are subject to signs(40) and other conducted research on the distance between crossing to another crossing and come with the following findings, According to this study, there should be a crossing between 160 and 200 meters (22). It refers to the above literature. I decided to place a flyover bridge on 150 m to 200 m from one to another.

b) Provision walkway distance between railway and road network at least an area of 1.5 m conducted research on sidewalk distance with this finding; The walkway must have a minimum width of 1.53 m (5 feet) for its entire length. All utility poles, traffic signal poles, café railings, benches, newspaper boxes, and other structures that could intrude on the sidewalk space must be kept at a distance of 1.53 meters. For a sidewalk to be accessible, it must include intersecting curb ramps. Hence, this measure also considers their presence(32).

C) Installation of traffic signalling system on every crossing level, conducted research on safety and risks analysis at the railway crossing showing the issues raised included whether or not there were automatic barriers, mechanical barriers, warning signals, magneto phones, a flagman present at the crossing at all times, stop signs available at the crossing on both tracks and the availability of a safe board in both the local language and other languages. With respect to percentages, it is demonstrated that the RLC lacks magneto phones, mechanized barriers, and flagmen. Automatic barrier provision, only 12%, needs to be addressed. In order to reduce train-road user collisions at RLCs, gates are thought to be more effective than "other traffic control devices at crossings such as flashing lights, bells, and signs(33). The findings affirm that the security and signalling system is crucial to conflict between the railway and road network.

d) Provision of combined turn bay and zebra crossing at every 350 meters for the reason of economy and reduction of a considerable number of flyover bridges; Courage K et al. l. Conducted research on interchange and they came up with a solution saying that at two-way roads, the minimum distance between turn bay and another is equal to 305 meters (27). With these solutions, the social conflicts will be solved 100% without demolishing any infrastructure, and the two transportation systems will continue operating socially conflict-free.

4.7.2. Solutions to economic conflicts

Economic conflicts identified during this research are 1) Difficulties in crossing the transportation system for services, 2) Inaccessibility of vehicles supplying goods to the shops, 3) customers' vehicles to access the shops and long distance travelled by systems users' vehicles to change road direction 4) Traffic congestion at the existing turn bay. Due to the mentioned problems, the researcher decided to:

a) Provide a vehicle turn bay at 350 meters based on the number of lanes and operational speed, based on the railway alignment where places need a flyover bridge turn bay. Conducted research on interchange, and they came up with a solution saying that at two-way roads, the minimum distance between the turn bay and another is equal to 305 meters. (27) Referring to this, I decided to use a distance of 350 meters for reasons of economy.
b) Provision of a signalling system at a very turn bay to facilitate free movement of trains, vehicles and pedestrians, conducted research on safety and risks analysis at the railway crossing showed the issues raised included whether or not there were automatic barriers, mechanical barriers, warning signals, magneto phones, a flagman present at the crossing at all times, stop signs available at the crossing on both tracks and the availability of a safe board in both the local language and other languages. With respect to percentages, it is demonstrated that the RLC lacks magneto phones, mechanized barriers, and flagmen. Automatic barrier provision, only 12%, needs to be addressed. In order to reduce train-road user collisions at RLCs, gates are thought to be more effective than "other traffic control devices at crossings such as flashing lights, bells, and signs(33).

4.8. Mitigation for future LRT projects

The government has constructed Addis Ababa Light Rail Transit through a Chinese company on a Build, operate and transfer contract. The railway is operational dispute the conflicts created by its alignment to avoid conflicts in future projects; when the LRT pass through a city, it will be essential to consider the following measures: Consider the distance between road network and railway where is enough land by using results found in the manual done by Kruzyna said that the distance between road network and railway must not be less than 92 meters(22).

The above alignment may not be possible due to different reasons like lack of space; therefore, instead of making an alignment that will create conflicts in operation, researchers suggest using bridges for railway alignment. This will facilitate the interchange between the two systems. Where railways can use the bridges and vehicles use the ground.

