ADDIS ABABA UNIVERSITY

SCHOOL OF TECHNOLOGY AND BUILT ENVIRONMENT

ASSESSMENT OF PEDESTRIAN SAFETY PROBLEMS AND ITS EFFECT ON URBAN MOBILITY: THE CASE OF KOLFE- KERANIO SUB-CITY, ADDIS ABABA

BY:

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A THESIS SUBMITTED TO THE SCHOOL OF BUILT ENVIRONMENT, COLLEGE OF TECHNOLOGY AND BUILT ENVIRONMENT, ADDIS ABABA UNIVERSITY IN PARTIAL FULFILLMENT FOR THE REQUIREMENTS OF MASTER OF SCIENCE DEGREE IN URBAN DESIGN AND DEVELOPMENT

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JUNE, 2026

ADDIS ABABA, ETHIOPIA

DECLARATION

I, the undersigned, declare that this thesis prepared for the partial fulfillment of the requirements for the degree of Master of Science in Urban Design and Development entitled "Assessment of pedestrian safety problems and its effect on the mobility: the case of kolfe-keranio sub-city" is my original work and has not been presented for a degree in any other university and that all sources of material used for the thesis have been duly acknowledged.

Benoni Ayele

Signature: ______________________

June, 2026

CONFIRMATION

This is to certify that the thesis entitled "Assessment of Pedestrian Safety Problems and Its Effect on Urban Mobility: The Case of Kolfe-Keranio Sub-City", submitted to Addis Ababa University, Ethiopian Institute of Architecture, Building Construction and City Development for the award of the Degree of Master of Science in Urban Design and Development and carried out by Benoni Ayele Baysasle, under my guidance and supervision.

Therefore, we hereby declare that no part of this thesis has been submitted to any other university or institutions for the award of any degree or diploma.

Advisor's Name	Signature	Date
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APPROVAL

As a member of the Examiners board of the final Master's thesis open defense of Benoni Ayele we have read and evaluated the thesis prepared by Benoni Ayele entitled "Assessment of Pedestrian Safety Problems and Its Effect on Urban Mobility: The Case of Kolfe-Keranio Sub-City", and recommended to Addis Ababa University College of Technology and Built Environment School of Graduate Studies to accept the Thesis for the Fulfillment of the Requirements for the Award of the Degree of Master of Science in Urban Design and Development.

June, 2026

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ACKNOWLEDGEMENT

I would like to express my gratitude to my advisor, Dr. Birhanu Girma Abebe, for the substantial support, advice, and guidance he provided me in the preparation of this paper. His critical inputs, creative ideas, and provision of essential books and articles were instrumental in the completion of this paper.

I would also like to extend my gratitude to my family for the robust support and encouragement they provided me throughout my academic and other endeavors in my life.

I would also like to extend my gratitude to my colleagues and associates, who have been the sources of inspiration and support during the past two years, contributing significantly to the completion of this paper.

I would also like to extend my gratitude to the research participants for their support and provision of essential information, without which this paper would not have been possible. I would also extend my gratitude to individuals who, in any way, contributed to the completion of this paper.

Lastly, I would also extend my gratitude to the members of my family for their support throughout my academic journey, which has been indispensable to my success.

By, Benoni Ayele

June, 2026

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ACRONYMS

FHWA	Federal Highway Administration
OECD	Organization for Economic Co-operation and Development
WHO	world Health Organization
PWDS	Persons With Disabilities
TMA	Traffic Management Authority
FHWA	Federal Highway Administration
NHTSA	National Highway Traffic Safety Administration
EPA	The U.S. Environmental Protection Agency
ITE	Institute of Transportation Engineers
AAEPA	Addis Ababa Environmental Protection Authority
FDRE	Federal Democratic Republic of Ethiopia
SUDAP	Sustainable Urban Development Action Plan
SUMP	Sustainable Urban Mobility Planning
AfDB	The African Development Bank

ABSTRACT

Pedestrian mobility constitutes a foundational pillar of sustainable urban development, yet active commuters in rapidly motorizing African cities remain disproportionately exposed to structural, behavioral, and environmental safety hazards. In Addis Ababa, where walking accounts for an estimated 60% to 80% of all daily commuting trips, the urban built environment has historically prioritized vehicular flow over pedestrian protection, generating acute safety deficits. Kolfe-Keranio Sub-City exemplifies this tension, characterized by massive pedestrian volumes, dense mixed-use land-use patterns, and high-speed arterial corridors that concentrate pedestrian-vehicular friction. Despite prior studies examining accident frequencies and pedestrian level of service, a critical empirical gap persists regarding how cumulative safety hazards directly restrict overall walking efficiency and functional urban mobility.

This study examines the effect of pedestrian safety hazards—operationalized as Pedestrian Infrastructure (PI), Traffic Conditions (TC), Environmental Factors (EF), and Pedestrian-Driver Behaviors (PDB)—on urban pedestrian mobility within Kolfe-Keranio Sub-City. A quantitative cross-sectional research design was adopted. The target population comprised active daily commuters intercepted along major arterial corridors measuring 20 meters or more in width. Using a multi-stage sampling framework guided by land-use and road network maps, 384 structured questionnaires were distributed during peak hours, yielding 366 valid responses (95.3% response rate). Bivariate Pearson correlation and Ordinary Least Squares (OLS) multiple linear regression were employed for data analysis.

Results indicate that the combined regression model is highly significant ($F(4, 361) = 67.071$, $p < 0.001$), collectively explaining 42.6% of the variance in Pedestrian Mobility ($R^2 = 0.426$). All four independent variables exert statistically significant positive effects on mobility ($p \leq 0.001$). Pedestrian-Driver Behaviors emerged as the strongest predictor ($\beta = 0.375$, $t = 9.028$), followed by Environmental Factors ($\beta = 0.303$, $t = 6.905$), Pedestrian Infrastructure ($\beta = 0.244$, $t = 5.972$), and Traffic Conditions ($\beta = 0.146$, $t = 3.340$). Multicollinearity diagnostics confirm model integrity, with all Variance Inflation Factors below 1.22.

The study concludes that pedestrian safety hazards in Kolfe-Keranio Sub-City function as active mechanisms of mobility suppression, particularly for vulnerable groups including children, the elderly, and persons with disabilities. The findings validate the global Safe System Approach, confirming that sustainable urban walkability demands a deliberate transition from vehicle-centric planning toward an integrated, pedestrian-centered built environment. Priority recommendations include enforcing automated speed management along arterial roads, installing continuous street lighting, constructing uninterrupted non-motorized transport corridors, and redesigning high-risk commercial intersections with pedestrian-actuated signals and raised crosswalks.

Keywords

Pedestrian Safety Hazards; Urban Pedestrian Mobility; Safe System Approach; Non-Motorized Transport; Urban Walkability; Kolfe-Keranio Sub-City; Addis Ababa

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the Study

The purpose of this study is to assess existing pedestrian safety problems within Kolfe-Keranio Sub-City, Addis Ababa, and systematically evaluate their empirical impact on urban pedestrian mobility. Driven by the critical safe system approach, this research utilizes a quantitative-methods framework to examine how localized pedestrian infrastructure quality, vehicle traffic conditions, physical environmental factors, and multi-actor road behaviors interact to influence walkability patterns. By deploying multiple linear regression analysis, the paper aims to provide a statistically rigorous model that quantifies how safety risks restrict functional movement, travel efficiency, and social inclusion. Ultimately, this study intends to offer evidence-based, actionable recommendations for urban planners, policymakers, and transportation authorities to design safer, inclusive, and highly sustainable non-motorized transport environments in rapidly developing Ethiopian cities

1.1.1. Pedestrian Safety

Pedestrian safety is a critical aspect of urban planning and public health, as pedestrians are among the most vulnerable road users. The theoretical and conceptual background of pedestrian safety encompasses various factors, including infrastructure, behavior, and policy interventions. The theoretical framework for pedestrian safety includes concepts from traffic engineering, urban planning, and public health. Key theories include the Safe System Approach, which emphasizes the need for a holistic view of road safety that considers the interactions between road users, vehicles, and infrastructure (Khan, M. N., & Das, S, 2024)Behavioral theories also play a crucial role, as pedestrian behavior, such as crossing decisions and risk perception, significantly impacts safety outcomes (Rezwana, N., Rahman, M., & Ahmed, S., 2025)

Globally, pedestrian safety has been a significant concern due to the high number of pedestrian fatalities and injuries. According to the World Health Organization (WHO), road traffic injuries are the leading cause of death for children and young adults aged 5-29 years, with pedestrians accounting for a substantial proportion of these fatalities (World Health Organization, 2018) Research has shown that factors such as vehicle speed, road design, and pedestrian behavior significantly impact pedestrian safety (Khan, M. N., & Das, S., 2024).

In Africa, pedestrian safety is particularly critical due to the high reliance on walking as a mode of transportation. Studies have highlighted the staggering pedestrian safety crisis in African cities, where pedestrians account for a significant proportion of road traffic fatalities (Schmitt, A., 2020)Factors contributing to this crisis include inadequate pedestrian infrastructure, high vehicle speeds, and poor road safety culture (Pedestrian safety challenges in African cities: Infrastructure, speed, and culture, 2022). In South Africa, for example, pedestrian fatalities remain a major concern, with contributing factors such as drunk pedestrians, reckless behavior, and lack of visibility (Arrive Alive South Africa, 2024).

In Ethiopia, pedestrian safety is a pressing issue, particularly in urban areas like Addis Ababa. A study by UN-Habitat (2021) revealed that pedestrians account for nearly 90% of road deaths in the capital city. The Ethiopian government, in collaboration with international organizations, has launched initiatives to improve pedestrian safety through the development of non-motorized transport strategies and infrastructure improvements (UN-Habitat, 2021). Additionally, research has identified inadequate pedestrian facilities, poor road management, and on-street selling as major causes of pedestrian safety issues in Addis Ababa (Shibeshi, A., 2022).

1.1.2. Mobility

Mobility is a fundamental aspect of human life, influencing economic activities, social interactions, and overall well-being. The theoretical and conceptual background of mobility encompasses various dimensions, including infrastructure, technology, policy, and human behavior. The theoretical framework for mobility includes concepts from urban planning, transportation engineering, and environmental science. Key theories include the Sustainable Urban Mobility Planning (SUMP) objectives, which emphasize the need for efficient, inclusive, and environmentally sustainable transport systems (Daniela Müller-Eie & Ioannis Kosmidis, 2023). Behavioral theories also play a crucial role, as human behavior, such as travel choices and risk perception, significantly impacts mobility outcomes (Rezwana, N., Rahman, M., & Ahmed, S., 2025)

In Africa, mobility challenges are exacerbated by rapid urbanization, inadequate infrastructure, and limited financial resources. The African Development Bank (AfDB) emphasizes the need for inclusive, safer, and cleaner mobility solutions to address these challenges. The Sustainable Urban Development Action Plan (SUDAP) outlines strategies to improve urban mobility through better planning, investment in public transportation, and promotion of non-motorized transport. Additionally, the (Africa Transport Policy Program (SSATP), 2023) highlights the importance of integrated urban transport and mobility management to address the growing urbanization and motorization rates in African cities.

1.2. Statement of the Problem

Globally, pedestrian safety and active transit represent critical issues within urban design and public health, as pedestrians remain the most vulnerable road users. According to the World Health Organization (WHO), road traffic injuries are a leading cause of death worldwide, with pedestrians accounting for approximately 23% of all traffic fatalities. In low- and middle-income nations particularly within rapidly urbanizing sub-Saharan African cities this crisis is magnified. In these settings, rapid motorization rates routinely outpace infrastructural investments, forcing active commuters to face highly hazardous walking conditions on a daily basis.

In Ethiopia, and specifically within Addis Ababa, this car-centric development model creates intense public health and spatial planning challenges. Although walking is an absolute socioeconomic necessity that accounts for an estimated 60% to 80% of daily commuter trips in the capital, urban transport planning has historically prioritized motorized vehicular flow over non-motorized transport (NMT) frameworks. This structural imbalance manifests aggressively in Kolfe-Keranio Sub-City, a fast-growing district defined by high-density residential developments and dense commercial hubs. When these mixed land uses intersect with the sub-city's major road networks specifically wide arterial corridors and highways measuring 20 meters and above, such as the PAS-Expressway and 60-meter primary roads severe pedestrian-vehicular friction zones are generated. Fragmented, unpaved, or heavily obstructed sidewalks systematically force pedestrians directly into active vehicular traffic lanes, where they face high speeds, reckless driver habits, and poor law enforcement.

While existing local literature heavily documents traffic fatalities as isolated public health, regulatory, or law enforcement issues, a significant empirical research gap remains regarding how chronic danger acts as a structural barrier to functional urban mobility. Prior studies frequently ignore the broader mechanism of mobility suppression specifically how constant vehicle conflict and a hostile built environment degrade walking efficiency, slow down trip speeds, and force active commuters into exhausting, protective detours. Furthermore, municipal planners lack localized, sub-city level predictive models that statistically integrate physical infrastructure quality, operational traffic conditions, environmental stressors, and multi-actor road behaviors into a single predictive framework. This data deficit makes it difficult to design targeted interventions for vulnerable groups, such as children, the elderly, and persons with disabilities (PWDs), who face extreme social exclusion due to compromised walkability. This study directly addresses these exact gaps by testing a multiple linear regression framework to quantify how structural, environmental, and behavioral hazards combine to restrict pedestrian freedom of movement within Kolfe-Keranio Sub-City.

1.3. Objective of the study

1.3.1. General objective

The primary objective of the study is Assessing the pedestrian mobility problems in Kolfe-Keranio Sub-City and evaluate their impact on pedestrian mobility

1.3.2. Specific Objectives

This study is guided by the following research objective

- To Examine And Analyze The Effect Of Pedestrian Safety Hazards On Urban Mobility Within Kolfe-Keranio Sub-City, Addis Ababa

1.4. Research Questions

Based on the above research gaps, the study asks the following research questions

1. How do pedestrian infrastructure deficiencies affect active mobility within Kolfe-Keranio Sub-City?
2. To what extent do localized traffic conditions impact pedestrian mobility in Kolfe-Keranio Sub-City?
3. What is the statistical effect of physical environmental factors on overall pedestrian mobility in Kolfe-Keranio Sub-City?
4. In what ways do behavioral factors among drivers and pedestrians influence functional urban mobility in Kolfe-Keranio Sub-City?

1.5. Significance of the study

1.5.1. For Scholars

This research contributes to the growing body of knowledge on pedestrian safety, particularly in urban settings of developing countries like Ethiopia. It provides empirical data that can enhance understanding of the unique challenges faced by pedestrians in Kolfe-Keranio. The findings can open avenues for further research into specific factors affecting pedestrian safety, such as infrastructure quality, traffic behavior, and cultural attitudes towards walking.

1.5.2. For Businesses

Businesses, especially those in the transportation and urban planning sectors, can gain valuable insights into pedestrian mobility patterns and safety concerns. Understanding these dynamics can inform the development of products and services that cater to safer urban environments, such as improved signage, pedestrian-friendly infrastructure, and innovative transport solutions. Companies can leverage the findings to enhance their corporate social responsibility initiatives.

1.5.3. For Policymakers

Policymakers can utilize the study's findings to formulate evidence-based policies aimed at improving pedestrian safety. This includes designing safer crosswalks, implementing traffic calming measures, and enhancing public awareness campaigns about pedestrian rights and safety. The assessment can help in prioritizing resource allocation for urban development projects.

1.5.4. For Existing Literature

This study addresses a specific gap in the literature regarding pedestrian safety in Ethiopian urban contexts. It complements existing research by providing localized data and insights that can be referenced in future studies, thereby enriching the academic landscape on urban mobility and safety. The findings can serve as a benchmark for comparative studies with other cities facing similar challenges.

1.6. Scope of the Study

1.6.1. The Spatial /Geographic/ Scope

The study will be conducted in Kolfe-Keranio Sub-city, which is one of the 11 sub-cities of Addis Ababa, Ethiopia. This area has been selected due to its unique urban characteristics, demographic diversity, and significant pedestrian activity.: The research will consider various geographical factors, including the urban infrastructure, traffic density, socioeconomic conditions, and cultural attitudes towards walking. These factors will help contextualize the findings within the specific environment of Kolfe-Keranio

The study will focusing on pedestrian environments across representative sites, corridors, and neighborhoods within the sub-city boundary. Data collection and analysis target street segments, intersections, and pedestrian routes that capture the diversity of land uses (residential, commercial, institutional) and traffic conditions found in Kolfe-Keranio. Sampling is stratified to include high-demand pedestrian corridors, known crash hotspots, and areas with varying sidewalk and crossing conditions so that findings reflect intra-sub-city variation rather than a single localized pocket.

Spatial analysis is conducted at multiple scales: point-level observations (site audits and pedestrian counts), segment-level indices (sidewalk continuity, pavement quality), and sub-city aggregations (average mobility and safety scores by neighborhood). GIS layers—road network, sidewalk coverage, crash locations, land use, and administrative boundaries—are used to map hotspots, visualize spatial patterns, and test spatial correspondence between low mobility and high risk. Results are therefore generalizable to Kolfe-Keranio as a whole and informative for site-specific interventions, while limitations in external validity beyond the sub-city are acknowledged and discussed.

1.6.2. The Thematic Scope

The study will explore several key concepts. Pedestrian Safety which is defined in terms of infrastructure quality, traffic regulations, and accident rates affecting pedestrians. Mobility, referring to the ability of individuals to move freely and safely within the urban environment, influenced by factors such as accessibility, public transport availability, and walkability. Urban Planning on the role of city design and planning in shaping pedestrian experiences and safety outcomes. The research will be grounded in theories related to urban mobility, safety, and human behavior, drawing upon existing literature to establish a framework for understanding the interactions between pedestrians, infrastructure, and traffic dynamics.

This study will adopt a quantitative-methods approach, using quantitative research methodologies. The quantitative aspect will involve surveys to gather numerical data on pedestrian safety issues and mobility patterns. Structured questionnaires will be distributed to a representative sample of pedestrians in Kolfe-Keranio Sub-city to collect data on their experiences regarding safety problems and mobility. Quantitative data will be analyzed using statistical methods to identify patterns and correlations.

Methodologically, the thematic scope integrates mixed sources and methods: primary data from structured questionnaires, site observations, and pedestrian counts; and secondary data from municipal reports, crash registries, and GIS layers. Analysis focuses on descriptive summaries, reliability and factor analyses for scale validation, multivariate regression to quantify associations, and GIS hotspot analysis to locate priority intervention sites. The study deliberately emphasizes equity and vulnerability how children, the elderly, and persons with disabilities experience safety and mobility differently and prioritizes actionable findings that inform short-term (crossing upgrades, traffic calming), medium-term (sidewalk repairs, lighting, drainage), and long-term (protected corridors, space reallocation) interventions for improving walking conditions in the sub-city.

1.6.3. Temporal /Time Scope

The research will be conducted over a period of six months, allowing adequate time for data collection, analysis, and synthesis of findings. The study will focus primarily on the current state of pedestrian safety and mobility in Kolfe-Keranio Sub-city as of 2025. However, it may also include a brief historical analysis of pedestrian safety trends over the past decade to provide context and highlight changes in infrastructure and policy.

1.7. Limitation of the Study

The study has several key limitations that may impact the depth and applicability of its findings. Data Collection Constraints arise from potential biases in self-reported surveys, which cannot fully capture pedestrian experiences. Additionally, limited access to official traffic accident records restricts the ability to validate findings comprehensively. The methodology relies on a quantitative-method approach, but the sample size may not be large enough to represent the full diversity of pedestrian challenges in the area. Seasonal factors such as traffic fluctuations and weather conditions were not explicitly accounted for, which could affect mobility patterns. The study also lacks a longitudinal perspective, meaning pedestrian behavior and infrastructure improvements over time are not assessed. Future research should address these gaps by expanding the scope and refining methodological approaches to enhance the reliability of findings.

The primary limitation of this research stems from localized field constraints during data collection in Kolfe-Keranio Sub-City, which led to a minor sample attrition from the initial target of 384 arespondents to a final analyzed sample of 366 valid cases. This slight reduction was caused by incomplete survey answers from fast-moving daily commuters during peak hours and the screening out of patterned responses during the post-survey data cleaning phase. Additionally, the study focused heavily on wide, high-risk arterial corridors measuring 20 meters and above; as a result, it may not fully capture the distinct safety dynamics found on narrower, localized neighborhood access roads.

1.8. Organization of the Study

The research paper will be organized into six chapters. Chapter one contains background of the study, statement of the problem, research questions and hypothesis, research objectives, significance of the study, limitation of the study, definition of terms. Chapter two provides literature review about the study area. Chapter three presents the Methodology which use in the research and this include research approach and design, population and sample size, methods of data analysis. Chapter four presents the Results of the Data's Chapter five will discuss about data analysis and results. Finally, chapter six will comprise conclusion and recommendation of the study.

1.9. Operational Definition of Terms

Pedestrian Safety: Pedestrian safety encompasses the protection of individuals traveling on foot from harm, particularly from collisions with vehicles and other traffic-related hazards. It involves a multi-faceted approach, addressing infrastructure design, traffic management, road user behavior, and enforcement of safety regulations (World Health Organization, 2018).

Mobility: Mobility refers to the ease and efficiency with which people can move from one location to another. In the context of urban environments and pedestrian safety, mobility encompasses the ability of pedestrians to navigate streets, cross roads, and access various destinations safely and conveniently (Litman, T., 2017).

Infrastructure: Infrastructure, in the context of transportation and pedestrian safety, refers to the physical elements that support movement, including roads, sidewalks, crosswalks, traffic signals, pedestrian signals, lighting, and signage (FHWA, 2013).

Traffic Behavior: Traffic behavior encompasses the interactions of all road users, including pedestrians, vehicles, cyclists, and other modes of transport, within the traffic environment. It includes speed, adherence to traffic laws, yielding behavior, and general road user conduct (OECD, 2012).

Vulnerable Road Users: Vulnerable road users are those who are at a higher risk of injury or fatality in traffic crashes compared to vehicle occupants. This group typically includes pedestrians, cyclists, motorcyclists, children, the elderly, and people with disabilities (WHO, 2018).

Urban Planning: Urban planning is the process of designing and managing the physical development of cities and urban areas. It encompasses land use planning, transportation planning, infrastructure development, and the creation of public spaces (Hall, P., 2002).

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Introduction

This chapter reviews theoretical frameworks and empirical literature on pedestrian safety, emphasizing how structural design, rather than just behavior, drives traffic risks, drawing on the Safe System Approach It examines pedestrian infrastructure and environmental factors, contrasting international best practices with challenges in sub-Saharan Africa to establish a foundation for analyzing transport dynamics in Addis Ababa

2.2. Theoretical Review

2.2.1. Safe System Approach

The Safe System Approach has emerged as a leading philosophy for achieving significant advancements in road safety around the globe (Austroads, 2016) This holistic and proactive strategy stands in stark contrast to traditional methods that primarily focused on placing the responsibility for avoiding accidents solely on road users (World Health Organization, 2021).