When the city is very congested, the alignment of the railway can be done using tunnels. This allows the double use of surface on the ground and underground, which is a good land management strategy, but with the challenge of easy access from road to railway, this requires a good design.

For the consultancy conflicts highlighted by the AALRT staff, the mitigation is better to follow the planning phases by involving stakeholder consulting end users.

4.9. Cost-benefit on solutions and mitigations

The conflict solutions highlighted are based on different parameters for social, traffic and economic conflicts caused by the alignment of the railway. The comparison between parameters has confirmed that the alignment of LRT causes conflicts. The most beneficial solution for all conflicts is to provide a turn bay at each 350 m of the transportation system. The turn bay will also be used as a zebra crossing for pedestrians. For security reasons for the road network and railway users, it is better to install a signalling system at the turn bay and zebra crossing to minimize accidents.

For mitigations on future LRT projects, many ways of mitigating have been proposed, and the most cost-benefit mitigation is to construct the railway separated 92 meters away from the road network and provide an access road to the railway. Other mitigations are very expensive, such as bridges and tunnels, so these are to be avoided unless it is impossible, such as in the presence of rivers, marshland and high hills.

5. Conclusion and Recommendations

5.1. Conclusion

The study investigated the conflicts between the railway and road network at Addis Ababa Light Rail Transit, comparing two scenarios. Scenario 1 considered railway and road networks combined, and scenario 2 considered roads without LRT. The two railway lines selected for scenario 1 were the East-West line and the North-south Road line chosen from the stadium to Bole. The parameters for social conflicts were: pedestrians waiting time to cross, pedestrians travelling distance to access the next crossing level, the walkway distance between the railway and road network, safety and security at the crossing level, waiting for the area before crossing level, peak hours effects. The economic parameters were: business owners crossing for services, vehicle supplying goods access to shops, customers and business owners' vehicles access to shops and Railway alignment contribution on business around.

Social conflicts investigated were: 1. Railway crossing times per day caused by railway alignment, 2. Long distance between two successive crossings, 3. Long Waiting time before crossing the railway, 4. Pedestrians are delayed in crossing during peak hours; 5. Need for a walkway area at the crossing between the railway and road network. 6. Insufficient Security and safety at the crossing level. Solutions for the social conflicts are a) Construction of an inclusive flyover bridge at 150 to 200 m to solve the waiting time, crossing time and crossing the system's conflicts. b) Provision of walkway distance between railway and road network at least an area of 1.5 m to solve the conflicts of insufficient waiting area between railway and road conflict, c) Installation of a traffic signalling system on every crossing level to solve the conflict of insufficient security and safety at crossing level and d) Provision of combined turn bay, signalling and zebra crossing at a every 350 meters for reason of economy and reduction of vast number of flyover bridges for all social conflict.

The economic conflicts investigated were: 1) Difficulties in crossing the transportation system for services by Business owners, 2) Inaccessibility of vehicles supplying goods to the shops, 3) Business owners' and customers' vehicles to access the shops, 4) Traffic congestion at the existing turn bay, solutions on the economic were: a) provide a vehicle turn bay at a very 350 meters based on the number of lanes and to operational speed to the conflicts of service seeking both sides, vehicles inaccessibility to shops and the traffic congestion on existing turn bay, b) Provision of signalling system at a very turn bay to facilitate free movement of trains, vehicles and pedestrians and avoid accidents at turn bays. The mitigations for future projects are to provide the two systems interchange between railway and road network by 1) aligning the railway at least 92 meters away from the road network and providing an access road for interchange 2) where road and railway intersect better to use bridges or made tunnel 3) for the consulting challenges it better for next project to consult end users, stakeholders and respect all phases of planning of a project. Therefore, considering the results of this research will contribute to minimizing the existing conflicts between the Addis Ababa Light Rail Transit and the road network and also will contribute to avoiding any conflict in all LRT future projects.

5.2. Recommendations

Based on the concluding remark and concept design, the following recommendations are proposed to the Ethiopian Railway Corporation and Addis Ababa Light Rail Transit:

- To construct the flyover bridges to avoid social conflicts based on the long-distance pedestrians travel from crossing to crossing, long waiting time to cross, and crossing times per day.
- To Construct walkways between the railway and road networks for pedestrians to stand in waiting to cross when the railway and road are busy.
- To provide a robust signalling system at each crossing to solve the conflict based on security and safety.
- To construct the turn bays on each 350 m of railway and road network to fight against the difficulties of accessing the business around the system, the traffic congestion at the existing turn bay caused by the long distance between two turn bays can facilitate business owners to access on other sides of the system for goods seeking.
- To survey the alignment of the next AALRT project to avoid conflicts during and after its implementation.
- To use advanced alignment techniques such as separation of road and railway where there is enough land and tunnels or bridges where there is not enough land, especially in cities.

5.3. Proposed future studies

A conflict-free project is the dream of every planner and manager. Achieving this requires several studies; this study was focused on an investigation between railway and road networks, especially at AALRT. Some proposed studies are:

- Design appropriate walkway between railway and road network for AALRT case.
- Come with a detailed study showing the inclusive flyover bridge design for AALRT pedestrians.
- Design the on-ground, underground and above-ground turn bays according to the site's topography at AALRT.
- Conduct the comparison study on flyover bridges and combined zebra crossing and turn bay, considering economy and security.

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APPENDICES (A&B)

Addis Ababa University

Addis Ababa Institute of Technology

African Railway Center of Excellence

RAILWAY ROAD USER SURVEY QUESTIONNAIRE (WITH CONSENT)

Thank you for joining me today; I am a Master's student at Addis Ababa Institute of Technology. The African Railway Center of excellence funded this research of my Master's work. I want to ask you some questions related to your views on the accessibility of the railway and road network system from Stadium Station to Ayat and Stadium to Kality. The objective of this survey is to collect data related to your habit of crossing the two transportation systems, which has fundamental importance. The planning and design of special infrastructures for solving the crossing challenge will be highlighted in this survey. You are invited to participate in this research because your role as a passenger will be a milestone and is highly appreciated. The information will help the government, transportation operators, researchers, and stakeholders better understand and design structures that do not create conflicts. I kindly request your valuable time for this interview, and I will ensure your confidentiality in the treatment of the given information.

Researcher information

Researcher Name:……………………………………………………………………………………

Questionnaire No…………………………… **Interview time…………………………**

Date of Interview………………………………..

Name of Advisor:……………………………………………………………………………….

Checking Date………………………………….. Date of Data Entry………………………….

Part A: Socio-Economic Characteristics

Please tick the answer:

Question 1: What is your Gender?

☐ Male ☐ Female

Question 2: What is your Age?

☐ Below 15 ☐ 15 to 25 ☐ 26 to 35 ☐ 36 to 45 ☐ Above 45

Question 3: What is your Education Level?

☐ Primary ☐ High school ☐ Diploma ☐ Degree ☐ Masters ☐ PhD

Question 4: What is your average Household income?

☐ Below 4000 ☐ 4000 to 6000 ☐ 6000 to 8000 ☐ 8000 to 10000 ☐ Above 10000

Question 5: What is your Household size?

☐ 1 to 4 ☐ 5 to 7 ☐ 8 to 10 ☐ Above 10

Question 6: Do you have a disability of any form? ☐ No ☐ Temporary ☐ Permanent

Question 7: Do you cross the railway and road? ☐ Yes ☐ No

Part B: Travel Habits

Question 8: What is your favorite transportation mode?

☐ Train ☐ Bus ☐ Taxi ☐ Other……………………………..

Question 9: How many times per day do you cross the railway and road?

☐ 2 ☐ 4 to 6 ☐ 8 to 10 ☐ Above 10

Question 10: How long it takes you from your home to the crossing point?

☐ 10m ☐ 10 to 50m ☐ 60 to 100m ☐ 100 to 150m ☐ 200 to 250m

☐ 300 to 350m☐. Above 350m

Question 11: Do you cross the railway and road for service-seeking?