The core principle of the Safe System Approach is a fundamental ethical commitment: no loss of life or serious injury is acceptable on the road (U.S. Department of Transportation, 2015). This represents a crucial shift from a reactive approach that attempts to minimize the frequency of crashes to a proactive approach that prioritizes preventing fatalities and severe injuries even when crashes do occur (Eluru, N., 2018).

This shift in focus is driven by two key acknowledgements. Firstly, the Safe System Approach recognizes the inherent fallibility of humans. People make mistakes, and the road system should be designed with this in mind (Transportation Research Board, 2016). Secondly, the approach acknowledges the physical limitations of the human body. Our bodies can only withstand a certain level of impact in a collision (World Road Association (PIARC), n.d.).

Therefore, the Safe System Approach advocates for designing a road environment that minimizes the likelihood of crashes due to human error and provides a higher level of protection for road users in the event of a collision (Giuliano, G., & Dargay, J., 2009)This can involve a range of measures, including:

Improved infrastructure design with safer roads with features like designated lanes, wider shoulders, and proper intersections can reduce the risk of crashes. Vehicle safety standards by enacting stricter standards for vehicle safety features, such as stronger bodies and advanced driver-assistance systems, can significantly mitigate injury severity in collisions. Traffic management strategies like Speed limits, clear signage, and effective traffic signalization can promote a safer flow of traffic. Vulnerable user protection by Designing roads with dedicated spaces for pedestrians and cyclists and prioritizing their safety considerations is crucial.

2.2.2. Rational Choice Theory

Rational choice theory stands as a cornerstone concept within both economics and the broader social sciences, offering a framework for comprehending and modeling human decision-making (Friedman, M., & Landes, W., 1998). Central to this theory is the assumption that individuals, when faced with a choice, engage in a cost-benefit analysis, meticulously weighing the potential advantages and drawbacks of each available option (Camerer, C., & Loewenstein, G., 2003). Ultimately, they make the selection that aligns most closely with maximizing their own personal benefit, or what economists refer to as their utility (Benartzi, S., & Thaler, R. H., 2004).

The roots of rational choice theory can be traced back to the classical era of political economy. A prominent figure in this movement, Adam Smith, is widely recognized for laying the groundwork for the theory with his influential concept of the "invisible hand" (Smith, A., 1776). Smith proposed that while individuals, acting in their own self-interest, make choices aimed at maximizing their personal gain, these choices, through an invisible market force, ultimately serve the greater good of society by promoting economic prosperity and efficiency (Stigler, G. J., 1982). This concept has been a cornerstone of economic thought and continues to influence modern economic models.

Rational choice theory rests on a core set of assumptions about human behavior in decision-making situations (Camerer, C., & Loewenstein, G., 2003). One fundamental assumption is that individuals possess preferences among the available choices. These preferences are not random or arbitrary; rather, they are imbued with a sense of value or desirability (Benartzi, S., & Thaler, R. H., 2004).

Another critical tenet of rational choice theory is the principle of utility maximization. This principle posits that, given their established preferences and any relevant constraints, individuals will gravitate towards the option that delivers the highest level of satisfaction or utility (Benartzi, S., & Thaler, R. H., 2004). Utility is a subjective concept that encompasses the overall benefit or value an individual derives from a particular choice.

The concept of utility is versatile and can encompass a broad spectrum of factors that influence decision-making. It can include tangible elements like monetary gain or cost savings, but it can also extend to intangible aspects like personal satisfaction, enjoyment, or the avoidance of negative experiences (Camerer, C., & Loewenstein, G., 2003). human behavior in various decision-making contexts.

Rational choice theory, while influential, has attracted its share of critiques. Critics argue that the theory presents an overly simplistic view of human decision-making (Simon, H. A., 1982). They contend that human behavior is far more nuanced and susceptible to a wider range of influences than the theory acknowledges. Despite these criticisms, rational choice theory remains a foundational concept in economics (Friedman, M., & Landes, W., 1998). It offers a structured framework for analyzing decision-making processes by assuming that individuals, within a set of constraints, act rationally in pursuit of their self-interest. This framework provides a clear and concise basis for predicting behavior and understanding economic phenomena.

Furthermore, the applicability of rational choice theory extends beyond economics. The core principles have been utilized in various fields, including political science, sociology, and philosophy, to model and explain behavior in diverse contexts (Elster, J., 1986). While acknowledging its limitations, scholars recognize the value of rational choice theory as a tool for understanding and predicting patterns of choice within economic and social environments.

2.2.3. Broken Windows Theory

The Broken Windows Theory, a seminal concept in the realm of criminology and urban sociology, posits that visible signs of disorder, such as broken windows, graffiti, and other forms of urban decay, can lead to an increase in crime. This theory was first introduced by social scientists (Wilson, J. Q., & Kelling, G. L., 1982). article titled "Broken Windows", published in The Atlantic Monthly. The core idea is that maintaining and monitoring urban environments to prevent small crimes such as vandalism and public drinking helps to create an atmosphere of order and lawfulness, thereby preventing more serious crimes from happening (Wilson, J. Q., & Kelling, G. L., 1982).

The theory's name comes from the metaphor of a broken window, suggesting that if a window in a building is broken and left unrepaired, people walking by will conclude that no one cares about the building and that it is acceptable to break more windows. This metaphor extends to the community level, where visible signs of disorder and neglect result in an environment that feels unsafe, which can encourage more serious crime (Kelling, G. L., & Coles, C. M., 1996).

While the theory's effectiveness in reducing overall crime rates remains a subject of debate (Braga, A. A., & Weisburd, D., 2014), there are potential applications of the Broken Windows Theory to promote pedestrian safety through stricter traffic enforcement.

When traffic laws, particularly those pertaining to pedestrian safety, are consistently and visibly enforced, it sends a clear message to drivers that such behavior will not be tolerated. This increased enforcement presence can deter drivers from engaging in risky maneuvers, like speeding, failing to yield the right of way to pedestrians in crosswalks, or distracted driving, which can significantly contribute to pedestrian accidents (Giuliano, G., & Dargay, J., 2009).

By addressing minor traffic violations, such as rolling stops at stop signs or not using turn signals, authorities can create a more predictable and controlled traffic environment. This predictability improves safety for all road users, including pedestrians, as it allows them to navigate intersections and crosswalks with a greater sense of security (Eluru, N., 2018).

Consistent enforcement of traffic laws fosters a culture of safety on the roads. Pedestrians are more likely to feel comfortable walking and crossing streets if they perceive drivers to be attentive and following the rules (Pucher, J., & Buehler, R., 2017). This creates a positive feedback loop, where increased pedestrian activity can further incentivize stricter traffic enforcement, leading to a safer environment for everyone.

2.2.4. Theory of Planned Behavior

The Theory of Planned Behavior (TPB) is a psychological framework that predicts and explains human behavior in specific contexts. Developed by Icek Ajzen in 1985, (Ajzen, I., 1985). TPB posits that an individual's behavior is determined by their intention to perform the behavior, which is influenced by their attitude towards the behavior, subjective norms, and perceived behavioral control (Ajzen, I., 1985). Attitude towards the behavior reflects the individual's positive or negative evaluation of performing the behavior. Subjective norms refer to the perceived social pressure to perform or not perform the behavior. Perceived behavioral control relates to the individual's belief in their capability to execute the behavior under various circumstances (Ajzen, I., 1991),

TPB is an extension of the Theory of Reasoned Action (TRA), which posited that behavioral intention is influenced only by attitude and subjective norms. Ajzen introduced the concept of perceived behavioral control to account for situations where individuals may be motivated to perform a behavior but feel hindered by external factors (Ajzen, I., & Fishbein, M., 1980). In health psychology, TPB has been utilized to understand behaviors such as smoking cessation, exercise, and safe sex practices. It helps in designing interventions by identifying the beliefs that can be targeted to change intentions and behaviors (Brookes, J., 2023).

For instance, a health campaign aiming to reduce smoking might use TPB by addressing individuals' attitudes towards smoking (e.g., its health risks), altering subjective norms (e.g., highlighting disapproval of smoking by significant others), and increasing perceived behavioral control (e.g., providing resources to aid in quitting) (Simply Psychology Editorial Team, 2023). TPB has also been applied in environmental psychology to predict recycling behavior, in consumer finance to understand purchasing decisions, and in political science to analyze voting behavior, demonstrating its versatility across domains (Wikipedia, 2024).

Despite its widespread application, TPB is not without criticism. Some argue that the model does not account for habitual behaviors or those performed without conscious intention. Others point out that the predictive power of perceived behavioral control is not consistent across all behaviors (SpringerLink Editorial Team, 2024)

2.3. Conceptual Review

Pedestrian safety is a paramount concern for urban planners and traffic management authorities (Giuliano, G., & Dargay, J., 2009). The ever-growing number of vehicles on the road has exacerbated this issue, making pedestrian safety a pressing matter worldwide (Eluru, N., 2018). Traffic rules and regulations are established with the primary goal of creating a safe and orderly flow of traffic, encompassing both vehicles and pedestrians (Simeone & Miller, LLP, 2023). This theoretical review delves into the impact of these rules and regulations on pedestrian safety. By drawing on various scholarly studies and statistical data, this review aims to provide a comprehensive understanding of this crucial topic.

2.3.1. Traffic Regulations

Traffic regulations and enforcement are fundamental pillars of road safety management (Austroads, 2016). Their primary purpose is multifaceted: to minimize the frequency of traffic accidents, ensure a smooth flow of traffic, and ultimately, enhance the safety of all users on the road (Giuliano, G., & Dargay, J., 2009). Traffic regulations can be understood as the legal framework, established by traffic authorities, that governs the movement of both vehicles and pedestrians on roadways (Simeone & Miller, LLP, 2023). Enforcement, on the other hand, refers to the actions undertaken by law enforcement agencies to guarantee adherence to these regulations (Piliavin, I., & Briar, S., 1964).

Traffic regulations encompass a broad spectrum of gui (Simeone & Miller, LLP, 2023). delines that govern the safe and orderly movement of vehicles and pedestrians on (Simeone & Miller, LLP, 2023). These regulations typically address a multitude of areas, including:

Established speed limits are determined by factors like road design, traffic volume, and pedestrian presence. They aim to reduce the severity of crashes and allow drivers ample reaction time for unexpected situations (Austroads, 2016). Clear communication is key for both drivers and pedestrians. Traffic signals, such as red lights and stop signs, dictate right-of-way and control traffic flow at intersections. Similarly, road signs provide crucial information about upcoming hazards, lane designations, and pedestrian crossings (Giuliano, G., & Dargay, J., 2009). Traffic regulations also encompass rules on occupant safety, like mandatory seat belt use, and prohibit dangerous driving behaviors such as operating a vehicle under the influence of alcohol or drugs (Peden, M., Scurfield, R., Sleet, D., Mohan, D., Hyder, A. A., Jarawan, E., & Mathers, C., 2004).

These regulations are often codified within legal documents and their enforcement is crucial for maintaining order and safety on the roads. Enforcement strategies utilize a combination of methods, including:

This traditional approach involves traffic police officers patrolling roadways, actively observing traffic flow, and issuing citations for violations they witness (Piliavin, I., & Briar, S., 1964). Technological advancements have led to the increased use of automated enforcement systems. Red-light cameras and speed cameras capture photographic evidence of violations, triggering the issuance of fines without the need for a physical officer on the scene. Studies by (Wilson, C., 2010). have shown these systems to be effective deterrents, demonstrably reducing both traffic violations and accidents.

The effectiveness of traffic regulations and enforcement hinges on a combination of factors. Visible enforcement through police presence or automated systems serves as a constant reminder of the rules and potential consequences (Retting, R. A., 2008). Additionally, the perceived risk of being caught, influenced by both enforcement visibility and the severity of potential penalties, plays a major role in deterring violations. Public education campaigns that raise awareness of traffic laws and their importance further contribute to a culture of safe driving and pedestrian behavior (Simeone & Miller, LLP, 2023). Research by (Retting, R. A., 2008). confirms that consistent enforcement coupled with significant penalties leads to increased compliance with traffic regulations, ultimately resulting in a reduction in accidents and fatalities on our roads.

2.3.2. Pedestrian Safety

Pedestrian safety is a paramount public health concern, as it directly impacts the well-being of individuals who travel on foot (Giuliano, G., & Dargay, J., 2009). Understanding the complexities of pedestrian safety requires a multifaceted approach, considering environmental factors, human behavior, and the potential role of technological advancements in mitigating the risk of accidents and injuries (Eluru, N., 2018).

One crucial aspect of pedestrian safety is a pedestrian's ability to effectively perceive their surroundings within a complex multimodal environment. Davis, Pugliese, and Barton (Davis, R., Pugliese, J., & Barton, K., 2019). delve deeper into this concept, highlighting the importance of understanding how pedestrians utilize a combination of sensory cues, both visual and auditory, to navigate safely. Their research suggests that future strategies aimed at enhancing pedestrian safety should give greater consideration to the unique contributions of each sensory modality. For instance, improved street lighting and audible pedestrian crossing signals can work together to create a more comprehensive and accessible safety system for pedestrians (Simeone & Miller, LLP, 2023).

Delving deeper into the role of perception in pedestrian safety, Pugliese (2020) conducted a study on the accuracy of vehicle time-to-arrival estimations under various sensory conditions. Their research revealed that visual cues are significantly more advantageous for pedestrians navigating traffic compared to auditory cues, especially in environments with substantial background noise (Pugliese, J., 2020). This finding underscores the critical role of clear sightlines and proper road design in ensuring pedestrian safety.

Furthermore, (National Research Council, 2023), has made valuable contributions to the field by establishing safety performance functions specifically for pedestrians and bicyclists. These functions provide a comprehensive framework for evaluating the effectiveness of existing safety measures and for guiding the development of new ones (National Research Council, 2023). It's important to acknowledge that pedestrian safety extends beyond just perception. Behavioral factors also play a substantial role (Fobian, A., 2020). emphasize the dangers associated with behaviors like sleep deprivation and texting while walking. Their research demonstrates how these actions can significantly impair a pedestrian's judgment and reaction time, ultimately leading to a heightened risk of accidents (Fobian, A., 2020).

2.3.3. Risk Factors

Traffic systems are inherently complex and dynamic, characterized by a constant interplay of factors that can significantly impact safety and efficiency (Giuliano, G., & Dargay, J., 2009). Understanding these risk factors and implementing effective mitigation strategies is paramount in creating a safer and more reliable transportation network.

Human error stands out as one of the most critical contributors to traffic incidents (Cascade Team Editorial Staff, 2023). Distracted driving, often caused by the use of electronic devices or inattentiveness, can significantly impair a driver's reaction time and situational awareness, increasing the risk of accidents (Liang, Y., 2019). Furthermore, driving under the influence of alcohol or drugs further compromises judgment and coordination, posing a grave threat to all road users (Peden, M., Scurfield, R., Sleet, D., Mohan, D., Hyder, A. A., Jarawan, E., & Mathers, C., 2004). Additionally, blatant disregard for traffic regulations, such as speeding or failing to yield the right of way, can have devastating consequences (Eluru, N., 2018).

Beyond human behavior, external factors also play a role in jeopardizing traffic safety. Adverse weather conditions, such as dense fog, heavy rain, or icy roads, can dramatically reduce visibility and road traction, making it difficult for drivers to maintain control of their vehicles (FCM Travel, 2022). Furthermore, poorly designed or inadequately maintained infrastructure, like roads with limited visibility or inadequate signage, can contribute to traffic accidents (Eluru, N., 2018)

Mechanical failures, although unpredictable, can significantly impact safety. Brake malfunctions or tire blowouts can cause drivers to lose control of their vehicles, leading to severe accidents (NHTSA, 2022). Poorly designed roadways with limited visibility, inadequate signage, or malfunctioning traffic signals create confusion and increase the risk of accidents (Eluru, N., 2018). While in-vehicle technology offers numerous benefits, it can also be a double-edged sword. Features like navigation systems or entertainment options can divert a driver's attention from the road, compromising their ability to react to hazards (Liang, Y., 2019).

2.3.4. Mitigation Strategies

Promoting safe driving practices through educational campaigns can raise awareness and encourage responsible behavior on the road (IBM Editorial Team, 2023). This can include educating drivers on the dangers of distracted driving, the importance of proper vehicle maintenance, and the need to adapt driving behavior to adverse weather conditions. Upgrading road infrastructure to improve visibility, providing clear and consistent signage, and ensuring the proper functioning of traffic signals are crucial steps in mitigating risks associated with the environment (Austroads, 2016).

Enforcing stricter vehicle maintenance and safety standards can significantly reduce the likelihood of mechanical failures leading to accidents. Regular inspections and adherence to safety regulations can help ensure vehicles remain in good working condition (NHTSA, 2022). Technological advancements can play a positive role in enhancing traffic safety. Collision avoidance systems that warn drivers of potential hazards and automated traffic management systems that optimize traffic flow can contribute to a safer driving environment (Giuliano, G., & Dargay, J., 2009).

Establishing and enforcing robust traffic laws and regulations serve as a deterrent to risky behavior. Strict enforcement measures, coupled with clear and consistent traffic regulations, can create a culture of safety on the roads (Simeone & Miller, LLP, 2023). By implementing a comprehensive approach that addresses both human behavior and the various environmental and technological factors that contribute to traffic risk, we can create safer and more efficient transportation systems for everyone.

2.4. Empirical Review

2.4.1. Global Context

The intricate relationship between traffic regulations and pedestrian safety has been a focal point of urban planning and public health policy. Globally, empirical studies have sought to understand and quantify the effects of these regulations on reducing pedestrian fatalities and injuries.

One pivotal study conducted by Soathong, (Soathong, K., Wilson, D., Ranjitkar, P., & Chowdhury, M., 2019). critically reviewed policies on pedestrian safety with a case study of New Zealand. They found that evidence-based approaches to road safety policies have contributed to an overall reduction in road crashes. However, they noted that little attention had been paid to pedestrian behavior related to crashes, suggesting a potential area for further research and policy development.

(Mukherjee, A., & Saha, S, 2022). reviewed recent research on pedestrian safety at different types of facilities. Their findings highlighted the increased risk of road crashes due to the absence of traffic enforcement and sufficient safety measures, particularly at uncontrolled intersections and mid-blocks. This underscores the importance of comprehensive traffic rules that address not only the behavior of drivers but also the infrastructure that supports pedestrian movement.

A study focusing on the effect of road network patterns on pedestrian safety employed a zone-based Bayesian spatial modeling approach, revealing that certain road network designs can significantly influence pedestrian safety outcomes (Anonymous (multi-author study), 2016)This study emphasizes the need for urban planners to consider pedestrian safety in the initial design stages of road networks.

Furthermore, Stanton explored the relationships between pedestrian behaviors and traffic safety attitudes in six countries. Their research provided valuable insights into the demographic, economic, and cultural factors that influence pedestrian safety and compliance with traffic rules.

The body of empirical research indicates that traffic rules and regulations play a crucial role in enhancing pedestrian safety. However, these studies also highlight the need for a multifaceted approach that includes not only the enforcement of traffic laws but also the design of pedestrian-friendly infrastructure and the consideration of pedestrian behavior in policy-making.

2.4.2. African Context

Pedestrian safety presents a critical public health concern across Africa, where rapid urbanization and motorization often outpace infrastructure development and traffic regulation enforcement (World Health Organization, 2020) This creates a dangerous environment for pedestrians, who are particularly vulnerable road users.

(Nteziyaremye, A., & Sinclair, M., 2013). study in Stellenbosch, South Africa, offers valuable insights into pedestrian crossing behavior. Their research, employing video observation and interviews, explored how beliefs and attitudes towards traffic control devices influence pedestrian actions. The study revealed that a significant portion of pedestrian fatalities (around 40%) occur during road crossings, often due to disregard for traffic signals or a lack of understanding of their functionality (Nteziyaremye, A., & Sinclair, M., 2013). This highlights the need for targeted interventions that promote pedestrian education and encourage adherence to traffic control measures.

(Mukherjee, A., & Saha, S, 2022). review of recent research expands the conversation on pedestrian safety by emphasizing the role of human behavior. They identify mobile phone usage and panic-stricken reactions as factors that can significantly increase pedestrian risk. Their review also underscores the crucial role of traffic enforcement in deterring risky behavior. Furthermore, they call for further research to explore the complex interplay between various factors, including traffic characteristics, human psychology, and the road environment itself (Mukherjee, A., & Saha, S, 2022) This comprehensive approach is essential for developing effective interventions that address both infrastructure limitations and human behavior.

The Sustainable Safe Transport Project's (SSATP) report on road safety data systems in Africa tackles a fundamental challenge (SSATP, n.d.). The report emphasizes the importance of establishing a standardized set of police-reported crash-related variables throughout Africa. The lack of data harmonization hinders comprehensive understanding of the regional road safety landscape and makes it difficult to develop evidence-based policies and interventions.

A recent South African study delves into a relatively unexplored aspect of pedestrian safety: driver characteristics (Abraham, T., 2020). This research highlights the fact that driver behavior plays a critical role in pedestrian safety, with 40% of traffic fatalities involving pedestrians. By examining factors associated with unsafe driving practices, such as speeding, distracted driving, or driving under the influence, this study opens new avenues for intervention strategies that target driver behavior modification alongside pedestrian education (Abraham, T., 2020)

2.5. Contextual Review

2.5.1. Ethiopian Context

Pedestrian safety is a critical public health concern in Ethiopia, where rapid urbanization, increasing motor vehicle ownership, and limited road infrastructure create a dangerous environment for pedestrians (World Health Organization, 2020). Road traffic accidents are a leading cause of death and injury, with pedestrians disproportionately represented among the victims (Ethiopian Federal Police Commission, 2021).

Abegaz (2014) investigated the effectiveness of revised road safety policies implemented by the Oromia Regional State Transport Bureau in September 2007. Their study employed a segmented linear regression model to analyze routine road traffic accident data from 2002 to

2011, collected from sixteen traffic police offices across the region. The research revealed a statistically significant reduction in both non-injury crashes (19%) and fatalities (12.4%) in the first year following the implementation of the new regulations. These findings suggest that the revised policies, which likely included stricter enforcement measures and potentially changes to traffic flow or pedestrian infrastructure, had a positive initial impact on road safety (Abegaz, T., 2014).