☐ No ☐ yes

Question 12: How many times do you wait for trains and cars to cross?

☐ 2 min ☐ 5 to 10 min ☐ 10 to 15 min ☐ 15 to 20 min ☐ Above

Question 13: How often did you wait before the railway construction to cross the road?

☐ 1 min ☐ 2 to 5 min ☐ 5 to 10 min ☐ 10 to 15 min ☐ Above

Question 14: Which time is it too difficult to cross?

☐ 6 to 9☐ AM, 12 to 2☐ PM, 4 to 8☐ PM Other

Question 15: At which crossing is easy to cross (The line from Stadium to Ayat)?

☐ Guard shola1 ☐ megenagna ☐ Civil service college ☐ Guard shola2

Question 16: At which crossing is easy to cross (The line from Stadium to Kality)?

☐ Riche ☐ Temenja yazh ☐ Lancha ☐ Nefas silk2

Question 17: Do you cross the railway and road for which purpose?

☐ Work ☐ School ☐ Home ☐ Shopping ☐ Visiting Relatives/ Friends ☐ Other

Question 18: What mode of transport do you use to cross the railway and road?

☐ Foot ☐ Ride ☐ Taxi ☐ Bus ☐ Motor bicycle ☐ bicycle

Question 19: Which of the following do you regularly travel with during your trip?

☐ Alone ☐ Group ☐ Children ☐ Luggage ☐ Elderly/Disabled ☐ Other

Question 20: Which do you fear crossing the most?

☐ Railroad ☐ Roadway ☐ Pedestrian way

Part C: Crossing Satisfaction and Preference

Please tick where Applicable

1= Very Poor 2= Poor 3= Neutral 4= Good 5= Very Good

	Part C: Passenger Satisfaction Preferences					
		1	**2**	**3**	**4**	**5**
	Crossing Condition					
1	Easy to cross the railway and road from side to side					
2	The time it takes to cross the railway and road combined is reasonable					
3	Reasonable distance between crossing and crossing					
4	Inter-connectivity between the railway and road network					
5	Railway and road crossing level accessibility					

6	The area for standing waiting for crossing is enough.					
7	Signalling at the crossing level is sufficient and operational.					
8	Safety and Security indicators at the crossing					
9	Rain and sunlight shed at the crossing.					
10	Enough crossings to the line					
	Selling Challenges (for Sellers)					
1.	Access to goods on the other side of the transportation system					
2.	Access to your cars to cross the railroad and road network, bringing goods					
3.	Availability of service on both sides of the transportation system					
4.	Custom exchange on both sides is					
5.	Custom cars quickly crossing chance is					
6.	The location of the transportation system's contribution to the business is					

Appendices B: Road users' questionnaire

Part A: Socio-Economic Characteristics

Please tick the answer:

Question 1: What is your Gender?

☐ Male ☐ Female

Question 2: What is your Age?

☐ Below 15 ☐ 15 to 25 ☐ 26 to 35 ☐ 36 to 45 ☐ Above 45

Question 3: What is your Education Level?

☐ Primary ☐ High school ☐ Diploma ☐ Degree ☐ Masters ☐ PhD

Question 4: What is your average Household income?

☐ Below 4000 ☐ 4000 to 6000 ☐ 6000 to 8000 ☐ 8000 to 10000 ☐ Above 10000

Question 5: What is your Household size?

☐ 1 to 4 ☐ 5 to 7 ☐ 8 to 10 ☐ Above 10

Question 6: Do you have a disability of any form? ☐ No ☐ Temporary ☐ Permanent

Part B: Travel Habits

Question 7: What is your favorite transportation mode?

☐ Train ☐ Bus ☐ Taxi ☐ Other……………………………..

Question 8: How many times per day do you cross the road?

☐ 2 ☐ 4 to 6 ☐ 8 to 10 ☐ Above 10

Question 9: How long it takes you from your home to the crossing level?

☐ 10m ☐ 10 to 50m ☐ 60 to 100m ☐ 100 to 150m ☐ 200 to 250m ☐ 300 to 350m ☐ Above 350m

Question 10: Do you cross the road for service-seeking?

☐ No ☐ yes

Question 11: How many times do you wait to cross?

☐ 20 seconds ☐ 30 to 40 seconds ☐, 1 to 2 min ☐, 3 to 4 min ☐ Above

Question 12: Which time is it too difficult to cross?

☐ 6 to 9 ☐ AM, 12 to 2 ☐ PM, 4 to 8 ☐ PM Other

Question 13: Do you feel secure at the crossing level?

☐ **Yes** ☐ **No**

Question 14: Is the distance between two lanes enough to access the other side of the road?

☐ **Yes** ☐ **No**

Part C: Business owners' perception

Question 15: Is it easy to cross for customers' goods seeking on the other side of the road?

☐ **Yes** ☐ **No**

Question 16: Can vehicles supplying goods easily access your shop?

☐ **Yes** ☐ **No**

Question 17: Is it easy for customers with vehicles to access your shop?

☐ **Yes** ☐ **No**

Question 18: Does the road location contribute to your business?

☐ **Yes** ☐ **No**

Question 19: at which time do you receive many customers?

☐ 6 to 9am ☐ 12 to 2pm ☐ 4 to 8pm ☐ Other

Translated Questionnaire

ክፍል ሀ፡ ማህበራዊ እና ኢኮኖሚያዊ ሁኔታ

እባክዎ ምላሽዎ ላይ ምልክት ያድርጉ፡

ጥያቄ 1፡ ፆታዎን ይግለፁ

☐ **ወንድ** ☐ **ሴት**

ጥያቄ 2፡ በየትኛው የዕድሜ ክልል ውስጥ ይገኛሉ?

☐ ከ15 በታች ☐ ከ15 እስከ 25 ☐ ከ26 እስከ 35 ☐ ከ36 እስከ 45 ☐ ከ 45 በላይ

ጥያቄ 3፡ የትምህርት ደርጃዎ?

☐ የመጀመሪያ ደረጃ ☐ ሁለተኛ ደረጃ ☐ ዲፕሎማ ☐ ዲግሪ ☐ ማስትሬት ☐ ዶክትሬት

ጥያቄ 4፡ የቤተሰብዎ ድምር ወርሃዊ ገቢ ምን ያክል ይሆናል?

☐ **ከ**4000 በታች ☐ ከ4000 እስከ 6000 ☐ ከ6000 እስከ 8000 ☐ ከ8000 እስከ 10000 ☐ ከ10000 በላይ

ጥያቄ 5፡ በቤትዎ ውስጥ የሚኖሩ ሰዎች ብዛት?

☐ ከ1 እስከ 4 ☐ ከ5 እስከ 7 ☐ ከ8 እስከ 10 ☐ ከ10 በላይ

ጥያቄ 6፡ ማንኛዉም አይነት የአካል ጉዳት አለበዎት? ☐ የለብኝም ☐ ጊዜያዊ ጉዳት ☐ አዎ

ጥያቄ 7፡ በዕለት ከዕለት እንቅስቃሴዎ የባቡር እና የመኪና መንገድ ያቋርጣሉ? ☐ **አዎ** ☐ አላቋርጥም

ክፍል ለ፡ የጉዞ (እንቅስቃሴ) ልምድዎን በተመለከተ

ጥያቄ 8፡ በአብዛኛው ለጉዞዎ የሚመርጡት የመጓጓዣ አይነት የቱ ነዉ?

☐ ባቡር ☐ ባስ ☐ ታክሲ ☐ ሌላ..................................

ጥያቄ 9፡ በቀን ለምን ያክል ጊዜ የባቡር እና የመኪና መንገድ ያቋርጣሉ?

☐ ከ2 በታች ☐ ከ4 እስከ 6 ☐ ከ8 እስከ 10 ☐ ከ10 በላይ

ጥያቄ 10፡ ከቤትዎ እስከ ባቡር ወይም መኪና መንገድ ማቋረጫዉ ለመድረሰ ምን ያክል ይርቃል?