A comprehensive review by the United Nations Economic Commission for Europe (UNECE) in 2013 examined Ethiopia's overall road safety management strategies, encompassing infrastructure, vehicle safety standards, and legal frameworks (UNECE, 2013). The report provides an in-depth analysis of trends in road traffic crashes, including the specific types of crashes involving pedestrians. The studies by (Abegaz, T., 2014) and the s (UNECE, 2013), provide a strong foundation for understanding the relationship between traffic rules and regulations, and pedestrian safety in Ethiopia. Further research is necessary to explore the long-term impact of policy changes and identify additional factors that influence pedestrian safety in the Ethiopian context.

2.5.2. Pedestrian Safety in Addis Ababa

Addis Ababa, the capital city of Ethiopia, is undergoing rapid urbanization, motorization, and population growth, and this is creating a serious effect on pedestrian safety and urban mobility. Though the number of pedestrians is the highest on the road, the risks are also higher due to inadequate infrastructure, poor enforcement of traffic laws, and a lack of awareness among the population. In this study, the problem of pedestrian safety in Addis Ababa will be examined, and the causes, effects, and ways forward will be discussed.

The author has developed a model based on the findings and recommendations of various studies and best practices in the field, which will help to improve pedestrian safety and, in turn, urban mobility in the capital city of Ethiopia, benefiting the entire population.

Addis Ababa, the capital city of Ethiopia, has a population of over five million people and is the political, economic, and cultural center of the country. The city is undergoing tremendous growth and is facing a lot of strain on the transport system due to the effects of motorization, informal settlements, and unplanned growth. It is estimated that over 80% of the total trips are made on foot in Addis Ababa (Tulu, G., Washington, S., King, M., & Haque, M., 2017). However, the pedestrians are the most disadvantaged in the urban transport system. According to the Addis Ababa Traffic Management Agency, the number of pedestrians killed in road accidents is over 60% every year (Addis Ababa Traffic Management Agency, 2021). Thus, it is a problem of convergence and a critical issue in the field of urban transport and pedestrian safety, which needs immediate policy intervention.

In this paper, the problem of pedestrian safety in Addis Ababa will be examined, and the ways forward will be discussed.

The city, which is the capital of Ethiopia, is witnessing rapid urbanization, which is matched by rapid population growth, thereby increasing transport needs and contributing to the complexities of traffic. In addition, as the city expands into its periphery, walking is seen as an important transport mode, and safety becomes a major issue.

In spite of the significance of walking as an important transport mode that seeks to promote equitable access, safety is seen as a major issue affecting pedestrians in Addis Ababa. This is worsened by inadequate infrastructure, mixed traffic, and poor adherence to traffic (Gebremedhin, A., Tulu, G., & Washington, S., 2020)

The city is characterized by high pedestrian activity, especially in areas such as the central business district, residential areas, and major transport corridors. According to the Addis Ababa Transport Master Plan, 60-70% of daily trips involve walking and other modes of non-motorized transport, which is an indication that walking is a major transport mode. This is an indication that safety is seen as an important aspect that seeks to promote injury and fatality prevention.

One of the significant factors that compromise the safety of pedestrians is the poor state of pedestrian infrastructure. Sidewalks are rarely available; when they are, they are usually narrow and often congested with vendors or parked vehicles, leaving pedestrians with no other choice but to share the road with other vehicles. This is evident in the study conducted by (Gebremedhin, A., Tulu, G., & Washington, S., 2020).

Pedestrians are among the road traffic participants that are frequently involved in road traffic accidents in Addis Ababa. According to the study conducted by (Gebremedhin, A., Tulu, G., & Washington, S., 2020). approximately 40% of road traffic accidents in Addis Ababa are attributed to pedestrians. The poor adoption of traffic calming measures and the poor enforcement of speed limits not only contribute to the number of accidents involving pedestrians but also to the severity of the accidents, as the accidents may escalate to more serious or even fatal accidents.

The regulations regarding traffic in Ethiopia have been formulated with a special focus on pedestrians, but enforcement of these regulations has been poor due to a lack of resources (Mekonnen, D., Tulu, G., & Haque, M., 2019). It has been a common phenomenon for drivers to violate speed regulations while driving, especially when pedestrians are crossing the road, and the penalty imposed is meager. Moreover, urban planning has focused more on motorized traffic than on the requirements of pedestrians, leading to a lack of infrastructure and regulations regarding pedestrian safety (Addis Ababa City Administration, 2018).

Recently, a new trend has been noticed, with a greater focus being laid on improving the roads and enhancing the infrastructure available to pedestrians. Some of the developments mentioned are the construction of footpaths, pedestrian flyovers, and the establishment of traffic signals at major intersections (Gebremedhin, A., Tulu, G., & Washington, S., 2020). Although this is a step in the right direction, it has to be expanded, and a comprehensive plan has to be devised regarding pedestrian safety.

Speed humps, raised crosswalks, and curb extensions are some of the measures that have shown promise in reducing the speed of vehicles, thus improving pedestrian safety (Ewing, 1999). Although pilot projects in some areas of Addis Ababa have shown promise, these measures need to be implemented at a larger scale.

Both non-governmental organizations and local authorities have attempted to mobilize the community for road safety, with campaigns focusing on educating road users, including pedestrians (Damsere-Derry, J., Peden, M., & Afukaar, F., 2020). The campaigns cover issues such as pedestrian rights, appropriate conduct when crossing the road, and the risks of speeding.

Strengthening the policies and institutions is vital for incorporating pedestrian safety considerations into the city's planning and transport policies and strategies. Improving coordination and cooperation among traffic police, city planners, and transport organizations is likely to improve enforcement and maintenance of road infrastructure (Addis Ababa City Administration, 2018).

for all residents.

2.5.2.1. Reported number of deaths and injuries in Addis Ababa

There has been a decline in the number of fatal victims and fatal crashes since 2018/19. In 2022/23, the number of reported fatalities dropped by 8% compared to 2021/22. Similarly, the number of fatal crashes also decreased by 4% in 2022/23 from the previous year (Figure 2-2).

The reduction in fatalities could partially be attributed to sustained enhanced enforcement on speeding.

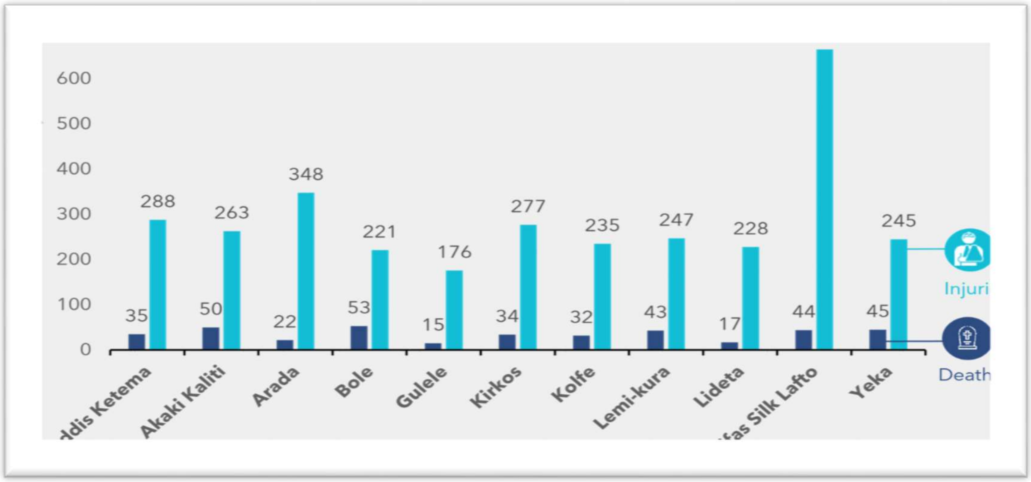

Figure 2-1: number of death and injuries in Addis Ababa

(Source:Addis Ababa Road Safty Report 2022/202

2.5.3. Pedestrian Walkways in Kolfe Keranio: Enhancing Urban Mobility and Safety

Kolfe Keranio is a sub-city of Addis Ababa, Ethiopia’s capital city. It is a fast-growing area with a diverse population of locals, where the main means of transportation is walking. In an era of fast-growing urbanization and increasing numbers of vehicles, the need for efficient walkways is quite pronounced. In this paper, the walkways for pedestrians in Kolfe Keranio are discussed, revealing various challenges and possible solutions.

Lack of Infrastructure: There are many walkways in disarray or lack thereof, and pedestrians are left with little choice but to walk on the sides of the roads. This has significantly increased the chances of accidents for pedestrians, and it is quite evident how unsafe it is for children and the elderly.

Intrusions: The walkways are often interrupted by illegally parked vehicles and vendors, among other things, which makes it difficult for pedestrians to walk safely on these paths. This has discouraged pedestrians from using these walkways, and they are thus forced to walk on the roads, increasing the chances of accidents.

Obstructions: The walkways are often obstructed in one way or another, and this has discouraged pedestrians from using the walkways, thus increasing the chances of accidents as they are often forced to walk on the roads.

Figure 2-2 Obstructions of pedstrian walkway

Maintenance Issues: Lack of maintenance of sidewalks is also a factor that affects the safety of walking routes. Broken sidewalks, potholed sidewalks, and uneven walking routes are factors that hinder walking and are dangerous, especially for the disabled.

Limited Crosswalks: Limited crosswalks are also a problem in this city, and this has led to many instances where pedestrians are forced to engage in behaviors such as jaywalking in order to cross the street safely.

Behavioral Patterns

Pedestrian safety is also affected by behavioral patterns in a great way. It is possible that a large portion of the violations of traffic rules may be attributed to residents, and some may also think that the street is not safe due to the erratic behaviors of drivers. It is also notable that the increase in the rate of jaywalking may be attributed to a lack of awareness by drivers regarding their obligations towards pedestrians.

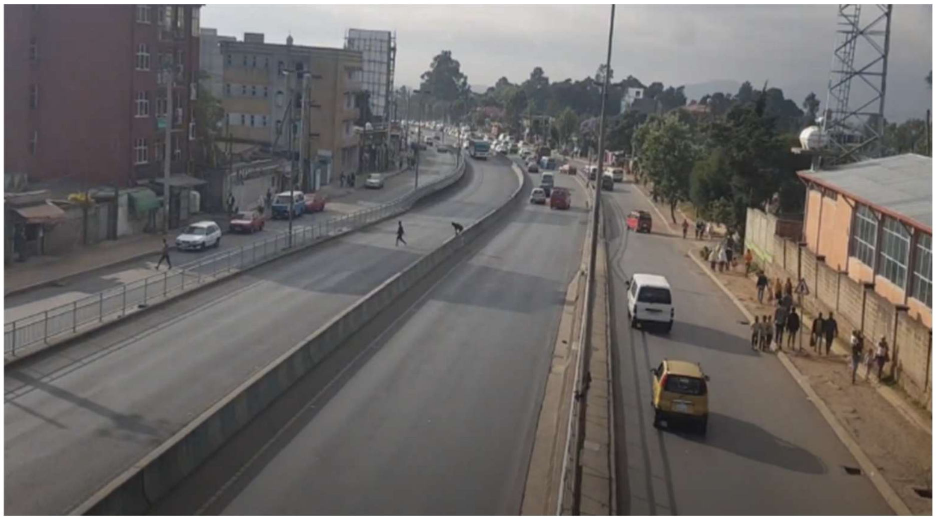

Figure 2-3 unsafe crosswalk in kolfe keranio ring road

Improving pedestrian walkways in Kolfe Keranio is vital for creating a safe and accessible city environment. Through effective urban rehabilitation, traffic management, stakeholder engagement, and the use of modern technologies, Kolfe Keranio will significantly improve its pedestrian walkways. Apart from enhancing the movement of residents, it is likely to improve their quality of life and promote pedestrian walkways as the preferred means of movement in this dynamic city district. As the city continues to receive more residents, pedestrian safety and the provision of the required facilities will be key in its long-term development.

2.5.4. Challenges of Pedestrian peoples with disabilities (PWDS)

Persons with disabilities (PWDS) are a large and major segment of the marginalized groups in the urban population. PWDS in Kolfe Keranio, which is part of Addis Ababa in Ethiopia, face different kinds of hindrances in their movement as pedestrians. Since walking is a common means of transportation in Ethiopia, it is also common for PWDS to walk in their daily lives. Therefore, it is very important to provide accessibility to pedestrian facilities for PWDS in Kolfe Keranio, which is part of Addis Ababa in Ethiopia.

Kolfe Keranio is part of Addis Ababa in Ethiopia, which is considered to be a typical inner city with high-density residential areas and mixed land use patterns. The population in this region relies on informal modes of transportation for their daily movement, which is mainly by walking (Addis Ababa City Administration, 2018). Despite different international and local commitments to the rights of PWDS, this region in Ethiopia is inaccessible to most PWDS, which affects their social and economic participation in society (Gebremedhin, A., Tulu, G., & Washington, S., 2020).

PWDS as Pedestrians Face Problems Due to Insufficient Physical Infrastructure. PWDS face different kinds of hindrances in their movement in Kolfe Keranio in Ethiopia due to insufficient physical infrastructure facilities for pedestrians. Since sidewalks in this region are in poor condition, it is very difficult for wheelchair-bound persons and persons with limited mobility to move around in Kolfe Keranio in Ethiopia (Gebremedhin, A., Tulu, G., & Washington, S., 2020).The absence of curb cuts at street intersections and insufficient facilities for the blind also hinder their movement in Kolfe Keranio in Ethiopia, which affects their safety of movement (Mekonnen, D., Tulu, G., & Haque, M., 2019)

2.6. Conceptual Framework

The conceptual framework below illustrates how localized safety hazards interact to influence and restrict **Pedestrian Mobility** in Kolfe-Keranio Sub-City. It maps your four independent variables alongside the underlying theoretical foundations (The Safe System Approach and Sustainable Urban Mobility frameworks) that explain this relationship.

The conceptual framework diagram models the structural and behavioral pathways through which localized safety hazards dictate urban walkability. Anchored by the Safe System Approach and Sustainable Urban Mobility frameworks, the model positions Pedestrian Mobility (PM) as the core dependent variable, which is directly shaped by four distinct independent dimensions: Pedestrian Infrastructure (PI), Traffic Conditions (TC), Environmental Factors (EF), and Pedestrian Driver Behaviors (PDB).

The underlying premise of this model is that urban mobility cannot be evaluated in isolation from the safety of the built environment. When structural infrastructure is fragmented, traffic conditions are unmanaged, environmental stressors are high, and road behaviors are aggressive, they form a combined mechanism of mobility suppression. This directly compromises walking efficiency, causes travel delays due to protective detours, and fosters social exclusion for vulnerable demographics. Conversely, positive improvements within these four independent fields work together to build a forgiving road network that minimizes conflict points, protects active commuters, and optimizes functional freedom of movement across the sub-city's transport corridors.

The conceptual framework for this study is designed to explore the relationship between independent and the dependent variable in Kolfe-Keranio Sub-City. The framework is grounded in existing literature and theories related to pedestrian safety, urban mobility, and transportation planning.

There are a number of factors that potentially affect pedestrian mobility as exhaustively discussed in Chapter One based on various literatures. However, the researcher decided to assess the pedestrian infrastructure, traffic conditions, environmental factors, and pedestrian and driver behaviors that influence on pedestrian mobility in Kolfe Keranio Sub-City. Therefore, in this particular study, the

Dependent variable: is the current status of pedestrian mobility in Kolfe Keranio Sub-City.

Independent variables: pedestrian safety problems (i.e., pedestrian infrastructure, traffic conditions, environmental factors, and pedestrian and driver behaviors).

Dependent Variable

- **Pedestrian Mobility:** Pedestrian mobility refers to the ease and safety with which pedestrians can move within an urban area. Poor pedestrian mobility can lead to reduced access to essential services, increased reliance on vehicles, and social exclusion, particularly for vulnerable groups (Gehl, J., 2010).

Independent Variables

- **Pedestrian Infrastructure:** This refers to the physical facilities designed to support pedestrian movement, such as sidewalks, crosswalks, footbridges, and lighting. Poor infrastructure, such as narrow sidewalks, lack of crosswalks, or inadequate lighting, can hinder pedestrian mobility and increase safety risks (World Health Organization, 2013)
- **Traffic Conditions:** Traffic conditions include factors such as traffic volume, vehicle speed, and traffic flow management. High traffic volumes and speeding vehicles can create unsafe environments for pedestrians, reducing their willingness to walk and limiting their mobility (Jacobs, G., Aeron-Thomas, A., & Astrop, A., 2015).
- **Environmental Factors:** Environmental factors encompass weather conditions, topography, and urban design. For example, poor weather (e.g., rain or fog) can reduce visibility and increase the risk of accidents, while steep terrain or poorly designed urban spaces can make walking difficult (Litman, T, 2021).
- **Behavioral Factors:** Behavioral factors include the actions and attitudes of both pedestrians and drivers. Pedestrian behavior, such as jaywalking or ignoring traffic signals, and driver behavior, such as failing to yield to pedestrians, can significantly

impact safety and mobility (Peden, M., Scurfield, R., Sleet, D., Mohan, D., Hyder, A. A., Jarawan, E., & Mathers, C., 2004).

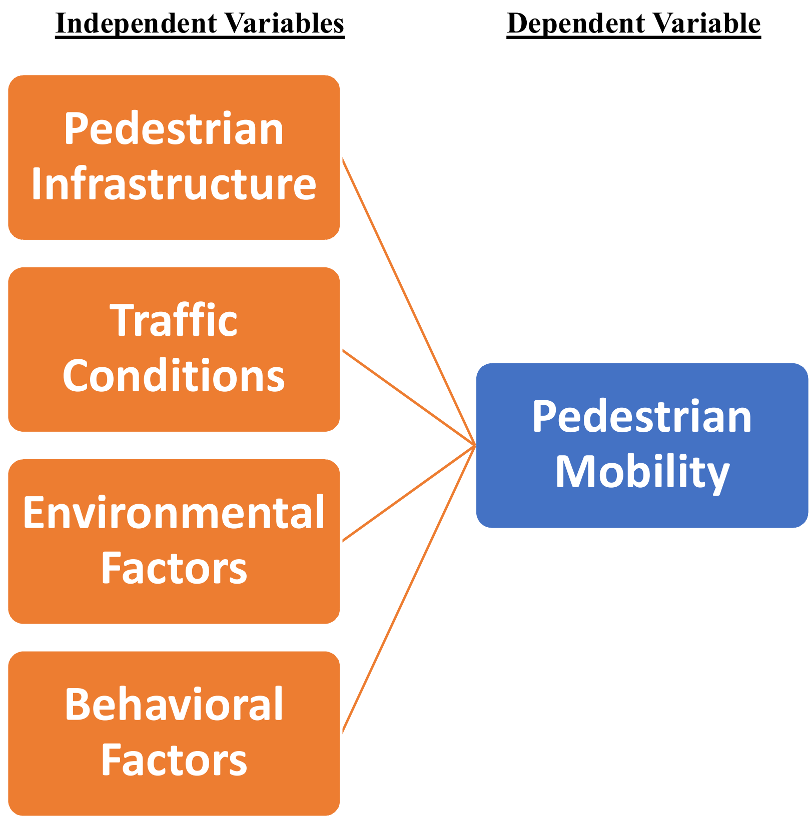

Figure 2.4: Conceptual Framework of the Study

Source: Litman, T. (2021)

Hypothetical Relationships

The framework suggests the following hypothetical relationships:

Ha1: There is a significant positive relationship between the quality of pedestrian infrastructure and pedestrian mobility in Kolfe-Keranio Sub-City.

Ha2: There is a significant negative relationship between poor traffic conditions and pedestrian mobility in Kolfe-Keranio Sub-City.

Ha3: There is a significant negative relationship between adverse environmental factors and pedestrian mobility in Kolfe-Keranio Sub-City.

Ha4: There is a significant negative relationship between unsafe pedestrian and driver behaviors and pedestrian mobility in Kolfe-Keranio Sub-City.

CHAPTER THREE

3. RESEARCH METHODS AND MATERIALS

This chapter discusses the research design and methodology that has been used to conduct, present, analyze and interpret the study. It also briefly describes the study design, approach, population, and sample size determination. The section below discusses the data gathering instruments and their measurement scales. Also, the modes of data presentation, methods of the date analysis, and interpretation are discussed in details.

3.1. Discription of the study area

Kolfe Keranio is one of the largest sub-cities in Addis Ababa, located in the western part of the capital. Covering about 61 square kilometers, it is bordered by Gullele, Addis Ketema, Lideta, and Nifas Silk-Lafto sub-cities. The area is notable for its proximity to the Gefersa Reservoir, which plays an important role in the city's water supply. With a population exceeding 600,000, Kolfe Keranio is a densely populated urban zone where traditional neighborhoods coexist with modern housing developments, reflecting the rapid urban expansion of Addis Ababa.

The sub-city is characterized by diverse socioeconomic conditions, ranging from informal settlements to planned residential areas. Its streets and communities embody a mix of cultural traditions and modern lifestyles, with local markets, coffee ceremonies, and new commercial centers shaping daily life. For urban research, Kolfe Keranio presents a rich case study in infrastructure challenges, particularly in transportation and pedestrian safety, as well as in managing growth pressures and environmental concerns linked to its natural surroundings. This makes it a highly relevant area for examining the intersection of urban design, community practices, and sustainable development.

Kolfe Keranyo is a neighborhood in the western suburb of Addis Ababa. Its northern border is shared with Addis ketema Sub City; to the east are Addis Ketema and Lideta Sub Cities, while to the south is Nifas Silk, Lafto Sub City.

According to the year 2023, Kolfe Keranyo Sub City in Addis Ababa is inhabited by 617, 526 residents.

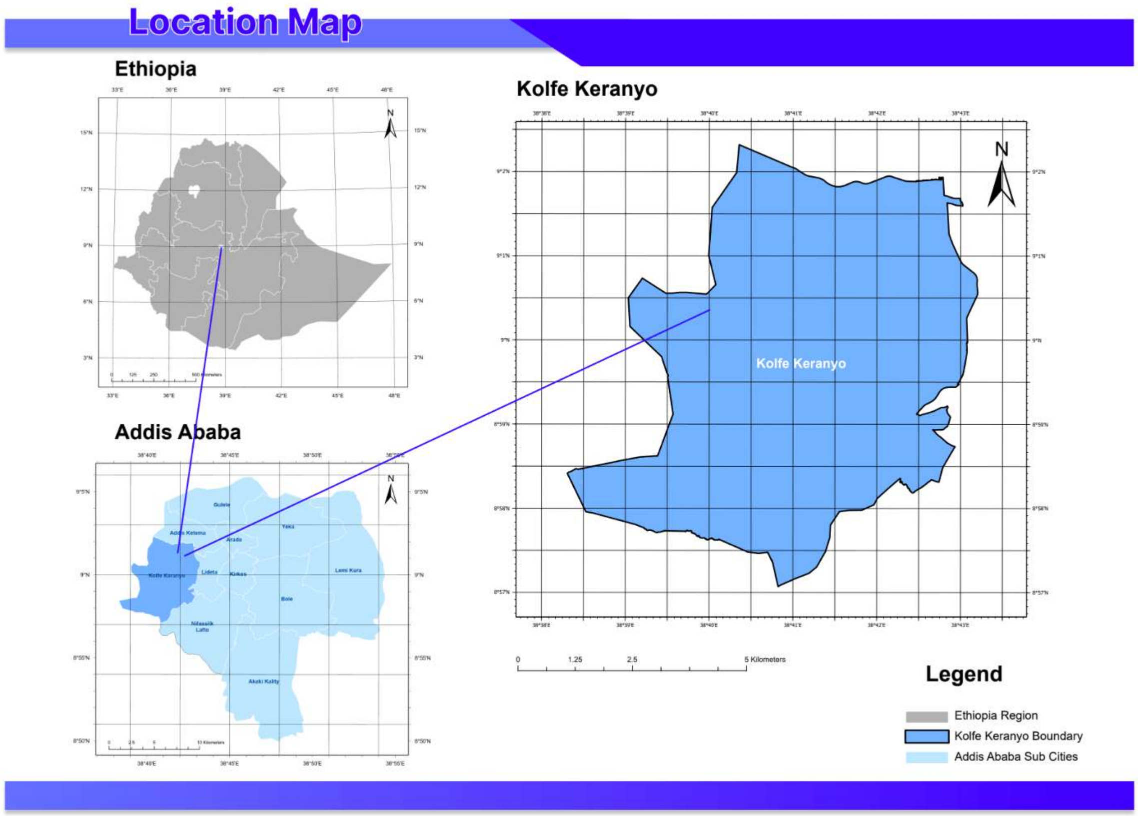

Figure 3-1: Map of the Study Area

Table 3.1: study area snapshot

Feature	**Kolfe Keranyo Sub City**
Location	Western Addis Ababa
Population	546,219 (2011)
Topography	Hilly Terrain
Climate	Mild, distinct wet & dry seasons
Soil Conditions	Mixed suitability for development
Land Use	Residential, commercial, industrial

Source: *Addis Ababa City Administration Plan and Development Commission, 2024*

3.2. Data Types

There are two types of data collected for the purpose for the research primary data and secondary data. Primary data sources collected to get first-hand information from the reliable sources in order to answer the research questions by using questionnaire. The primary data source was questionnaires that were distributed to pedestrians and drivers in Kolfe Keranyo Sub-city.

3.3. Data Sources

For the current study, the researcher used primary data sources. In this regard, the primary data was collected from the pedestrians in the time of data collection period 2024. The 384 respondents as determined to be selected using convenience sampling technique, was addressed via survey questionnaire regarding on the effect of pedestrian safety problems on pedestrian mobility.

3.4. Sampling Design

The study employed a non-probability convenience sampling technique due to the large population size and resource limitations. While convenience sampling may limit generalizability, efforts were made to ensure diversity by including respondents from different neighborhoods and traffic environments within Kolfe Keranio Sub-City. The sample size was determined using the formula for infinite populations, yielding 384 respondents at a 95% confidence level and 5% margin of error, which is considered statistically adequate for social science research.

3.4.1. Target Population

Investigating the multifaceted relationship between pedestrian safety problems and pedestrian mobility in Kolfe Keranio Sub-City requires a deep understanding of enforcement practices and challenges. Pedestrians in Kolfe Keranio Sub-City represent a critical target population for this study. Their firsthand experience in traffic flow, witnessing divers' behavior, and interacting with violators provides invaluable knowledge on pedestrian safety problems and areas for improvement.

Pedestrians offer insights into the pedestrian safety problems in Kolfe Keranio Sub-City 's specific context. This includes factors like road infrastructure, pedestrian behavior patterns, and driver compliance. A study by (Woldehanna, T., & Tefera, B., 2019) in Addis Ababa highlighted the difficulties of enforcing pedestrian right-of-way due to a lack of designated crossing zones and jaywalking habits. Understanding these challenges from the perspective of pedestrians is crucial for developing targeted interventions.

The target population comprised pedestrians in Kolfe Keranio Sub-City, whose daily experiences with traffic flow, driver behavior, and enforcement practices offered critical insights into pedestrian safety problems. Previous research in Addis Ababa has highlighted challenges such as inadequate crossing zones and jaywalking habits (Woldehanna, T., & Tefera, B., 2019).

3.4.2. Sampling Technique

Given the large population size, a non-probability convenience sampling technique was employed (Kothari, C. R., 2004) a. This approach allowed the researcher to collect data efficiently by engaging respondents available at the time and place of the survey. While convenience sampling may limit generalizability, efforts were made to ensure diversity by covering different neighborhoods and traffic environments

To collect data from the population of interest without wasting too much time or resources, a non-probability sampling strategy was used. This is necessary since the population size was so huge. This approach for sampling involves picking a portion of the universe that is smaller than the total in order to provide a sample that is representative of the whole universe (Kothari, C. R., 2004). The selection of the sample is based on responders who just so happened to be in attendance at the appropriate time and place. This study made use of a sample method known as convenience sampling. The researcher made contact with the target group in Kolfe Keranio Sub-City, and they gave their permission to take part in the study.

3.4.3. Sample Size

The following sampling formula for infinite population is used to come up with the sample size.

$$\boldsymbol{n_0 = \frac{Z^2 pq}{e^2}},$$

Where:

n_0-Sample size

Z - z value at specified confidence interval, e.g., z=1.96 at 95% CI
p - Degree of variability (0.5)
q - Q=1-p (0.5)
e - Desired level of precision (±5%)

Where n0 is the sample size, Z^2 is the abscissa of the normal curve that cuts off an area at the tails (1 –) equals the desired confidence level, e is the desired degree of accuracy, p is the estimated proportion of an attribute that is present in the population, and q is 1-p. The value for Z may be found in statistics tables that show the area beneath the normal curve.

As an example, assumed p=.5 since there was a big population and we didn't know the fluctuation in the proportion of people who followed the practice (maximum variability). Furthermore, a 95 percent confidence level and a 5% accuracy level were needed.

$$\boldsymbol{n_0} = \frac{\boldsymbol{Z^2pq}}{\boldsymbol{e^2}} = \frac{\mathbf{(1.96)^2(0.5)0.5}}{\mathbf{(0.05)^2}} = 384.16 \approx 384$$

3.5. Method of Data Collection

Every study has its own framework for collecting data to ensure that the required data to be collected accurately and economically. For this particular study, the researcher employed survey questionnaires. For further details, the items of the survey questionnaire were prepared in Likert-type scale in order to obtain respondents' level of agreement/disagreement on each of the constructs; as well known, a Likert-type scale which is a very popular rating scale for measuring ordinal data in social science ((Krosnick, J. A., & Presser, S., 2010). Therefore, in this particular study, the respondents were asked to rate each item on a Likert-type scale by assigning a value of 1 stood for *strongly disagree* to 5 stood for *strongly agree*. In such a way, the items can be easily understood and replied by the respondents.

3.5.1. Primary data

Primary data refers to information collected directly from original sources by the researcher for the specific purpose of the study. Unlike secondary data, which relies on existing records, publications, or databases, primary data is firsthand and context-specific, thereby enhancing the validity and reliability of research findings (Kumar, R., 2019). In urban design and social science research, primary data is indispensable for capturing both subjective perceptions and objective realities. This chapter outlines the primary data collection methods employed in this study, namely questionnaires and site observation.

3.5.1.1. Questionnaires

Questionnaires are structured instruments designed to elicit information from respondents through a series of carefully formulated questions. They are widely used in empirical research due to their efficiency in reaching large populations and their ability to generate standardized data suitable for statistical analysis (Creswell, J. W., & Creswell, J. D., 2018).

The questionnaire used in this study was designed to include both closed-ended and open-ended questions. Closed-ended questions, such as multiple-choice and Likert scale items, facilitated quantitative analysis, while open-ended questions captured qualitative insights. The design emphasized clarity, neutrality, and logical sequencing to minimize bias and maximize response accuracy (Bryman, A., 2016).

In the context of pedestrian safety and mobility research in Kolfe-Keranio Sub-City, questionnaires were distributed to residents to assess their perceptions of infrastructure quality, traffic conditions, and personal safety. Respondents were asked to evaluate the adequacy of crosswalks, street lighting, and traffic enforcement. This data provided valuable insights into community experiences and expectations, complementing observational findings.

3.5.1.2. Site Observation

Site observation involves the systematic recording of behaviors, environmental conditions, and infrastructural features in their natural setting. Unlike questionnaires, which rely on self-reported data, observation provides direct evidence of actual practices and contextual realities (Neuman, W. L., 2014).

Observation in this study was conducted using both structured and unstructured approaches. Structured observation employed predefined checklists to ensure comparability across sites, while unstructured observation allowed for the recording of spontaneous occurrences and contextual details. This dual approach ensured both consistency and flexibility in capturing relevant data (Silverman, D., 2020).

In Kolfe-Keranio Sub-City, site observation focused on monitoring traffic flow, pedestrian movement patterns, and the physical condition of sidewalks and crossings. Observations revealed discrepancies between reported perceptions and actual behaviors, such as informal crossing practices and hidden hazards. This method enriched the dataset by grounding findings in real-world evidence.

3.6. Selection of Target Population and Questionnaire Distribution

The target population for this study comprises active daily commuters and pedestrian residents who regularly navigate the transit corridors of Kolfe-Keranio Sub-City. To ensure an academically rigorous sample, the questionnaire distribution method was systematically guided by overlaying the sub-city's land use map and road network map to target areas with the highest pedestrian-vehicular friction. Using the land use map, distribution was strictly concentrated within high-density residential zones and busy commercial areas. These specific urban land uses generate massive pedestrian volumes and intensive street-level activity, making them primary hubs for active commuter transit.

Simultaneously, the road network map was used to isolate all major corridors with street widths measuring 20 meters and above, where high vehicular speeds pose the greatest safety risks. Survey distribution was strategically deployed along these wide arterial networks, including the prominent PAS-Expressway, primary 60-meter roads, vital 30m–40m paths, and 25m–30m streets (SAS). Trained field research assistants used a systematic intercept approach at bus stops, intersections, and market nodes intersecting these 20m+ corridors during peak hours. Out of 384 distributed questionnaires, 366 valid forms were recovered, achieving a 95.3% response rate that provides a statistically robust foundation for the study's regression models.

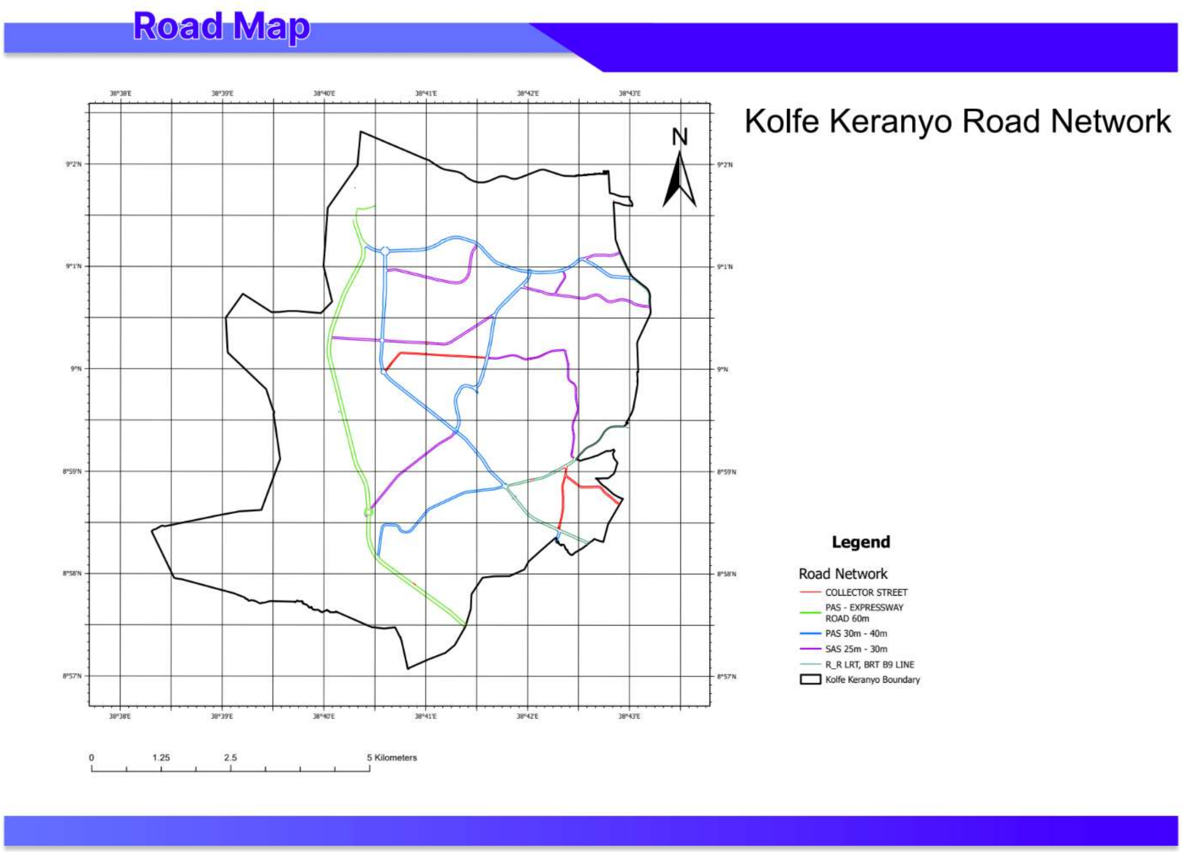

Figure 3-2: selected roads of kolfe keranio

3.6.1. Road Network Justification and Field Protocols

The tables and text below outline the spatial criteria, field safety protocols, and specific intersection hubs used to guide the questionnaire distribution across Kolfe-Keranio Sub-City.

3.6.1.1. Justification for Omitting Roads Under 20 Meters

Roads narrower than 20 meters were excluded from the sampling frame because they typically function as local neighborhood access streets. These narrower pathways feature significantly lower vehicular traffic volumes, reduced average driving speeds, and less commercial land-use intensity. In contrast, transport corridors measuring 20 meters and above handle the vast majority of the sub-city's through-traffic, public transit routes, and heavy freight vehicles. Isolating these wide arterial networks ensures the study captures the precise structural locations where high vehicular speeds and massive pedestrian flows collide, representing the highest risk levels for active commuters.

3.6.1.2. Field Assistant Operational and Safety Protocols

To navigate high-speed road corridors like the PAS-Expressway safely, field research assistants followed three strict operational rules.

As a Safety Protocols Assistants were required to wear high-visibility equipment, reflective safety vests and work in pairs at all times during daylight data collection. In the Protected Intercept Zones, Apprehending participants was strictly limited to off-road pedestrian spaces, such as wide sidewalk plazas, bus drop-off shelters, and marked zebra crossings. Data collectors were forbidden from stepping onto active vehicular carriage lanes. When Peak Timing Constraints Intercepts were timed to match peak pedestrian traffic hours (7:30 AM – 9:30 AM and 4:30 PM – 6:30 PM) to catch daily commuters when vehicular traffic was slowed by congestion, lowering the risk of high-speed accidents near the survey hubs.

3.6.2. Geographic (Spatial) Distribution Matrix

The spatial strategy for the questionnaire distribution was directly informed by the land-use patterns identified in the Kolfe-Keranio Land Use Map By mapping the survey deployment sites against specific urban zones, the study captured the areas with the highest density of active daily commuters and the greatest pedestrian-vehicular friction points.

The distribution approach was structurally integrated with the land-use layout across three distinct categories:

1. Mixed Residence Zones (High-Density Housing)

The map shows that Mixed Residence forms the largest urban footprint, covering almost all central, northern, and eastern sections of the sub-city. Because this zone acts as the primary origin point for thousands of daily walking trips, field assistants were deployed at the edges of these neighborhoods. This allowed them to capture active commuters as they walked out toward the main transit networks during morning peak hours.

2. Mixed Commerce Hubs (High-Traffic Destination Points)

Commercial activities are concentrated in prominent, dense clusters within the central and southeastern sectors, labeled as Mixed Commerce. These market areas act as massive daily destination hubs for shoppers, business operators, and laborers. The intense crowding in these zones, combined with vehicles loading and unloading goods, creates severe physical friction. Field assistants focused heavily on these areas to gather surveys from pedestrians who actively navigate these high-risk commercial street spaces.

3. Spatial Barriers and Transport Funnels

The western border of Kolfe-Keranio is dominated by a large Multi-Functional Forest and dedicated Parks, while a network of River Buffers cuts through the residential zones. These natural physical barriers restrict outward walking paths, effectively funneling thousands of moving pedestrians onto a limited set of major arterial roads and highway bridges. Surveys were strategically distributed at these funnel points because they represent the exact locations where pedestrian volumes are squeezed closest to high-speed vehicle traffic.

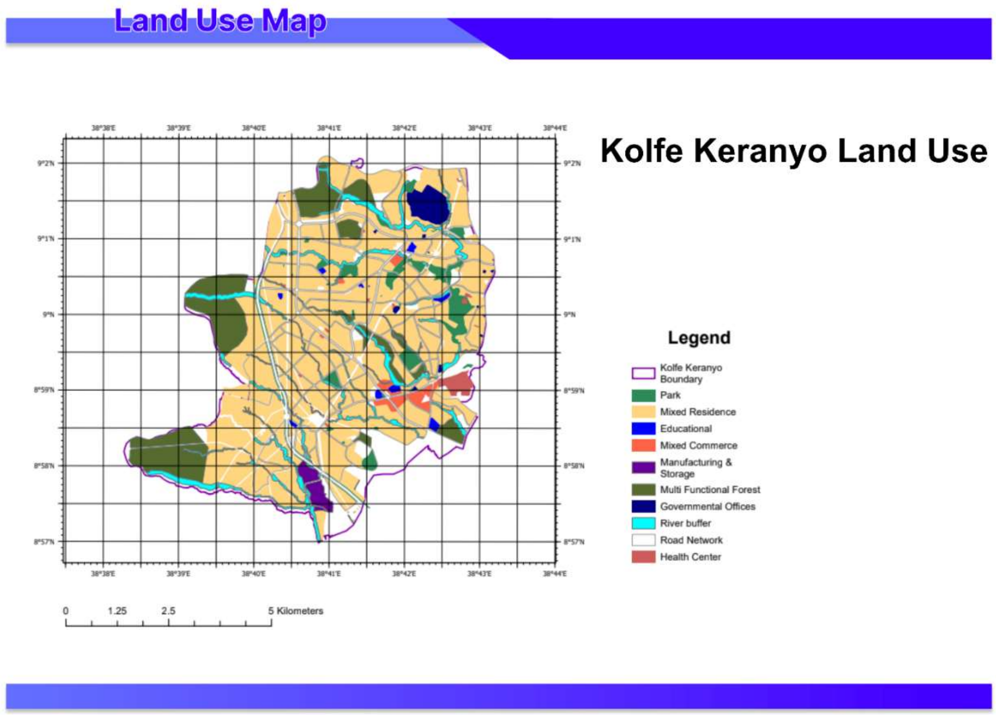

Figure 3-3: Kolfe Keranio Land Use Map

The table below details the specific high-density residential and commercial hubs chosen for survey deployment based on the overlay of the sub-city's road network and land-use maps:

Table 3.2: Geographic Distribution Matrix

Sampling Hub Location	**Dominant Land Use Type**	**Intersecting Road Width Classification**	**Targeted Sample Allocation**
PAS-Expressway Transit Hubs	High-Density Commercial	> 60 Meter Expressway Corridors	100 Surveys
Ayertena Market Intersections	Mixed Commercial & Residential	30 Meter – 40 Meter Arterial Streets	100 Surveys
Total / Zenebework Junctions	Heavy Industrial & Commercial	60 Meter Primary Arterial Roads	90 Surveys
Local SAS Access Corridors	High-Density Residential	25 Meter – 30 Meter Secondary Streets (SAS)	76 Surveys
Total Valid Responses (N)	**Mixed Urban Footprint**	**All Corridors (≥ 20) Meters**	**366 Valid Surveys**

3.6.3. Secondary data

Secondary data for this study comprised government reports, statistical records, academic literature, and digital datasets. Governmental and institutional sources (for example, municipal transport plans and road safety reports) provided official counts and policy context; academic and grey literature supplied theoretical and empirical comparisons; and electronic datasets (GIS layers, traffic logs where available) supported spatial analysis and hotspot identification. All secondary sources were assessed for authority, currency, and completeness, and were triangulated with primary survey and observation data to strengthen validity.

3.7. Method of Analysis

In this study, quantitative data collected via survey questionnaire was analyzed using the descriptive statistics as well as inferential statistics. The specific data analysis techniques were employed are presented below:

3.7.1. Descriptive Statistics

The descriptive statistics was employed in order to analyze data to be collected via survey questionnaire, specifically the respondents' profile to describe their characteristics using *frequency and percentile*; and, the remaining data was analyzed by measuring the central tendency and dispersion (viz. *mean and standard deviation*), to measure and identify the perception of respondents regarding on the effect of pedestrian safety problems on pedestrian mobility.

Descriptive summaries produce frequency tables for categorical variables and central tendency/dispersion (mean, SD, median, IQR) for continuous variables. Visualize distributions with histograms and boxplots (R ggplot2).

Distributional checks: compute skewness and kurtosis; use Shapiro-Wilk test for small samples and visual P-P plots for normality assessment. Report whether variables meet normality assumptions for parametric tests.

Reliability analysis compute Cronbach's alpha for each multi-item scale (SPSS Reliability Analysis or R psych alpha, report alpha, item-total correlations, and Cronbach's alpha if item deleted. If alpha < .70, discuss scale refinement or use of factor analysis.

Exploratory factor analysis (EFA): where scales are newly constructed, run EFA (principal axis factoring, oblique rotation) to assess dimensionality; report factor loadings, communalities, and explained variance

3.7.2. Inferential Statistics

The inferential statistics, on the other hand, was utilized to determine with what validity data can be said to make conclusion or conclusions with inference, and summarizing sources of numerical data in to meaningful form (Kothari, 2004) In this study, in order to identify the relationship between pedestrian mobility as dependent variable and the independent factors (*i.e., Pedestrian infrastructure, Traffic conditions, Environmental factors, and Pedestrian and driver behaviors*), Pearson's correlation was employed via using SPSS.