☐ ከ10 ሜትር በታች ☐ 10 እስከ 50ሜትር ☐ 60 እስከ 100ሜትር ☐ 100 እስከ 150ሜትር
☐ 200 እስከ 250ሜትር ☐ 300 እስከ 350ሜትር ☐ ከ 350ሜትር ብላይ

ጥያቄ 11፡ የባቡር እና መኪና መንገዱን አቋርጠው የሚሄዱበት ጉዳይ አለዎት?

☐ የለኝም ☐ አዎ

ጥያቄ 12፡ ባቡር እና መኪኖችን ለማቋረጥ ምን ያክል ጊዜ የጠብቃሉ

☐ 2 ደቂቃ ☐ ከ5 እስከ 10 ደቂቃ ☐ ከ10 እስከ 15 ደቂቃ ☐ ከ15 እስከ 20 ደቂቃ
☐ ከ20 ደቂቃ በላይ

ጥያቄ 13፡ የባቡር መንገዱ ከመሰራቱ በፊት የመኪና መንገዱን ለማቋረጥ ምን ያክል ጊዜ ይፈጅብዎት ነበር?

☐ 1 ደቂቃ ☐ ከ2 እስከ 5 ደቂቃ ☐ ከ5 እስከ 10 ደቂቃ ☐ ከ10 እስከ 15 ደቂቃ
☐ ከ15 ደቂቃ በላይ

ጥያቄ 14፡ የትኛው ጊዜ መንገዱን (የባቡር ወይም የመኪና) ለማቋረጥ የከብደዎታል?

☐ ከጠዋቱ 12፡00 እስከ 3፡00 ☐ ከቀኑ 6፡00 እስከ 8፡00 ☐ ከሰዓት 10፡00 እስከ ምሽቱ 3፡00 ☐
ሌላ

ጥያቄ 15፡ የትኛው የእግረኛ ማቋረጫ ቀላል (ምቹ) ነው የላሉ (ከስታዲዮም እስከ አያት ባለው መስመር)

☐ ጉርድ ሾላ 1 ☐ መገናኛ ☐ ሲቪል ሰርቪስ ኮሌጅ ☐ ጉርድ ሾላ 2

ጥያቄ 1፡ የትኛው የእግረኛ ማቋረጫ ቀላል (ምቹ) ነው የላሉ (ከስታዲዮም እስከ ቃሊቲ ባለው መስመር)

☐ ሪቸ ☐ ጠመንጃ ያዥ ☐ ላንቻ ☐ ነፋስ ስልክ 2

ጥያቄ 17፡ የመኪና እና ባቡር መንገዱን አቋርጠው የሚሄዱት ለምን ተግባር ነው?

☐ **ለስራ** ☐ ትምህርት ቤት ☐ ወደቤቴ ☐ ወደ ገበያ ☐ ዘመድ/ጓደኛ ለመጠየቅ ☐ ሌላ

ጥያቄ 18፡ የባቡር እና መኪና መንገዱን የሚያቋርጡት በየትኛዉ የመጓጓዣ አይነት ነው?

☐ በእግር ☐ ኮንትራት ታክሲ ☐ ታክሲ ☐ ባስ ☐ ሞተር ሳይክል
☐ ሳይክል

ጥያቄ 19፡ አብዛኛዉን ጊዜ ሲጓዙ ምን ይይዛሉ ወይም ከማን ጋር ይጓዛሉ?

☐ ብቻየን ☐ ብዙ ሆነን ☐ ህፃናት ጋር ☐ እቃ ይዤ ☐ ሽማግሌ/አካል ጉዳተኛ ጋር ☐ ከዚህ በተለየ

ጥያቄ 20፡ የቱን መሻገር ያስፈራዎታል?