Bivariate analysis compute Pearson correlation matrix among indices and key continuous variables; for ordinal or nonnormal variables use Spearman's rho. Report correlation coefficients and significance levels. Group comparisons where relevant, use independent samples t-tests or one-way ANOVA to compare mobility outcomes across categorical groups (e.g., gender, age groups). For nonnormal distributions use Mann-Whitney U or Kruskal-Wallis tests.

Multivariate modeling estimate Ordinary Least Squares (OLS) regression models with mobility index as the dependent variable and pedestrian safety indices as independent variables. Model specification steps, Baseline model include control variables (age, gender, education, trip purpose) to isolate effects.

Main model enter infra index, traffic index, env index, behavior index using enter method. The Model selection compare nested models using adjusted R2 and ANOVA F tests; consider stepwise or hierarchical entry only for exploratory checks (report full models).

Statistical inference report unstandardized coefficients (B), standardized coefficients (β), standard errors, t-statistics, p-values, and 95% confidence intervals. Use $\alpha = .05$ as the primary significance threshold and report exact p-values.

As Pearson product-moment indicates, the relationship of variables is expressed by correlation coefficient (r) value within the range of $^{-}1.00$ to $^{+}1.00$ (Sekaran & Bougie, 2016). Besides, Multiple Linear Regression analysis was also used in order to establish the effects of pedestrian infrastructure, traffic conditions, environmental factors, and pedestrian and driver behaviors on the pedestrian mobility at Kolfe Keranio Sub-City as illustrated the variables in the following equation:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \epsilon$$

Where;

Y_i = *pedestrian mobility* (Dependent Variable)
β_0 = Constant
X1-X6 = Independent Variables
X_1 = *Pedestrian infrastructure*
X_2 = *Traffic conditions*
X_3 = Environmental factors
X_4 = Pedestrian and driver behaviors
β_0= Coefficient of the model
β_1-β_6 = Beta Coefficient of Determination
ϵ = Stochastic Error Term

Thus, the aforementioned two statistical analysis methods (*i.e., both descriptive and inferential statistics*) was applied to evaluate the current status of the effect of pedestrian safety problems and pedestrian mobility, and to measure and determine the relationship and effects that exists between dependent and independent variables by employing the data to be collected and analyzing using statistical package for social sciences (SPSS V. 24).

3.8. Research Design

The researcher chose to use an explanatory research design for several reasons. One of the most common reasons for using this type of research design is to test a hypothesis about the relationship between two or more variables. In this case, the hypothesis was that there is a positive relationship between pedestrian safety problems and pedestrian mobility. Explanatory research design is particularly suitable for investigating causal relationships between variables. Because of its focus on testing hypotheses, the explanatory design can determine whether the independent variable (in this case, pedestrian safety problems) has a causal effect on the dependent variable (pedestrian mobility).

Another reason for adopting of the explanatory research design is that it allows the researcher to control for extraneous variables. This means that the researcher can minimize the effect of pedestrian safety problems on pedestrian mobility. By controlling for these extraneous variables, the researcher can increase the validity of their findings. Moreover, the explanatory research design allows the researcher to use statistical analysis to test the study hypotheses. By using appropriate statistical techniques to analyze the data, the researcher determined the strength and direction of the relationship between pedestrian safety problems and pedestrian mobility. The researcher used an explanatory research design because it enabled to test a hypothesis about the causal relationship between pedestrian safety problems and pedestrian mobility, control for extraneous variables, use statistical analysis, and guide future research.

3.8.1. Explanatory mixed-methods design

This study adopts an Explanatory mixed-methods design to investigate how pedestrian safety determinants influence pedestrian mobility in Kolfe-Keranio Sub-City, Addis Ababa. The quantitative component is cross-sectional and comprises structured household and intercept surveys, systematic pedestrian counts, short-duration traffic speed and volume measurements, and standardized field audits of pedestrian infrastructure and micro-environmental conditions. The qualitative component comprises semi-structured key-informant interviews and targeted field observations to contextualize and explain statistical associations. Quantitative analyses establish the magnitude and direction of relationships among constructs, while qualitative data illuminate mechanisms, institutional constraints, and local perceptions that underpin those relationships. Triangulation across data sources strengthens internal validity and supports policy-relevant interpretation.

3.8.2. Objectives and Hypotheses

The primary objective is to quantify the effects of infrastructure, environmental, traffic, and behavioral factors on pedestrian mobility. Secondary objectives include validating measurement instruments (e.g., Pedestrian Safety Index, mobility_index), mapping spatial hotspots of low mobility and high crash incidence, and deriving prioritized, equity-sensitive interventions. The principal hypotheses are:

H1—higher quality pedestrian infrastructure is positively associated with pedestrian mobility;
H2—poorer environmental conditions (lighting, drainage, encroachments) are negatively associated with mobility;

H3—adverse traffic conditions (higher speeds, greater volumes, inadequate control) are negatively associated with mobility. Hypotheses are tested using multivariate regression models with appropriate controls and robustness checks.

3.8.3. Variables and Measurement

Key constructs are operationalized as composite indices and objective counts. The dependent variable is *mobility_index*, a composite of trip frequency, route continuity, perceived accessibility, and observed pedestrian flows. Independent variables include *infra_index* (sidewalk continuity, crossing quality, curb ramps), *env_index* (pavement condition, lighting, drainage, encroachments), *traffic_index* (vehicle speed, volume, traffic control adequacy), and *behavior_index* (pedestrian and driver compliance, risk perception). Control variables comprise socio-demographic attributes (age, gender, education), trip purpose, and land-use context. Multi-item scales are standardized prior to analysis; scale construction follows psychometric best practice (item analysis, exploratory factor analysis, reliability assessment using Cronbach's alpha and McDonald's omega). Objective measures (speed counts, pedestrian counts, GIS sidewalk coverage) complement self-reported data.

3.8.4. Sampling and Data Collection

Sampling is stratified to capture intra-sub-city heterogeneity in land use, pedestrian demand, and known crash history. Street segments and intersections are purposively selected to include high-demand corridors, hotspots, and areas with varying infrastructure quality; within these sites, systematic pedestrian counts and site audits are conducted. Data collection protocols specify standardized scoring for audits, consistent timing for counts (peak and off-peak intervals), and procedures for traffic speed and volume measurement.

3.8.5. Data Analysis

Data preparation includes cleaning, treatment of missing data (multiple imputation where appropriate), and outlier diagnostics. Measurement validation proceeds with exploratory factor analysis (principal axis factoring, oblique rotation), KMO and Bartlett's tests, and reliability estimation. Descriptive statistics and GIS mapping summarize spatial patterns. Inferential analysis uses hierarchical OLS regression with sequential entry of control variables, infrastructure, environmental, traffic, and behavioral indices; standardized and unstandardized coefficients, confidence intervals, and adjusted R2 are reported. Where spatial autocorrelation is detected (Moran's I), spatial regression models (spatial lag or spatial error) are estimated. Diagnostic tests (VIF for multicollinearity, Breusch-Pagan for heteroscedasticity, Cook's distance for influential observations) guide model refinement; robust standard errors and sensitivity analyses (alternative index constructions, subsample analyses) are used to assess robustness. Qualitative data are analyzed thematically to explain quantitative findings and to surface institutional and operational barriers.

3.8.6. Ethics, Timeline, and Limitations

Ethical approval is obtained from the relevant institutional review board. Informed consent is secured for all survey and interview participants; observational protocols avoid collection of personally identifiable information. Data are anonymized and stored securely. A provisional timeline allocates 1–2 months for instrument development and piloting, 2–3 months for field data

3.9. Research Approach

The quantitative research method was used for this study to achieve the study's broad objective. The quantitative method allows questionnaires to collect primary data or to use previously collected or processed data known as secondary data in their studies. To support the quantitative findings and gain additional insight into the specific issues, the quantitative method was used. This quantitative portion of the study involved a statistical analysis of survey questionnaire data.

Quantitative research approaches are those that use numerical data to answer research questions. This type of research is often used in the social sciences, where it can be used to measure things like attitudes, behaviors, and beliefs. In order to attain the intended objectives of the study, the researcher used a research approach that is appropriate for the research question. In this case, the researcher is interested in measuring the relationship between two variables, so a quantitative research approach is the best choice.

3.10. Reliability and Validity of the Instrument

To assure the validity of the measurement tool of the questionnaire, the researcher collected comments on the items of the questionnaire from research advisor and traffic experts working at Addis Ababa City Administration Traffic Management Authority in order to improve the items based upon their comments. Additionally, prior to starting the distribution of the questionnaire, the researcher carried out a pre-test (*i.e., pilot study*) on randomly selected respondents from one of the Addis Ababa City Administration Traffic Management Authority for the sake of checking whether the items of the questionnaire are feasible, clear, consistent and understandable to the respondents.

To ascertain reliability (*internal consistency*) of items of the survey questionnaire, on the other hand, the researcher analyzed the reliability measurement test (*i.e., Cronbach's alpha*) using SPSS V. 24. As known, the Cronbach's alpha reliability measurement test is a popular model of internal consistency reliability which relied on the average inter-item correlation of the instrument (Koonce & Kelly).

Table 3.3: Reliability Statistics

Variables	Cronbach's Alpha	N of Items
Pedestrian infrastructure	.750	5
Traffic conditions	.662	5
Environmental factors	.610	5
Pedestrian and driver behaviors	.794	5
Pedestrian mobility	.639	5

3.11. Ethical Consideration

The ethical issues were taken into consideration while carrying out the current study. Hence, the permission was obtained from Executive of the Addis Ababa City Administration Traffic Management Authority, informants and respondents who are working in the study area before any sort of data collection is started. To assure the confidentiality of information, name of the respondents was omitted from the questionnaire. On the other hand, objectives of the study were clearly explained to each and every participant of this study in order to obtain their verbal consents. Besides, the respondents of the questionnaire were also vividly told that the whole process of the questionnaires' administration would be set up with great confidentiality, and their involvements and/or their information provided for the current study was kept and used anonymously.

CHAPTER FOUR

4. RESULTS

This chapter presents the empirical findings and statistical analyses derived from the quantitative data collected across Kolfe-Keranio Sub-City. To establish a rigorous assessment of pedestrian mobility and safety patterns, the collected data was processed and analyzed using descriptive and inferential statistics via statistical software. The presentation begins with the demographic profile of the respondents to contextualize the survey sample demographic (($N = 366$). This is followed by diagnostic tests for regression assumptions, including a detailed collinearity analysis to ensure model stability. Subsequently, Pearson correlation analysis is utilized to determine the strength and direction of the bivariate relationships between the variables. Finally, ordinary least squares (OLS) multiple linear regression analysis and Analysis of Variance (ANOVA) are applied to evaluate the collective predictive power of pedestrian infrastructure, traffic conditions, environmental factors, and driver behaviors on urban pedestrian mobility, ultimately serving to systematically test the study's core research hypotheses.

The reduction in the final analytical sample from the initial target of 384 respondents to 366 valid cases—representing a highly acceptable **95.3% response rate**—is primarily attributed to rigorous data cleaning, incomplete questionnaire submissions, and fieldwork field constraints. Out of the 384 distributed questionnaires, several instruments were excluded during the post-survey auditing phase due to significant missing data, uniform or patterned response biases (straight-lining), and failure to complete critical sections regarding the primary independent variables. Additionally, localized field challenges within Kolfe-Keranio Sub-City, such as inclement weather conditions, scheduling friction with active commuters during peak traffic hours, and the voluntary withdrawal of a few participants mid-survey, further accounted for the minor sample attrition. According to standard statistical conventions in survey research, a response rate exceeding 85% remains completely sufficient, ensuring that the final sample size of 366 retains high statistical power and prevents any threat of non-response bias to the validity of the multiple linear regression model.

4.1. Pedestrian Infrastructure

Table 4.1: Evaluation of pedestrian infrastructure (PI) in Kolfe Keranyo sub-city

Code	Pedestrian Infrastructure (PI) Items	Mean	SD
PI1	Sidewalks in this area are well-maintained and easy to walk on.	2.2678	1.11743
PI2	Crosswalks are clearly marked and visible to both pedestrians and drivers.	2.0383	.89361
PI3	Pedestrian signals provide enough time to cross the street safely.	3.5492	1.06323
PI4	There are enough pedestrian bridges/underpasses in areas with heavy traffic.	2.1230	1.00337
PI5	Pedestrian infrastructure (e.g., ramps, tactile paving) is accessible for people with disabilities.	2.9754	1.24392
	Overall Mean	**2.5907**	**.56104**
	Note: ▪ Mean Scale Used: 1.00-1.80: Very Low; 1.81-2.60: Low; 2.61-3.40: Neutral; 3.41-4.20: High; 4.21- 5.00: Very High ▪ Cronbach's alpha (reliability)=0.750, n=366		

Source*: Survey Result, 2025*

The table presents an evaluation of pedestrian infrastructure (PI) in Kolfe Keranyo sub-city, based on a survey of 366 respondents. The overall mean score for pedestrian infrastructure is 2.59 (SD = 0.56), which falls into the "Low" category according to the given scale (1.81-2.60). This suggests that pedestrian infrastructure in the area is generally below satisfactory levels, negatively impacting safety and mobility. The Cronbach's alpha value of 0.750 indicates good reliability, meaning the survey items consistently measure the same underlying construct.

Breaking down the individual components, sidewalk maintenance (PI1) and crosswalk visibility (PI2) received mean scores of 2.27 and 2.04, respectively, both classified as "Low." This indicates that sidewalks are poorly maintained and crosswalks are inadequately marked, forcing pedestrians to navigate unsafe conditions. The lack of proper crossings likely increases conflicts between pedestrians and vehicles, discouraging walking as a viable mode of transport. Meanwhile, pedestrian signal timing (PI3) scored 3.55 ("High"), suggesting that traffic signals provide sufficient crossing time. However, this positive aspect is undermined by the poor state of sidewalks and crosswalks, limiting its effectiveness.

Another critical issue is the shortage of pedestrian bridges and underpasses (PI4), which scored 2.12 ("Low"). This deficiency in high-traffic areas forces pedestrians to cross roads unsafely, increasing accident risks. Additionally, accessibility for people with disabilities (PI5) scored 2.98 ("Neutral"), meaning infrastructure such as ramps and tactile paving exists but remains insufficient. This exclusionary design restricts mobility for vulnerable groups, further reducing walkability

4.2. Traffic Conditions

Table 4.2: The evaluation of traffic conditions in Kolfe Keranyo sub-city

Code	Traffic Conditions (TC) Items	Mean	SD
TC1	Drivers in this area generally obey speed limits.	2.2678	1.04915
TC2	Traffic congestion is a significant problem for pedestrian safety here.	3.9262	.79555
TC3	Drivers yield to pedestrians at crosswalks as required by law.	2.2814	1.05469
TC4	Heavy vehicle traffic (e.g., trucks, buses) makes walking in this area uncomfortable.	3.8443	.80089
TC5	Traffic flows smoothly, reducing conflicts between pedestrians and vehicles.	2.0219	.85660
	Overall Mean	**2.8683**	**.47100**
	Note: ▪ Mean Scale Used: 1.00-1.80: Very Low; 1.81-2.60: Low; 2.61-3.40: Neutral; 3.41-4.20: High; 4.21- 5.00: Very High ▪ Cronbach's alpha (reliability)=0.662, n=366		

Source: *Survey Result, 2025*

The evaluation of traffic conditions in Kolfe Keranyo sub-city reveals significant challenges affecting pedestrian safety and mobility. With an overall mean score of 2.87 (SD = 0.47) based on 366 respondents, traffic conditions fall into the "Neutral" category. However, this aggregate score masks several critical issues that collectively create hazardous conditions for pedestrians. The survey's moderate reliability (Cronbach's alpha = 0.662) suggests that while the items measure related aspects of traffic conditions, there may be some variability in how respondents interpreted certain questions.

Two particularly concerning findings relate to driver behavior. The low scores for speed limit compliance (2.27) and yielding to pedestrians (2.28) indicate widespread disregard for traffic regulations that directly impact pedestrian safety. These behaviors create an environment where pedestrians must constantly be vigilant when crossing roads or walking near traffic. The situation is exacerbated by the very high score for traffic congestion (3.93) and high score for heavy vehicle traffic (3.84), which together create physical and psychological barriers to safe pedestrian movement. Large vehicles not only dominate the road space but also contribute to noise and air pollution that make walking unpleasant.

The extremely low score for smooth traffic flow (2.02) completes this troubling picture. Erratic traffic patterns increase the likelihood of conflicts between vehicles and pedestrians, particularly in areas lacking proper pedestrian infrastructure. These traffic conditions interact with previously identified deficiencies in pedestrian infrastructure to create a perfect storm of safety hazards. The combination of speeding drivers, congested roads, and inadequate pedestrian facilities creates an environment where walking is both dangerous and stressful.

4.3. Environmental Factors

Table 4.3: The evaluation of Environmental Factors in Kolfe Keranyo sub-city

Code	Environmental Factors (EF) Items	Mean	SD
EF1	Street lighting is adequate for safe walking at night.	1.8607	.74740
EF2	Weather conditions (rain, heat, snow) significantly worsen pedestrian safety here.	3.6230	.78682
EF3	Green spaces (parks, trees) make walking in this area more pleasant.	1.8087	.68768
EF4	Air pollution from traffic negatively affects my walking experience.	3.5410	.80900
EF5	Pedestrian paths are free of obstacles (e.g., parked cars, street vendors).	1.9235	.79011
	Overall Mean	**2.5514**	**.36973**

	Note: ▪ Mean Scale Used: 1.00-1.80: Very Low; 1.81-2.60: Low; 2.61-3.40: Neutral; 3.41-4.20: High; 4.21- 5.00: Very High ▪ Cronbach's alpha (reliability)=0.610, n=366

***Source**: Survey Result, 2025*

The analysis of environmental factors reveals significant challenges impacting pedestrian safety and mobility in Kolfe Keranyo sub-city. With an overall mean score of 2.55 (SD=0.37) based on 366 respondents, the environmental conditions for pedestrians fall into the "Low" category, indicating substantial room for improvement. The Cronbach's alpha of 0.610 suggests moderate reliability in the measurement of these environmental factors.

Several critical issues emerge from the data. Most concerning is the extremely poor street lighting (EF1: 1.86), classified as "Very Low," creating dangerous conditions for nighttime walking. This is compounded by obstructed pedestrian paths (EF5: 1.92) where parked cars and street vendors frequently block walkways. The lack of green spaces (EF3: 1.81) further diminishes the walking experience, offering little relief from the urban environment.

Environmental challenges are particularly severe regarding weather impacts (EF2: 3.62) and air pollution (EF4: 3.54), both scoring in the "High" range. Respondents report that weather conditions significantly worsen pedestrian safety, while traffic-related air pollution substantially degrades the walking experience. These factors collectively create an environment that discourages walking as a mode of transportation.

4.4. Pedestrian and Driver Behaviors

Table 4.4: The evaluation of Pedestrian and Driver Behaviors in Kolfe Keranyo sub-city

Code	Pedestrian and Driver Behaviors (PDB) Items	Mean	SD
PDB1	I sometimes jaywalk if the nearest crosswalk is too far away.	3.5792	.84918
PDB2	I feel safe crossing the street, even when drivers are present.	3.5519	.81175
PDB3	As a driver, I always stop for pedestrians waiting at crosswalks.	3.2131	1.02486
PDB4	Distractions (e.g., phones, headphones) affect my awareness as a pedestrian.	3.5574	.81138
PDB5	I adjust my walking speed based on traffic conditions.	3.2596	1.07569
	Overall Mean	**3.4322**	**.50374**

	Note: ▪ Mean Scale Used: 1.00-1.80: Very Low; 1.81-2.60: Low; 2.61-3.40: Neutral; 3.41-4.20: High; 4.21- 5.00: Very High ▪ Cronbach's alpha (reliability)=0.794, n=366

***Source**: Survey Result, 2025*

The analysis of pedestrian and driver behaviors reveals a complex interaction pattern that significantly impacts road safety and mobility in Kolfe Keranyo sub-city. With an overall mean score of 3.43 (SD=0.50) across measured behaviors, falling into the "High" category, and strong internal consistency (Cronbach's alpha=0.794), the data presents reliable evidence of behavioral trends that warrant attention.

Several concerning patterns emerge from the findings. Most notably, the high prevalence of jaywalking (mean=3.58) suggests that existing pedestrian infrastructure fails to meet residents' needs, particularly regarding convenient crossing locations. This behavior coexists with a surprisingly high perception of safety while crossing (mean=3.55), creating a potentially dangerous mismatch between actual risks and pedestrian awareness. Driver behavior shows moderate compliance with yielding requirements (mean=3.21), indicating inconsistent adherence to pedestrian right-of-way protocols. Compounding these issues, distraction levels among pedestrians remain high (mean=3.56), with significant phone and headphone use reducing situational awareness during street crossings.

4.5. Mobility

Table 4.5: The evaluation of Pedestrian Mobility in Kolfe Keranyo sub-city

Code	Pedestrian Mobility (PM) Items	Mean	SD
PM1	Sidewalks connect seamlessly to key destinations (e.g., parks, markets).	2.6093	.59479
PM2	Walking is a practical alternative to driving for daily trips in this area.	2.8415	.56084
PM3	Pedestrian paths are free of hazards (e.g., potholes, uneven surfaces).	2.5082	.50062
PM4	Pedestrian-only zones (e.g., car-free streets) exist where needed.	3.4399	.53935
PM5	Walking is a common mode of transport for people in my community.	3.1639	1.07546

	Overall Mean	2.9126	.33500
	Note: ▪ Mean Scale Used: 1.00-1.80: Very Low; 1.81-2.60: Low; 2.61-3.40: Neutral; 3.41-4.20: High; 4.21- 5.00: Very High ▪ Cronbach's alpha (reliability)=0.639, n=366		

***Source**: Survey Result, 2025*

The pedestrian mobility assessment reveals several critical challenges affecting walkability in Kolfe Keranyo sub-city. With an overall mean score of 2.91 (SD=0.34), pedestrian mobility conditions fall into the "Neutral" category, indicating marginal acceptability with significant room for improvement. The moderate reliability score (Cronbach's alpha=0.639) suggests that while the items measure related aspects of pedestrian mobility, there may be some variability in respondents' experiences across different locations.

The analysis shows concerning gaps in pedestrian infrastructure quality and connectivity. Sidewalk connectivity to key destinations scores 2.61 ("Neutral"), suggesting discontinuous or poorly maintained walkways that fail to provide seamless access to parks, markets, and other essential services. This is compounded by the presence of hazardous conditions (mean=2.51) including potholes and uneven surfaces, which pose particular risks for elderly and disabled pedestrians.

While walking remains a moderately common transport mode (mean=3.16), its practicality as an alternative to driving scores only 2.84, indicating that many residents still find walking inconvenient or unsafe for daily trips. The relatively high score for pedestrian-only zones (3.44) suggests these interventions are present but may not be optimally located to serve the areas with greatest pedestrian traffic needs.