☐ የባቡር መንገዱን ☐ የመኪና መንገዱን ☐ የእግረኛ መንገ

ክፍል ሐ፡ ስለ ማቋረጫ ቦታዎች ምቹነት በተመለከተ

እባክዎ የመረጡት ቦታ ላይ ምልክት ያድርጉ

1 = በጣም ዝቅተኛ 2 = ዝቅተኛ 3 = መጠነኛ 4 = ጥሩ 5 = በጣም ጥሩ

	ክፍል ሐ፡ የመንገድ ተጠቃሚዎች አስተያየት					
	የመሻገሪያ ሁኔታ	**1**	**2**	**3**	**4**	**5**
1	የባቡር እና መኪና መንገዱን አንድ ላይ ማቋረጥ ያለው ቅለት					
2	የባቡር መንገዱን እና የመኪና መንገዱን በአንድ ላይ ማቋረጥ ጊዜ ይወስዳል					
3	በእግረኛ ማቋረጫዎች መካከል ያለው ርቀት ምክንያታዊ የሚባል ነው					
4	የባቡር እና መኪና መንገዱ ያላችዉ ዉህድት (ጥምረት)					
5	የባቡር እና መኪና መንገድ ማቋረጫዎች ተደራሽነት					
6	መንገድ ለማቋረጥ ቆመዉ የሚጠብቁበት ቦታ ስፋት በቂነት					
7	እግረኛ ማቋረጫዎች ላይ ያሉት የትራፊክ መብራቶች በቂነት እና እየሰሩ መሆናቸው					
8	እግረኛ ማቋረጫዎች ላይ ያሉት የትራፊክ ደህንነት ምልክቶች					
9	በእግረኛ ማቋረጫዎች ላይ የሚገኙ የዝናብ እና ፀሀይ መጠለያዎች					
10	የባቡር መስመሩ ላይ ያሉ የእግረኛ ማቋረጫዎች ቁጥር በቂነት					
	ንግድ ላይ ያለው ተፅዕኖ (ለነጋዴዎች)					
1.	በመንገድ ማዶ ያሉ እቃዎችን ለማምጣት ያለው ምቹነት					
2.	ሸቀጥ/ እቃ ለማጓጓዝ የባቡር እና መኪና መንገድ ማቋረጫዎች ያላቸው ምቾት					
3.	በሁለቱም አቅጣጫ ትራንስፖርት በቀላሉ ማግኘትን በተመለከተ					
4.	ከመንገዱ አንፃር በሁሉም አቅጣጫ ለግብይት ያለው አምችነት					
5.	ተሽከርካሪ ለያዙ ሸማቾች የመንገድ ማቋረጫዎች ያላቸው አመችነት					

6.	የመጓጓዣ አገልግሎት መስጫ እና የንግድ ተቋማት ያላችው ውህደት					

Interview for AALRT Staff

1. Have you been there during the construction works of the LRT?

2. Have you been consulted during the implementation of the LRT?

3. LRT is placed between two roads. Were those two roads existing before?

4. Do you appreciate the location of the LRT compared to the road network?

5. Were preliminary studies conducted before the LRT was constructed?

6. Stakeholders have been consulted before the confirmation of the LRT location.

DAILY TRAFFIC COUNT SUMMARY SHEET

Road Name: ....**Road Number:** .... **Station Name:**..**Station Ref:** ....

Date: ..../.........../............**Directions of countTo:**.. **Hours Counted** **From:**....:... Hours **To:** ....:.... Hours

(DD/MM/YY) **From:**.. **Supervisor:** ....

Time	1 Heavy Truck	2 Medium Truck	3 Small Truck	4 Large Bus	5 Medium Bus	6 Micro Bus	7 Utility	8 Car	9 Auto-Rickshaw	10 Motor Cycle	11 Bicycle	12 Cycle-Rickshaw	13 **Train**	Total Motor	Total Non-M	Grand Total
06:00-07:00																
07:00-08:00																
08:00-09:00																
09:00-10:00																
10:00-11:00																

11:00-12:00																
12:00-13:00																
13:00-14:00																
14:00-15:00																
15:00-16:00																
16:00-17:00																
17:00-18:00																
18:00-19:00																
19:00-20:00																
Tot. One Way																