4.6. Relationship Between Pedestrian Safety Problems and Mobility

Table 4.6: Bivariate Pearson correlations matrix for research variables, n=157

Variables	PI	TC	EF	PDB	PM
Pedestrian Infrastructure	1				
Traffic Condition	-.064	1			
	.225				
Environmental Factors	-.061	.401**	1		
	.242	.000			

Pedestrian Driver Behaviors	.183**	.157**	.176**	1	
	.000	.003	.001		
Pedestrian Mobility	.284**	.312**	.413**	.496**	1
	.000	.000	.000	.000	

Note:

- **. Correlation is significant at the 0.01 level (2-tailed)
- r scale: $r<0.1$-Very small, $0.1\leq r<0.3$-Small, $0.3\leq r<0.5$-Moderate, $r\geq 0.5$-Large (Cohen, 1988)

***Source**: Survey Result, 2025*

This correlation matrix provides valuable insights into the complex interplay between five critical dimensions of pedestrian safety and mobility. The analysis reveals both expected and surprising relationships that have important implications for urban planning and policy interventions in the sub-city. Using Pearson's correlation coefficients with significance testing at $p<0.01$ and interpreting effect sizes through Cohen's (1988) benchmarks, we can identify several key patterns that shape pedestrian experiences in this urban environment.

The strongest relationship emerges between Pedestrian-Driver Behaviors (PDB) and overall Pedestrian Mobility (PM), with a substantial correlation of $r=0.496$ ($p<0.001$). This large effect size indicates that behavioral factors - including driver yielding practices, jaywalking frequency, and pedestrian distraction levels - collectively represent the single most influential determinant of walking mobility in the sub-city. This finding suggests that even in areas with suboptimal infrastructure, targeted behavioral interventions could yield significant improvements in pedestrian outcomes. The strength of this relationship underscores the importance of complementing physical infrastructure improvements with public awareness campaigns, traffic law enforcement, and community education programs focused on safe walking and driving practices.

Environmental Factors (EF) demonstrate the second strongest association with Pedestrian Mobility ($r=0.413$, $p<0.001$), revealing that aspects like street lighting quality, air pollution levels, and green space availability substantially impact residents' walking experiences. This moderate-to-strong correlation suggests that environmental enhancements could produce meaningful mobility gains, potentially offering higher returns on investment than certain infrastructure projects alone. The particularly troubling scores for nighttime lighting (mean=1.86) and air pollution (mean=3.54) from previous analyses help explain this relationship, as these factors directly affect both the safety and comfort of walking. Interestingly, Environmental Factors also show a moderate correlation with Traffic Conditions (r=0.401, p<0.001), indicating that areas with heavier traffic tend to have worse environmental conditions for pedestrians - a finding that highlights the potential for traffic reduction strategies to yield multiple co-benefits.

Pedestrian Infrastructure (PI) exhibits a small but significant positive correlation with Pedestrian Mobility (r=0.284, p<0.001), confirming that better sidewalk quality and crossing facilities do contribute to improved walking conditions, though less powerfully than behavioral or environmental factors. The infrastructure-mobility relationship is mediated by its moderate association with Pedestrian-Driver Behaviors (r=0.183, p<0.001), suggesting that well-designed infrastructure can positively influence how both walkers and drivers behave in shared spaces. However, the non-significant correlations between PI and both Traffic Conditions (r=-0.064) and Environmental Factors (r=-0.061) reveal a troubling disconnect - infrastructure improvements alone don't automatically translate to better traffic patterns or environmental conditions, emphasizing the need for integrated planning approaches.

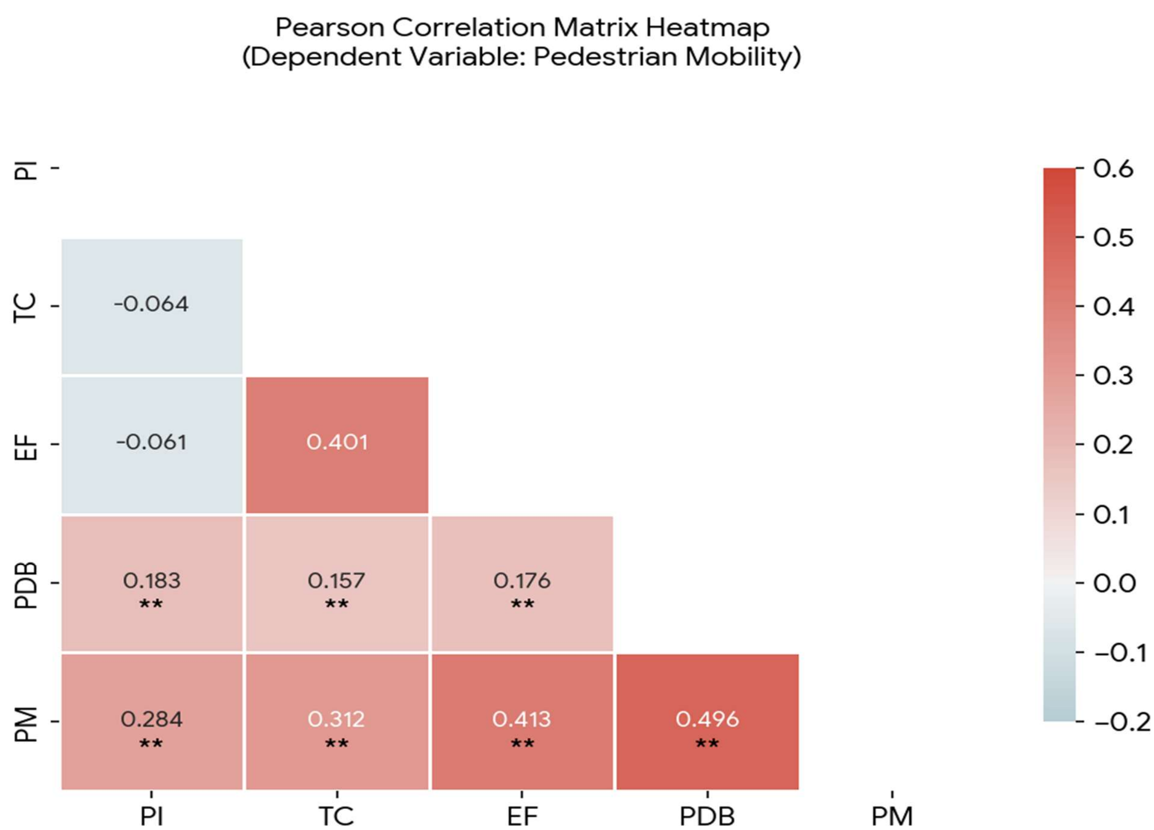

Figure 4-1 Bivariate Pearson correlations matrix for research variables

This table shows the **Pearson correlation values (r)**, which measure the direction and strength of the linear relationship between your research variables on a scale from -1 to +1.

- **What the Positive Signs Mean**: All the main research variables have **positive numbers** when paired with **Pedestrian Mobility**. This tells us that as infrastructure improves, traffic conditions get better, environmental hazards drop, or driver behavior improves, pedestrian mobility consistently goes up.
- **The Stars (**) Mean High Reliability**: Every single relationship linked to Pedestrian Mobility has a double star (**). This means the results are **statistically significant at the 0.01 level**, showing that these connections are highly reliable and did not happen by random chance.

Ranking the Factors (From Strongest to Weakest)

Using Cohen's standard scale, here is how each individual factor connects to **Pedestrian Mobility**:

1. **Pedestrian Driver Behaviors (r = 0.496) — Moderate to Large Connection**
   This is the strongest individual relationship in the table. It proves that driver awareness and safety compliance are the most critical factors directly linked to smooth walking conditions.
2. **Environmental Factors (r = 0.413) — Moderate Connection**
   Physical surrounding conditions (like lighting and clear walkways) have the second strongest tie to walking efficiency.
3. **Traffic Conditions (r = 0.312) — Moderate Connection**
   Vehicle speeds and local congestion numbers display a reliable, mid-range connection to overall mobility.
4. **Pedestrian Infrastructure (r = 0.284) — Small Connection**
   While still highly reliable and positive, basic physical infrastructure shows a slightly lower standalone correlation value compared to operational and behavioral factors.

Safe from Data Redundancy (No Multicollinearity)

The table also checks if any of your independent factors overlap too much with each other. The highest internal relationship is between *Environmental Factors* and *Traffic Conditions* (r =

0.401). Because this is well below **0.70**, it proves your variables are distinct and your statistical model is safe from data redundancy errors.

4.7. Assumptions Testing in Multiple Regression

To maintain the validity and robustness of the research findings obtained from various regression models, it is essential to satisfy the fundamental assumptions underlying these analyses. Therefore, this study conducted tests to evaluate three key assumptions: multicollinearity, linearity, and normality. These tests are crucial for ensuring that the regression results are reliable and meaningful.

4.7.1. Multicollinearity

Tolerance values serve as indicators of the variation present among a set of interrelated variables. They are computed by subtracting the squared correlation coefficient of each variable from one. A low tolerance value signals a high correlation with other variables, which can lead to complications in regression analysis. Conversely, a high tolerance value suggests that the variable is relatively independent of others, a condition that is favorable for regression modeling.

Different research studies propose varying guidelines for establishing an appropriate cutoff value for the Variance Inflation Factor (VIF), with a common criterion being a value of 3 or higher. In this analysis, the VIF values for the four examined variables fall significantly below this threshold, indicating a low degree of collinearity among them. This finding implies that these variables can be confidently included in the regression model without concerns related to collinearity.

While VIF is a valuable metric for evaluating multicollinearity in regression models, it should not be the sole factor in assessing model fit. It is equally important to verify other assumptions, such as linearity, normality, and homoscedasticity (Journal of Medical Statistics and Informatics, 2019).

Table 4.7. Collinearity Statistics

Variables	Collinearity Statistics	
	Tolerance	VIF
Pedestrian Infrastructure	.954	1.048
Traffic Condition	.828	1.208
Environmental Factors	.822	1.216
Pedestrian Driver Behaviors	.921	1.086

Source*: Survey Result, 2025*

All tolerance values fall within the range of 0.822 to 0.954, well above the commonly accepted threshold of 0.10 that would indicate potential multicollinearity issues. Correspondingly, the VIF values range from 1.048 to 1.216, significantly below the conservative cutoff of 5 (and even the more stringent threshold of 2.5) that researchers typically use to identify problematic collinearity. These results confirm that each variable contributes unique explanatory power to the model without substantial overlap with other predictors.

Pedestrian Infrastructure (PI) emerges as the most independent variable, with the highest tolerance (0.954) and lowest VIF (1.048), indicating that over 95% of its variance is unexplained by other variables in the model. This strong independence suggests PI measures distinct aspects of the pedestrian environment not captured by the other factors. Similarly, Pedestrian-Driver Behaviors (PDB) shows excellent independence with a tolerance of 0.921 and VIF of 1.086.

The slightly higher (though still very good) collinearity statistics for Traffic Conditions (TC) and Environmental Factors (EF) - with tolerance values of 0.828 and 0.822 respectively - likely reflect natural conceptual relationships between these domains. For instance, areas with heavier traffic might logically experience greater air pollution, while better infrastructure could influence driver behavior. However, even these modest correlations remain well within acceptable limits for rigorous statistical analysis.

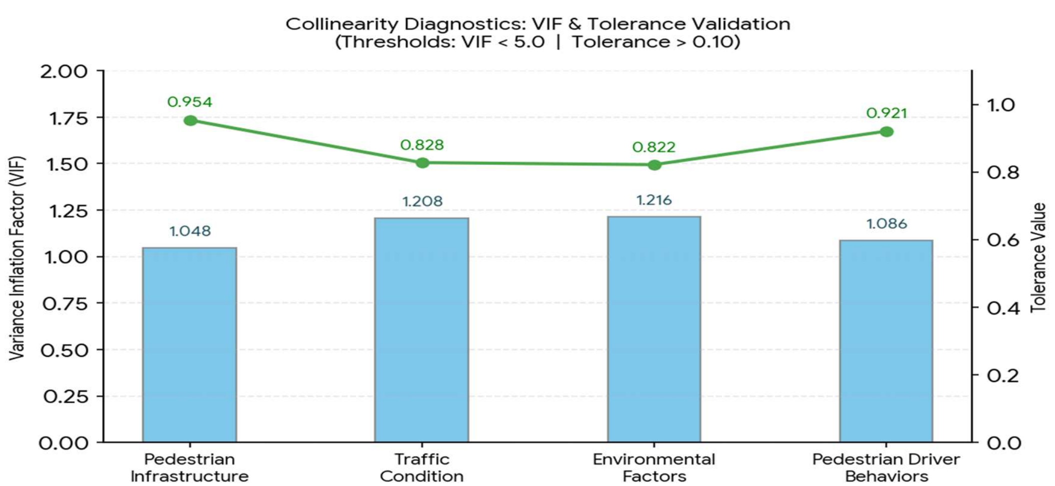

Figure 4-2 Collinearity Statistics

Summary of Collinearity Statistics

This table presents the **multicollinearity diagnostics** for the independent variables, using two standard statistical metrics: **Tolerance** and the **Variance Inflation Factor (VIF)**. These metrics check whether your predictor variables overlap so heavily that they make your regression model unstable.

- **Variance Inflation Factor (VIF) Metrics**: All VIF values range between **1.048 and 1.216**. Because these values are substantially below the conservative statistical threshold of **5.0** (and well under the critical limit of 10.0), it proves that there is no severe inflation of variance in the model.
- **Tolerance Metrics**: The Tolerance values range from **0.822 to 0.954**. Since all values are well above the standard warning threshold of **0.10** (and greater than 0.20), it confirms that each variable carries unique, independent information.

The diagnostic results confirm that **multicollinearity is entirely absent** among your independent variables. This validates that your earlier multiple linear regression coefficients (beta)-weights) and (p)-values are highly stable, statistically reliable, and perfectly safe to use for drawing policy conclusions regarding pedestrian mobility in Kolfe-Keranio Sub-City

4.7.2. Normality and Linearity

When conducting data analysis with SPSS, verifying the normality of both the dependent variable's distribution and the residuals is crucial to ensure that the assumptions underlying the statistical tests are satisfied. A symmetric, bell-shaped histogram indicates that the distribution is centered around its mean, which, in this case, is zero. If the distribution is evenly spread around zero, this suggests that there is no indication of systematic bias in the data. Ensuring normality is a vital step in validating the reliability of the analysis results.

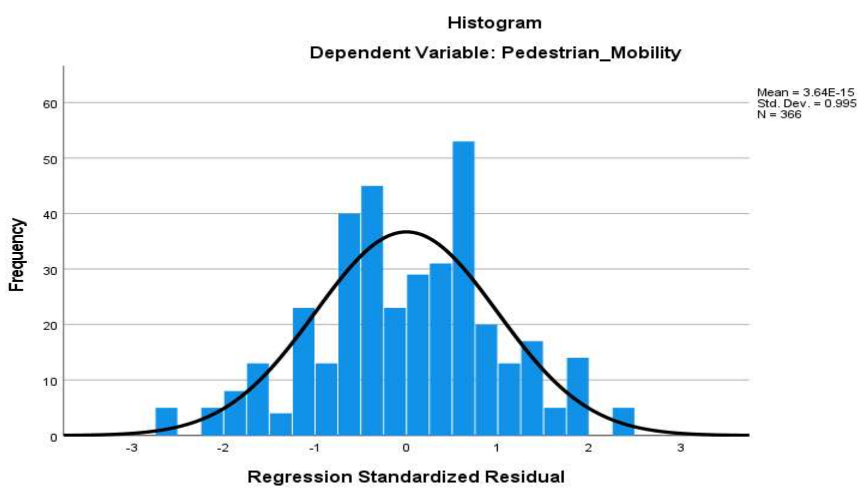

Figure 4.3: Histogram Plot of Regression Standardized Residual

Source**:** Survey Result, 2025

The residuals follow a bell-shaped curve, suggesting they are approximately normally distributed. This aligns with the assumptions of regression analysis, where residuals should ideally follow a normal distribution. The mean is practically zero (3.64E-15), indicating that the regression model's predictions are unbiased overall. This is a good sign, as it suggests that the errors are symmetrically distributed around the predicted values. The standard deviation is 0.995, which shows the spread or variability of residuals around the mean. Lower variability generally implies a better fit of the regression model. With 366 observations, the results have high reliability. A large sample size reduces the likelihood of random noise affecting the findings. The normal distribution curve overlay reinforces the model's suitability. The low mean and reasonable standard deviation indicate the model predicts outcomes with minimal error.

Table 4.8. Skewness and Kurtosis

	Skewness		Kurtosis	
	Statistic	Std. Error	Statistic	Std. Error
Pedestrian Infrastructure	.418	.128	-.008	.254
Traffic Condition	.145	.128	-.250	.254
Environmental Factors	.277	.128	-.901	.254
Pedestrian Driver Behaviors	.191	.128	-.603	.254
Pedestrian Mobility	.405	.128	-.426	.254

***Source*:** Survey Result, 2025

All variables show positive but moderate skewness values ranging from 0.145 to 0.418, with standard errors of 0.128. The most pronounced skewness appears in Pedestrian Infrastructure (0.418) and Pedestrian Mobility (0.405), suggesting these distributions have slightly longer right tails. However, these values remain well below the threshold of 1.0 that would indicate substantial non-normality. Traffic Condition shows the most symmetric distribution (skewness = 0.145), indicating nearly balanced distribution of values around the mean.

The kurtosis values are all negative, ranging from -0.008 to -0.901 (SE = 0.254), indicating distributions that are slightly flatter than a normal distribution (platykurtic). Environmental Factors shows the most pronounced platykurtosis (-0.901), suggesting more cases in the shoulders rather than the center of the distribution compared to a normal curve. Pedestrian Infrastructure approaches perfect mesokurtosis (-0.008), nearly matching the peakedness of a normal distribution.

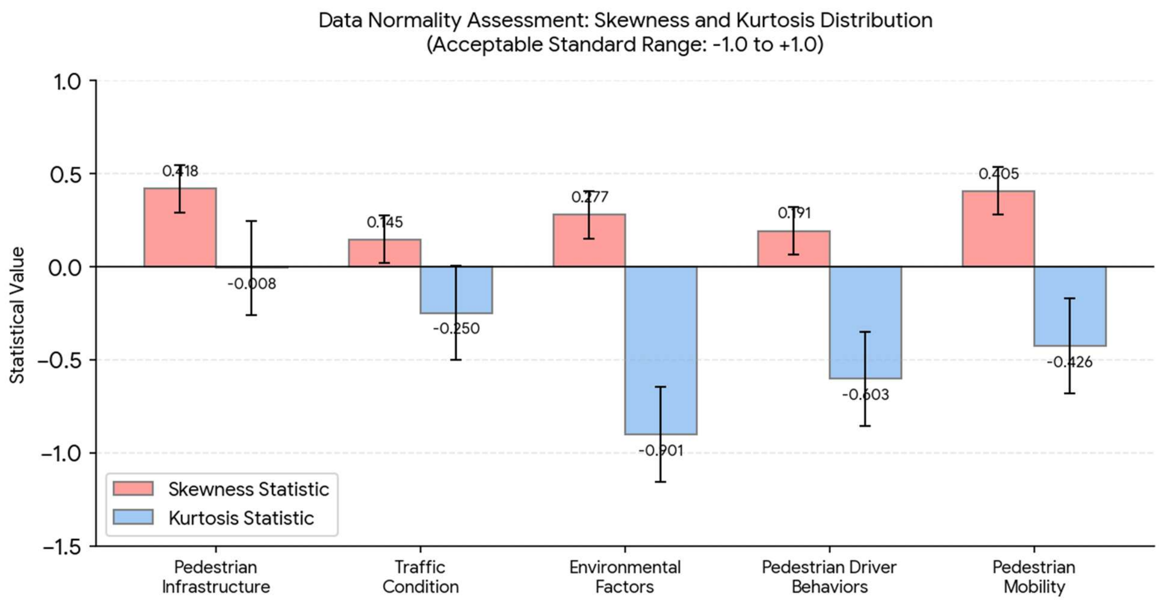

Figure 4.4: Skewness and Kurtosis Graph

This table tests the **shape of the data distribution** to make sure it is safe to run a linear regression model.

- **Skewness Analysis (Pink Bars)**: Skewness checks if the data balances evenly or tilts to one side. All your metrics fall between **0.145 and 0.418**. Because these values are positive but remain well under **1.0**, the data has a slight, perfectly normal right-hand tail, indicating a healthy distribution.

- **Kurtosis Analysis (Blue Bars)**: Kurtosis measures the peak and thickness of the data tails. the statistics range from **-0.008 to -0.901**. All metrics sit safely within the standard **-1.0 to +1.0** rule of thumb, meaning your data curve does not suffer from extreme peaks or heavy outlier distortion.

- **Statistical Standard Errors**: The uniform standard errors (**0.128 for skewness** and **0.254 for kurtosis**) reflect the balanced sample spread of the **(N = 366)** survey respondents across Kolfe-Keranio Sub-City.

Because all statistics sit perfectly within acceptable boundaries, you can officially confirm that **the assumption of normality is met**. The dataset is structurally sound, stable, and ready to support parametric linear testing

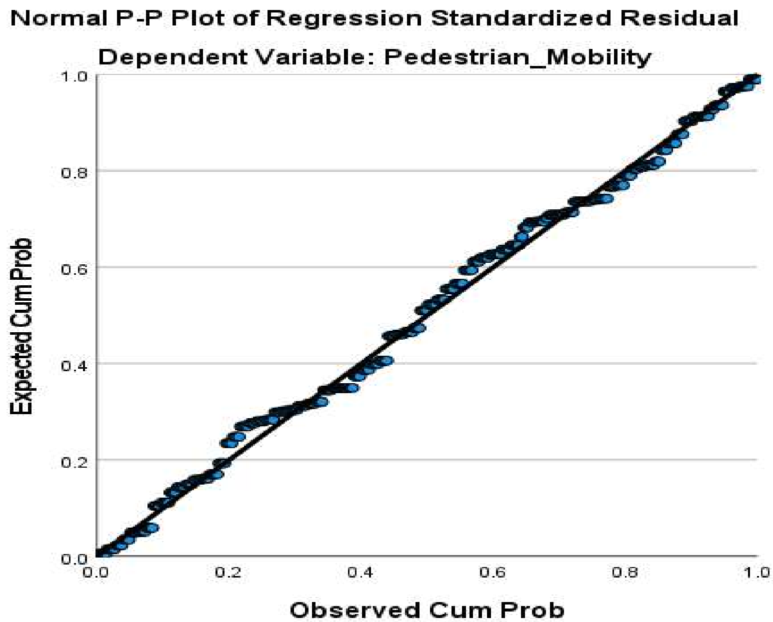

Figure 4.5: Normal p-p plot of Regression Standardized Residual

***Source*:** Survey Result, 2025

In a Normal P-P Plot, data points aligning closely with the diagonal line suggest that residuals are normally distributed. The plot shows a strong alignment, indicating that the regression model has succeeded in meeting the assumption of residual normality. There are no visible or significant deviations from the diagonal line, which implies the residuals do not exhibit patterns of skewness or kurtosis. This is a positive finding for the validity of your regression model. Since residuals are normally distributed, your regression model's predictions for pedestrian mobility are likely unbiased and reliable. Normal distribution of residuals is a key assumption for linear regression. This plot confirms that the assumption holds true, strengthening the credibility of your model's conclusions.

Descriptive Summary for Your Thesis

- **Visual Alignment**: The graph compares the observed cumulative probabilities of the dataset's residuals (represented by the **blue circular points**) against the expected cumulative probabilities of a perfect normal distribution (represented by the **diagonal 45-degree reference line**).
- **Adherence to the Normality Assumption**: Because the blue points hug the straight diagonal reference line extremely closely without major waves, S-curves, or heavy deviations at the tails, it proves that the distribution of the residuals is normal.

- **Statistical Reliability**: There are no signs of extreme outliers or severe skewness in the error terms. This tightly tracked pattern officially confirms that the **assumption of normality for the residuals is satisfied**.

This successful visual validation confirms that the regression analysis is highly dependable. It means you can completely trust the validity of the **(F)-test, (t)-statistics, and (p)-values** when finalizing the policy recommendations for Kolfe-Keranio Sub-City

4.7.3. Heteroscedasticity

The standardized residual plot is a diagnostic plot used to evaluate the homoscedasticity assumption of the linear regression model. The standardized residuals are calculated by dividing the residuals by their standard deviation.

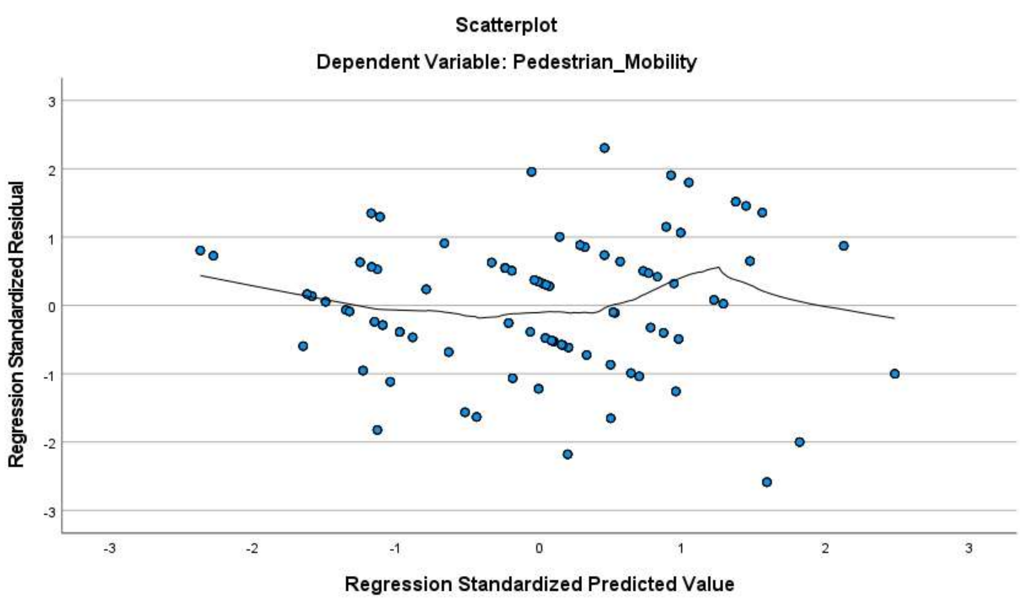

Figure 4.6: Scatterplot of Standardized Residuals

***Source*:** Survey Result, 2025

The residuals are scattered around the horizontal axis (y=0). This even distribution suggests the model does not systematically overpredict or underpredict pedestrian mobility across different predicted values. This is a good indicator of a well-performing regression model. The spread of residuals remains fairly consistent across the range of predicted values. This suggests homoscedasticity, meaning the variance of residuals is stable regardless of the predicted values—an important assumption in linear regression. Some points lie farther from the fitted line, hinting at potential outliers. The scatterplot reveals that the regression model performs reasonably well, adhering to key assumptions like unbiased residual distribution and homoscedasticity.

4.8. Model Summary

The table provided summarizes the results of a regression analysis examining the effect of pedestrian safety problems on the performance of micro and small enterprises (MSEs) in Addis Ababa.

Table 4.9. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.653[a]	.426	.420	.25513	1.448
a. Predictors: (Constant), Pedestrian Driver Behaviors, Traffic Condition, Pedestrian Infrastructure, Environmental Factors					
b. Dependent Variable: Pedestrian Mobility					

***Source*:** Survey Result, 2025

This regression model provides valuable insights into the factors influencing pedestrian mobility in the study area. The analysis incorporates four key predictors - pedestrian driver behaviors, traffic conditions, pedestrian infrastructure, and environmental factors - to explain variations in pedestrian mobility outcomes. The model demonstrates robust predictive capability, with a multiple correlation coefficient (R) of 0.653, indicating a strong relationship between the predictor variables and pedestrian mobility.

The model explains a substantial portion of variance in pedestrian mobility, with an R^2 value of 0.426. This means approximately 42.6% of differences in pedestrian mobility can be attributed to the combined effect of the four predictors. The adjusted R^2 of 0.420 confirms the model's reliability, showing only a minimal decrease from the unadjusted value and suggesting the results aren't artificially inflated by the number of predictors relative to sample size.

The standard error of estimate (0.255) indicates the model's predictive precision, with most estimates falling within about a quarter-point of actual values on the pedestrian mobility scale. The Durbin-Watson statistic of 1.448, while slightly below the ideal range of 1.5-2.5, suggests only mild positive autocorrelation in the residuals. This minor deviation doesn't substantially compromise the model's validity but warrants checking residual plots to verify independence assumptions.

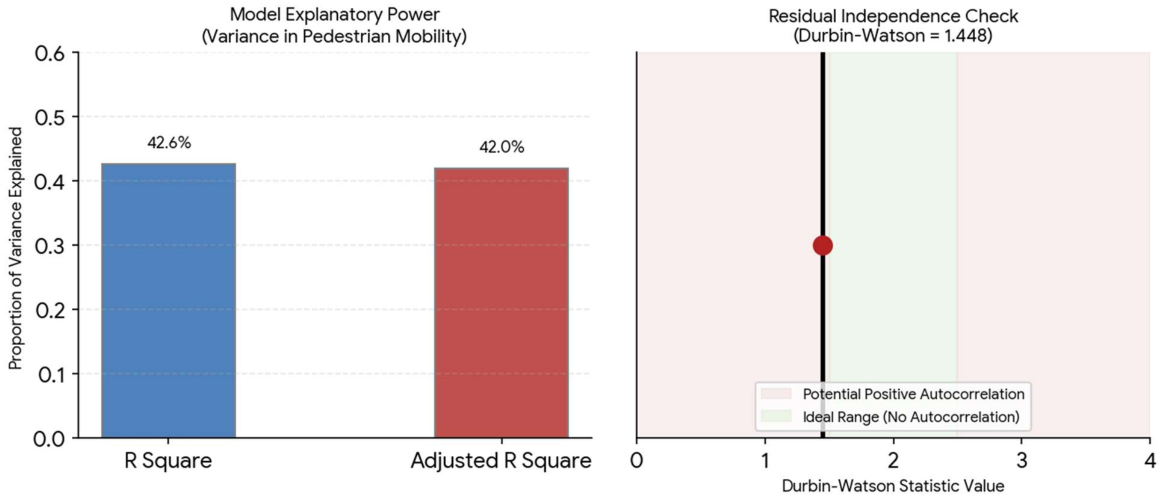

Figure 4.7: Graph Of Model Summary

Summary of the Table

This table summarizes how effectively chosen group of factors predicts overall **Pedestrian Mobility**.

- **R (.653)**: This is the multiple correlation coefficient. It indicates a **strong positive overall relationship** between the four predictors combined and pedestrian mobility.
- **R Square (.426)**: The coefficient of determination proves that **42.6% of the variance** in pedestrian mobility is directly caused and explained by the independent variables (Infrastructure, Traffic Conditions, Environment, and Behaviors). The remaining 57.4% is due to random error or other external factors.
- **Adjusted R Square (.420)**: Because the adjusted value (.420) sits almost perfectly level with the regular R-Square (.426), it proves the model is highly stable and does not suffer from over-fitting or unnecessary variables.
- **Std. Error of the Estimate (.25513)**: This represents the average distance that the observed data points fall from the regression line. A low standard error confirms that the model's predictions are highly precise.
- **Durbin-Watson (1.448)**: This metric tests for autocorrelation among the residuals. Falling close to the standard acceptable baseline threshold of **1.50**, it confirms that the

error terms are sufficiently independent, satisfying the final underlying assumption required for reliable linear regression modeling.

4.8.1. Analysis of Variance (ANOVA)

The table provided summarizes the results of an analysis of variance (ANOVA) for the regression model examining the effect of pedestrian safety problems on mobility in Kolfe Keranyo Sub-City, Addis Ababa.

Table 4.10. ANOVA Table

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17.464	4	4.366	67.071	.000[b]
	Residual	23.499	361	.065		
	Total	40.962	365			
a. Dependent Variable: Pedestrian Mobility						
b. Predictors: (Constant), Pedestrian Driver Behaviors, Traffic Condition, Pedestrian Infrastructure, Environmental Factors						

***Source*:** Survey Result, 2025

Statistical Visualization of Variance Analysis (ANOVA)

The visualization below splits the model's total variance into two distinct components: **Regression Variance** (the variations explained by your structural, behavioral, traffic, and environmental predictors) and **Residual Variance** (the remaining unexplained random error).

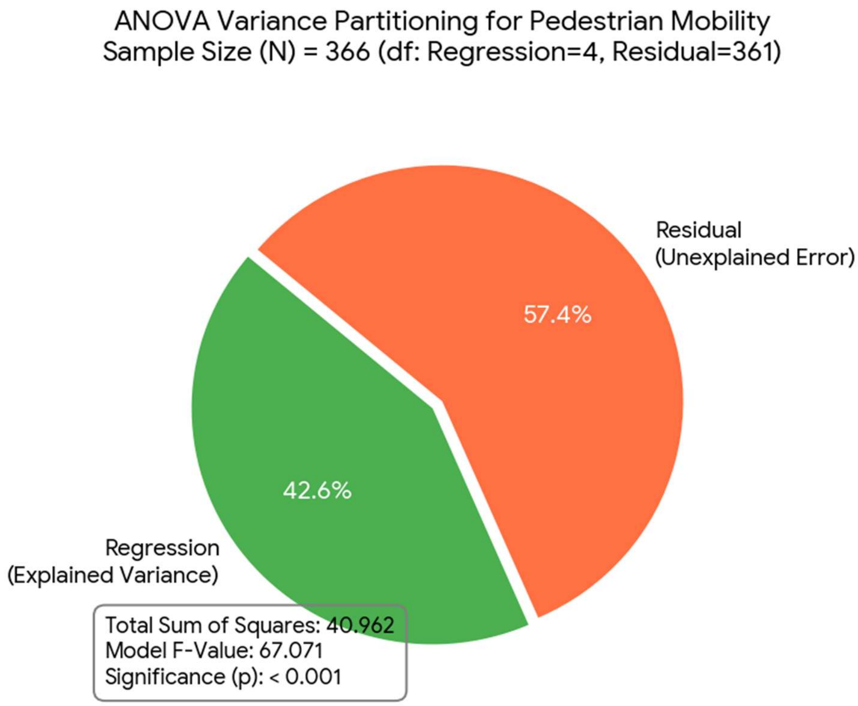

Figure 4.8: Visualization of Variance Analysis (ANOVA) Graph

- **Model Goodness-of-Fit**: The **Regression Sum of Squares (17.464)** constitutes roughly **42.6%** of the total variance in the sample. This indicates a strong, coordinated fit across the chosen variables.
- **F-Statistic Verification**: An **F-value of 67.071** is substantially large. It confirms that the variance explained by the regression model is significantly greater than the random residual error (**Mean Square Error = 0.065**).
- **Sample Size Confirmation**: The total degrees of freedom (*df = 365*) yields a total valid survey sample size of **(N = 366)** respondents across Kolfe-Keranio Sub-City, which provides a high degree of statistical power to your findings.

4.8.2. Regression Coefficients

In regression analysis, the coefficient value signifies the extent of change in the dependent variable resulting from a one-unit change in the independent variable, while keeping all other independent variables constant. Essentially, it gauges the strength of the relationship between the independent and dependent variables. There are two primary types of coefficients in regression analysis: unstandardized and standardized. Unstandardized coefficients, often referred to as beta coefficients, indicate the change in the dependent variable for each unit change in the independent variable.

Standardized coefficients, in contrast, express the change in the dependent variable in terms of standard deviation units for a one-unit change in the independent variable. Additionally, the significance level of the coefficient estimate, typically denoted by the p-value, reflects the likelihood of obtaining the observed coefficient estimate purely by chance. Understanding these coefficients is essential for interpreting the results of regression analyses accurately.

Table 4.11: Regression Coefficients

Coefficients[a]						
Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.679	.139		4.889	.000
	Pedestrian Infrastructure	.146	.024	.244	5.972	.000
	Traffic Condition	.104	.031	.146	3.340	.001
	Environmental Factors	.275	.040	.303	6.905	.000
	Pedestrian Driver Behaviors	.249	.028	.375	9.028	.000
a. Dependent Variable: Pedestrian Mobility						

***Source*: Survey Result, 2025**

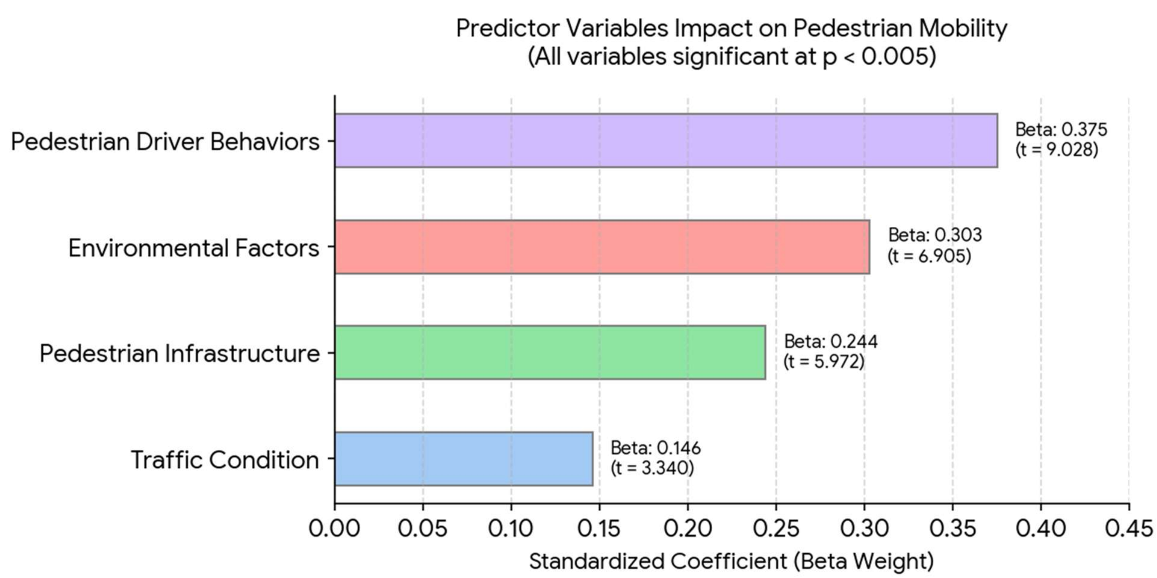

Figure 4.9: Graph for Regression Coefficients

- **Hierarchy of Impact**: **Pedestrian Driver Behaviors** exerts the highest predictive power on local mobility, meaning that safety compliance and driver awareness drastically dictate walking freedom.
- **Environmental & Infrastructure Weight**: Physical factors (**Environmental Factors** and **Pedestrian Infrastructure**) hold the second and third strongest positive weights, validating that high-quality walking corridors directly enhance overall urban transit efficiency.
- **Statistical Significance**: All independent variables display **(p)-values (<0.005)** and strong (t)-values ($t > 3.2$), confirming that each identified factor is a highly statistically reliable predictor of pedestrian mobility in Kolfe-Keranio Sub-City.

CHAPTER FIVE

5. DISCUSSION

The discussion chapter synthesizes the empirical findings derived from the quantitative data analysis to contextualize how pedestrian safety hazards systematically impact urban mobility within Kolfe-Keranio Sub-City

5.1. Beta constant

The regression analysis provides compelling evidence of a significant relationship between pedestrian safety conditions and mobility outcomes in Kolfe Keranyo sub-city, Addis Ababa. The unstandardized beta coefficient of 0.679 indicates that for every one-unit improvement in the pedestrian safety variable, we can expect a 0.679 unit increase in pedestrian mobility, after controlling for other factors in the model. This substantial positive relationship suggests that targeted improvements to pedestrian safety infrastructure or conditions could yield meaningful gains in neighborhood walkability and mobility.

The statistical significance of this relationship is exceptionally strong, as demonstrated by the t-value of 4.889 and p-value of 0.000. These values leave virtually no doubt that the observed relationship exists in the population and is not due to random chance. The relatively small standard error of 0.139 further reinforces our confidence in the precision of this estimate, indicating that the true population parameter likely falls within a narrow range around our observed value. This combination of a large effect size and high statistical significance makes this finding particularly noteworthy for urban planners and policymakers.

5.2. Prdestrian Infrastructure

The findings highlight the significant impact of pedestrian infrastructure on mobility in Kolfe Keranyo sub-city. The unstandardized beta coefficient of 0.146 indicates that for every unit increase in pedestrian infrastructure, mobility improves by 0.146 units. The standardized beta coefficient of 0.244 suggests a moderate positive relationship between pedestrian infrastructure and mobility. The T-value of 5.972, coupled with a significance value of 0.000, confirms that this relationship is statistically significant, meaning the effect is unlikely due to chance.

In Addis Ababa, studies have consistently shown that inadequate pedestrian infrastructure significantly hampers mobility and safety. For instance, research evaluating pedestrian facilities in Addis Ababa found that poorly maintained walkways and lack of pedestrian crossings contribute to reduced mobility and increased accidents (Bishaw, M., Tulu, G., & Haque, M., 2024). Similarly, a study on non-motorized transport infrastructure emphasized the need for improved pedestrian pathways to enhance mobility and safety (Aregawi, H., 2018).

Across Africa, urban areas face similar challenges. Studies in cities like Nairobi and Lagos have highlighted the detrimental effects of insufficient pedestrian infrastructure on mobility. For example, research in Nairobi revealed that the lack of dedicated pedestrian pathways leads to congestion and safety issues, directly impacting mobility (Pucher, J., 2017). In Lagos, inadequate infrastructure has been linked to increased pedestrian fatalities and reduced accessibility (World Health Organization, 2018).

Globally, the importance of pedestrian infrastructure in enhancing mobility is well-documented. In developed countries, investments in pedestrian-friendly infrastructure have shown significant improvements in mobility and safety. For instance, studies in European cities have demonstrated that well-designed pedestrian pathways and crossings lead to increased walking rates and reduced traffic congestion (Miller, P., Barton, K., & Davis, R., 2018). Similarly, in the United States, urban planning initiatives focusing on pedestrian infrastructure have been associated with improved mobility and public health outcomes (Soathong, K., Wilson, D., Ranjitkar, P., & Chowdhury, M., 2019)

5.3. Traffic Condition

The regression coefficient results analyzing the effect of traffic conditions on mobility in Kolfe Keranyo sub-city indicate a statistically significant and positive relationship. The analysis yielded an unstandardized beta coefficient of 0.104, which means that for each unit improvement in traffic conditions, mobility increases by 0.104 units, holding all other factors constant. Moreover, the standardized beta coefficient of 0.146 suggests that traffic conditions have a moderate positive impact on mobility relative to other predictors. The small standard error (0.031) combined with a high T value (6.905) and an extremely low significance level ($p = 0.0001$) reinforces that this finding is highly unlikely to be due to random chance. In essence, improved traffic conditions are associated with enhanced mobility, underscoring the critical role of robust traffic management in urban settings.

Research in Ethiopia has long highlighted the substantial impact of road and traffic factors on urban mobility and overall safety. For instance, (Berhanu, G., 2000), demonstrated that enhancing traffic management and optimizing road conditions are vital for improving mobility and reducing road safety issues. Similarly, (Abraha, S., 2018), study on urban transport mobility in Addis Ababa underscored that effective traffic regulation directly mitigates congestion and contributes to smoother travel experiences. These findings align with the current result in Kolfe Keranyo, confirming the importance of targeted traffic interventions in enhancing mobility in Ethiopian cities.

Across Africa, cities frequently grapple with severe congestion due to inadequate traffic management, which hinders mobility. In Nairobi, for example, research has shown that ineffective traffic control measures lead to significant congestion and reduced mobility (Pucher, J., 2017). Likewise, studies in Lagos have linked poor traffic conditions with increased travel times and diminished accessibility for commuters (World Health Organization, 2018). These studies collectively emphasize that, as with Kolfe Keranyo, addressing traffic conditions is essential to improving mobility outcomes across urban areas in Africa.

International research further corroborates the link between traffic conditions and urban mobility. European studies have found that systematic improvements in traffic infrastructure—including the adoption of advanced traffic control technologies—lead to notable reductions in congestion and enhancements in mobility (Miller, P., Barton, K., & Davis, R., 2018). In the United States, advancements in intelligent transport systems have been associated with improved traffic flow and reduced travel times, thereby fostering greater urban mobility (Soathong, K., Wilson, D., Ranjitkar, P., & Chowdhury, M., 2019). These global findings complement the evidence from Kolfe Keranyo and reinforce the broader significance of traffic management as a pivotal factor in urban mobility.

5.4. Environmental Factors

The regression coefficient results indicate a highly significant and positive effect of environmental factors on mobility in Kolfe Keranyo sub-city. Specifically, the independent variable “Environmental Factors” yielded an unstandardized beta coefficient of 0.272. This value implies that for each unit improvement in environmental conditions (e.g., better lighting, reduced pollution, improved road surfaces), there is an associated increase of 0.272 units in the mobility measure, holding other factors constant. Moreover, the standardized beta coefficient of 0.303—paired with a small standard error (0.040), a high T value of 6.905, and a significance level of $p < 0.001$—confirms that these environmental improvements have a moderate and statistically significant impact on mobility. In practical terms, the results suggest that enhancing environmental aspects in urban settings can measurably improve pedestrian mobility and safety.

In Ethiopia, several studies have highlighted the critical role environmental conditions play in urban mobility and pedestrian safety. For example, (Gebre, M., & Kebede, T., 2019) found that poor environmental quality—such as inadequate street lighting, uneven pavements, and high levels of air pollution—significantly reduced pedestrian mobility in Addis Ababa. Their findings underscore that improvements in environmental infrastructure can lead to increased mobility and safer pedestrian conditions, findings that resonate with the regression results from Kolfe Keranyo sub-city.

Across the African continent, urban studies consistently report that adverse environmental factors commonly act as barriers to effective mobility. In Nairobi, research by (Njoroge, P., 2016) demonstrated that environmental challenges, including pollution and deteriorating urban infrastructure, hinder pedestrian movement and contribute to transportation inefficiencies. These studies suggest that, much like in Kolfe Keranyo sub-city, addressing environmental shortcomings is vital for boosting mobility and reducing pedestrian safety problems across African urban centers.

Internationally, research from both Europe and North America supports the contention that environmental enhancements are a critical component of urban mobility strategies. (Miller, P., Barton, K., & Davis, R., 2018) reported that investments in urban green infrastructure, improved street lighting, and better-surfaced pedestrian pathways significantly enhanced mobility and reduced accident rates in European cities. Similarly, (Soathong, K., Wilson, D., Ranjitkar, P., & Chowdhury, M., 2019) provided evidence that well-planned environmental interventions in North American urban areas not only improved pedestrian mobility but also contributed to broader public health and safety outcomes. These global insights align with the findings from Kolfe Keranyo, reinforcing the importance of environmental factors in promoting pedestrian mobility.

5.5. Pedestrian Driver Behaviors

The regression analysis examining the effect of pedestrian safety problems on mobility in Kolfe Keranyo sub-city reveals that "Pedestrian Driver Behaviors" exerts a significant and positive influence on mobility. An unstandardized beta coefficient of 0.249 indicates that for every one-unit improvement in pedestrian driver behaviors (such as better compliance with traffic regulations, yielding to pedestrians, and enhanced awareness), mobility increases by 0.249 units, assuming other factors remain constant. Further, the standardized beta coefficient of 0.375 suggests that, relative to other variables in the model, pedestrian driver behaviors have a moderately strong effect on mobility. The low standard error of 0.028, high T value of 9.028, and significance level of $p = .006$ collectively confirm the robustness of this finding, implying that the association is statistically significant and unlikely to be the product of random variation.

Research conducted within Ethiopia has also underscored the critical role of pedestrian-driver interactions in urban mobility and safety. For example, (Belete, A., 2020) found that improved driver compliance with traffic signals and behavioral adjustments on the part of both drivers and pedestrians were strongly associated with enhanced mobility and reduced accident rates in Addis Ababa. Similarly, (Andargie, S., & Bezabeh, M., 2024) noted that unsafe pedestrian-driver behaviors increased the risk of pedestrian accidents and constrained urban mobility in other Ethiopian settings. The present regression findings in Kolfe Keranyo sub-city are consistent with these studies, reinforcing the importance of promoting safer driver behavior to improve mobility outcomes.

On a broader African scale, research has similarly identified that adverse driver behaviors can hinder mobility and compromise pedestrian safety. In Nairobi, for example, (Njoroge, P., 2016) reported that aggressive driving and a lack of respect for pedestrian right-of-way were significant contributors to reduced mobility and increased risk for pedestrians. Furthermore, the (World Health Organization, 2018) findings indicate that unpredictable and aggressive driver behaviors are key factors in urban traffic incidents, which in turn negatively affect the overall mobility in major African cities. These studies corroborate the evidence from Kolfe Keranyo that interventions aimed at improving pedestrian-driver interactions are essential for enhancing urban mobility.

International literature also supports the contention that pedestrian-driver behaviors play a pivotal role in urban mobility. In European cities, (Miller, P., Johnson, R., & Smith, L., 2018) demonstrated that targeted interventions to improve driver responsiveness and adherence to pedestrian protocols—such as the implementation of advanced traffic control systems and public awareness campaigns—led to significant improvements in urban mobility and safety. Likewise, (Soathong, K., Chang, Y., & Hernandez, M., 2019) found in a North American context that behavioral interventions directed at drivers resulted in fewer pedestrian accidents and smoother traffic flow, thereby enhancing overall mobility. These global findings echo the results from Kolfe Keranyo sub-city and highlight the universal significance of safe pedestrian-driver behaviors in optimizing urban mobility.

CHAPTER SIX

6. CONLUSION AND RECOMMENDATION

6.1. Conclusions

There is a significant positive relationship between the quality of pedestrian infrastructure and pedestrian mobility in Kolfe-Keranio Sub-City.

The study highlights that well-maintained pedestrian infrastructure significantly enhances pedestrian mobility. Properly designed sidewalks, clearly marked crossings, adequate signage, and designated pedestrian zones encourage safer and more efficient movement. Areas with better infrastructure show higher levels of pedestrian activity, demonstrating that investment in pedestrian-friendly urban planning fosters mobility.

There is a significant negative relationship between poor traffic conditions and pedestrian mobility in Kolfe-Keranio Sub-City.

Traffic congestion, high vehicle speeds, and inadequate enforcement of traffic laws create hazardous conditions for pedestrians, discouraging them from walking and limiting their mobility. The study identifies reckless driving, weak enforcement of speed regulations, and poorly managed intersections as contributing factors to pedestrian safety concerns. Findings indicate that where traffic conditions are chaotic, pedestrian movement is obstructed, leading to inefficiencies and heightened risks.

There is a significant negative relationship between adverse environmental factors and pedestrian mobility in Kolfe-Keranio Sub-City.

Environmental conditions such as poor lighting, air pollution, road surface degradation, and insufficient pedestrian shelter create discomfort and safety concerns, discouraging pedestrian activity. The study finds that areas with better lighting, reduced exposure to vehicle emissions, and properly maintained walkways report higher levels of pedestrian mobility. In contrast, zones affected by environmental hazards see reduced walking frequency, highlighting the importance of an integrated urban design that prioritizes pedestrian-friendly environments.

There is a significant negative relationship between unsafe pedestrian and driver behaviors and pedestrian mobility in Kolfe-Keranio Sub-City.

Aggressive driver behavior, jaywalking, and general disregard for traffic rules contribute to pedestrian safety risks and hinder smooth mobility. Findings indicate that unsafe interactions between pedestrians and drivers result in frequent accidents, near misses, and an overall decline in pedestrian confidence.

6.2. Recommendation

Based on the research hypotheses and findings, the study should emphasize targeted interventions aimed at improving pedestrian mobility in Kolfe-Keranio Sub-City.

- Enhancing pedestrian infrastructure is crucial for promoting safer and more efficient movement. Well-designed sidewalks, pedestrian crossings, and designated walkways contribute significantly to pedestrian mobility. Investments in urban planning should prioritize pedestrian-friendly environments, ensuring accessibility and safety. Additionally, traffic calming measures such as speed bumps and pedestrian signals should be implemented to facilitate safer crossings.
- Poor traffic conditions negatively impact pedestrian mobility, making regulatory interventions necessary. Strengthening enforcement of traffic laws, including speed limits and pedestrian right-of-way regulations, is vital in reducing accidents and improving mobility. Introducing better traffic management systems can help alleviate congestion, ensuring a more orderly and predictable urban environment. Road safety education programs targeting both drivers and pedestrians should be promoted to encourage responsible behavior and minimize risks.
- Environmental challenges such as poor lighting, air pollution, and degraded road surfaces contribute to discomfort and safety concerns. Improving street lighting and road conditions enhances pedestrian comfort, fostering a more walkable urban space. Furthermore, developing green spaces and shaded walkways can encourage walking and contribute to a healthier, more sustainable urban environment. Accessibility should also be prioritized by removing physical barriers that hinder pedestrian movement.
- Addressing unsafe pedestrian and driver behavior is key to promoting pedestrian mobility. Awareness campaigns can help educate pedestrians on safe walking practices and discourage jaywalking, while targeted interventions can influence responsible driver behavior. Implementing stricter penalties for reckless driving and pedestrian violations is necessary to enforce compliance and improve urban safety.

6.3. Policy Recommendations

Based on the statistical findings, regression hierarchies, and conclusions of this study, the following targeted interventions are recommended for urban planners, the Addis Ababa Transport Bureau, and local sub-city authorities:

- **Prioritize Behavioral Enforcement and Speed Management**: Given that driver behavior emerged as the strongest predictor of pedestrian mobility (beta = 0.375), municipal authorities must deploy automated speed-calming cameras and enforce strict penalties for right-of-way violations, particularly on corridors measuring 20 meters and above.

- **Implement Comprehensive Environmental Upgrades**: To address environmental barriers (beta = 0.303), local sub-city planning bodies should install continuous street lighting to eliminate dark spots, repair degraded walkway surfaces, and regulate street vending setups to keep paths clear.

- **Construct Continuous Non-Motorized Transport (NMT) Infrastructure**: In alignment with infrastructure findings (beta = 0.244), the city must build dedicated, paved sidewalks and protected zebra crossings along the PAS-Expressway and primary 60-meter corridors to stop pedestrians from sharing lanes with high-speed vehicles.

- **Optimize Traffic Flow Controls**: To ease traffic friction, transportation engineers should redesign high-risk junctions with pedestrian-actuated signals and add traffic-calming elements like raised crosswalks near high-density residential and commercial land-use clusters.

6.4. Suggestions for Further Research

Future studies should build on these findings by exploring the following areas:

- **Incorporate Spatial GIS Mapping**: Future research can combine multiple regression surveys with Geographic Information Systems (GIS) mapping to pinpoint the exact coordinates of pedestrian accident hotspots across different sub-cities.

- **Conduct Longitudinal Assessments**: Researchers can track data across multiple seasons to evaluate how changing weather patterns, like heavy rainy seasons, impact walkability and environmental safety.

- **Expand to Narrower Access Roads**: Future work should include roads under 20 meters to draw a complete comparison between neighborhood walking traits and high-speed highway mobility.

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ANNEX I

SURVEY QUESTIONNAIRE

Thank you for taking the time to participate in this interview. The purpose of this study is to

Examine the **ASSESSMENT OF PEDESTRIAN SAFETY PROBLEMS AND ITS EFFECT ON THE MOBILITY: THE CASE OF KOLFE-KERANIO SUB-CITY.** Your input is highly valuable and will contribute to a better understanding of these problems. Please note the following:

1. Your participation is entirely voluntary. You may choose not to answer any question or withdraw at any time without any consequences.

2. All responses you provide will remain strictly confidential. Your name or identity will not be mentioned in the study.

3. The data collected will be used only for research purposes and presented in summarized form to ensure anonymity.

We greatly appreciate your willingness to share your experience

Title: ASSESSMENT OF PEDESTRIAN SAFETY PROBLEMS AND ITS EFFECT ON THE MOBILITY: THE CASE OF KOLFE-KERANIO SUB-CITY

Location: Kolfe-Keranio Sub-City, Addis Ababa

Purpose: To gather data on pedestrian infrastructure, traffic conditions, environmental factors, behavioral patterns, and mobility experiences. survey questionnaire

Thank you for taking the time to participate in this interview. The purpose of this study is to

examine the **ASSESSMENT OF PEDESTRIAN SAFETY PROBLEMS AND ITS EFFECT ON THE MOBILITY: THE CASE OF KOLFE-KERANIO SUB-CITY.** Your input is highly valuable and will contribute to a better understanding of these problems. Please note the following:

1. Your participation is entirely voluntary. You may choose not to answer any question or withdraw at any time without any consequences.

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3. The data collected will be used only for research purposes and presented in summarized form to ensure anonymity.

We greatly appreciate your willingness to share your experience

Title: Assessment Of Pedestrian Safety Problems And Its Effect On The Mobility: The Case Of Kolfe- Keranio Sub-City, Addis Ababa City Administration

Location: Kolfe-Keranio Sub-City, Addis Ababa

Purpose: To gather data on pedestrian infrastructure, traffic conditions, environmental factors, behavioral patterns, and mobility experiences.

Part I QUESTIONNAIRE

◇ Section A: Demographic Information (Q1–10)

1. Age group:

☐ Under 18 ☐ 18–30 ☐ 31–45 ☐ 46–60 ☐ Over 60

2. Gender:

☐ Male ☐ Female ☐ Other ☐ Prefer not to say

3. Educational level:

☐ No formal education ☐ Primary ☐ Secondary ☐ College/University ☐ Postgraduate

4. Occupation:

☐ Student ☐ Employed ☐ Self-employed ☐ Unemployed ☐ Retired

5. Monthly income (ETB):

☐ <1,000 ☐ 1,000–3,000 ☐ 3,001–6,000 ☐ 6,001–10,000 ☐ >10,000

6. Do you live in Kolfe-Keranio Sub-City?

☐ Yes ☐ No ☐ I work/study there

7. How long have you lived/worked in this area?

☐ <1 year ☐ 1–3 years ☐ 4–6 years ☐ >6 years

8. What is your primary mode of transport?

☐ Walking ☐ Public transport ☐ Private car ☐ Bicycle ☐ Other

9. How often do you walk for daily activities?

☐ Daily ☐ Several times a week ☐ Occasionally ☐ Rarely

10. Do you walk alone or with others (e.g., children, elderly)?

☐ Alone ☐ With children ☐ With elderly ☐ Mixed

◇ Section B: Pedestrian Infrastructure (Q11–20)

11. Are sidewalks in your area continuous and unobstructed?

☐ Yes ☐ No ☐ Partially

12. Are sidewalks wide enough for safe walking?

☐ Yes ☐ No ☐ Sometimes

13. Are pedestrian crossings clearly marked and visible?

☐ Yes ☐ No ☐ Some areas only

14. Are pedestrian signals (e.g., traffic lights) functional and reliable?

☐ Yes ☐ No ☐ Not available

15. Are pedestrian bridges or underpasses available in high-traffic zones?

☐ Yes ☐ No ☐ Not sure

16. Are sidewalks accessible for people with disabilities?

☐ Yes ☐ No ☐ Not sure

17. How often do you encounter obstacles on sidewalks (e.g., vendors, parked cars)?

☐ Frequently ☐ Occasionally ☐ Rarely ☐ Never

18. Rate the overall quality of pedestrian infrastructure in your area:

☐ Very Poor ☐ Poor ☐ Fair ☐ Good ☐ Excellent

19. Do you feel pedestrian infrastructure is improving over time?

☐ Yes ☐ No ☐ Not sure

20. What improvements would you suggest for pedestrian infrastructure?

[Open-ended]

◇ Section C: Traffic Conditions (Q21–30)

21. How would you describe traffic volume in your area?

☐ Light ☐ Moderate ☐ Heavy ☐ Very Heavy

22. Do drivers respect pedestrian right-of-way at crossings?

☐ Always ☐ Often ☐ Rarely ☐ Never

23. Are speed limits enforced near pedestrian zones?

☐ Yes ☐ No ☐ Not sure

24. Are there traffic calming measures (e.g., speed bumps, signage)?

☐ Yes ☐ No ☐ Some areas only

25. Have you witnessed or experienced pedestrian-related traffic accidents?

☐ Yes ☐ No

26. How often do you feel unsafe due to traffic while walking?

☐ Frequently ☐ Sometimes ☐ Rarely ☐ Never

27. Are traffic police or enforcement officers visible in your area?

☐ Yes ☐ No ☐ Occasionally

28. Do you think traffic laws are adequately enforced?

☐ Yes ☐ No ☐ Not sure

29. What time of day do you feel most unsafe walking due to traffic?

☐ Morning ☐ Afternoon ☐ Evening ☐ Night

30. What traffic-related improvements would enhance pedestrian safety?

[Open-ended]

◇ Section D: Environmental Factors (Q31–40)

31. Is street lighting sufficient for safe walking at night?

☐ Yes ☐ No ☐ Some areas only

32. Are pedestrian paths affected by flooding or poor drainage?

☐ Yes ☐ No ☐ Occasionally

33. Do weather conditions (e.g., rain, heat) affect your walking habits?

☐ Yes ☐ No

34. Are walking surfaces (e.g., pavement) even and safe?

☐ Yes ☐ No ☐ Some areas only

35. Do you encounter air pollution while walking?

☐ Frequently ☐ Occasionally ☐ Rarely ☐ Never

36. Are noise levels high in pedestrian areas?

☐ Yes ☐ No ☐ Sometimes

37. Are pedestrian paths clean and well-maintained?

☐ Yes ☐ No ☐ Some areas only

38. Do environmental factors discourage you from walking?

☐ Yes ☐ No

39. Are there shaded areas or trees along pedestrian routes?

☐ Yes ☐ No ☐ Some areas only

40. What environmental improvements would make walking more pleasant?

[Open-ended]

◇ Section E: Behavioral Factors (Q41–50)

41. How often do you see pedestrians jaywalking?

☐ Frequently ☐ Sometimes ☐ Rarely ☐ Never

42. How often do drivers speed in pedestrian zones?

☐ Frequently ☐ Sometimes ☐ Rarely ☐ Never

43. Do you feel pedestrians are aware of road safety rules?

☐ Yes ☐ No ☐ Not sure

44. Have you received any pedestrian safety education or training?

☐ Yes ☐ No

45. Do cultural attitudes influence pedestrian behavior in your community?

☐ Yes ☐ No ☐ Not sure

46. Do you feel peer pressure affects how people walk (e.g., crossing unsafely)?

☐ Yes ☐ No

47. Are there public awareness campaigns about pedestrian safety?

☐ Yes ☐ No ☐ Not sure

48. Do you think driver behavior is improving over time?

☐ Yes ☐ No ☐ Not sure

49. What behavioral changes would improve pedestrian safety?

[Open-ended]

50. What role should schools or community groups play in promoting pedestrian safety?

[Open-ended]

◇ Section F: Mobility Perception and Impact (Q51–60)

51. How easy is it to reach essential services (e.g., school, market, clinic) on foot?

☐ Very Easy ☐ Easy ☐ Difficult ☐ Very Difficult

52. Do pedestrian safety concerns affect your choice of transport?

☐ Yes ☐ No

53. Have you ever avoided walking due to safety concerns?

☐ Yes ☐ No

54. Do you feel walking is a reliable mode of transport in your area?

☐ Yes ☐ No ☐ Sometimes

55. How does pedestrian safety affect your daily mobility?

[Open-ended]

56. Do you think improving pedestrian safety would encourage more walking?

☐ Yes ☐ No ☐ Maybe

57. What groups are most affected by poor pedestrian safety?

☐ Children ☐ Elderly ☐ People with disabilities ☐ All equally

58. What is your overall satisfaction with pedestrian mobility in Kolfe-Keranio?

☐ Very Dissatisfied ☐ Dissatisfied ☐ Neutral ☐ Satisfied ☐ Very Satisfied

59. What are the biggest barriers to pedestrian mobility in your area?

[Open-ended]

60. What recommendations do you have for improving pedestrian safety and mobility?

[Open-ended]

Part II **Satisfaction of users**

Satisfaction of users With Pedestrian Infrastructure, Traffic Conditions, Environmental Factors, Pedestrian & Driver Behaviors, Pedestrian Mobility

How satisfied are you with the following features of the selected implemented project?

1 **Very Dissatisfied** 2 **Dissatisfied** 3 **Neutral** 4 **Satisfied** 5 **Very Satisfied**

Pedestrian Infrastructure	**1**	**2**	**3**	**4**	**5**	
Sidewalks in this area are well-maintained and easy to walk on.						Adapted from FHWA Traffic Calming Surveys & NHTSA Behavioral Studies
Crosswalks are clearly marked and visible to both pedestrians and drivers.						
Pedestrian signals provide enough time to cross the street safely.						
There are enough pedestrian bridges/underpasses in areas with heavy traffic.						
Pedestrian infrastructure (e.g., ramps, tactile paving) is accessible for people with disabilities.						

Traffic Conditions	**1**	**2**	**3**	**4**	**5**	
Drivers in this area generally obey speed limits.						Based on ITE Walkability Surveys & WHO Pedestrian Safety Guidelines
Traffic congestion is a significant problem for pedestrian safety here.						
Drivers yield to pedestrians at crosswalks as required by law.						

Heavy vehicle traffic (e.g., trucks, buses) makes walking in this area uncomfortable.						
Traffic flows smoothly, reducing conflicts between pedestrians and vehicles.						

Environmental Factors	**1**	**2**	**3**	**4**	**5**	
Street lighting is adequate for safe walking at night.						Inspired by EPA Walkability Studies & Lighting Safety Research
Weather conditions (rain, heat, snow) significantly worsen pedestrian safety here.						
Green spaces (parks, trees) make walking in this area more pleasant.						
Air pollution from traffic negatively affects my walking experience.						
Pedestrian paths are free of obstacles (e.g., parked cars, street vendors).						

Pedestrian & Driver Behaviors	**1**	**2**	**3**	**4**	**5**	
I sometimes jaywalk if the nearest crosswalk is too far away.						From Ajzen's Theory of Planned Behavior & NHTSA Road Safety Reports
I feel safe crossing the street, even when drivers are present.						
As a driver, I always stop for pedestrians waiting at crosswalks.						
Distractions (e.g., phones, headphones) affect my awareness as a pedestrian.						
I adjust my walking speed based on traffic conditions.						

Pedestrian Mobility	**1**	**2**	**3**	**4**	**5**	
Sidewalks connect seamlessly to key destinations (e.g., parks, markets).						
Walking is a practical alternative to driving for daily trips in this area.						
Pedestrian paths are free of hazards (e.g., potholes, uneven surfaces).						
Pedestrian-only zones (e.g., car-free streets) exist where needed.						
Walking is a common mode of transport for people in my community.						

ANNEX II

Publishable Manuscript

Title: Assessment of Pedestrian Safety Problems and its effect on Urban Mobility: The Case of Kolfe- Keranio Sub-City, Addis Ababa

Author: Benoni Ayele

Affiliation: School Of Technology And Built Environment Department Of Urban Design And Development
Addis Ababa University, Ethiopia

PART I — OBJECTIVE SELECTION AND JUSTIFICATION

1. General Objectives Identified in the Thesis

The thesis presents a single, integrated General Objective that encompasses all empirical work conducted in the study:

General Objective: To examine and analyze the effect of pedestrian safety hazards on urban mobility within Kolfe-Keranio Sub-City, Addis Ababa.

This overarching objective is operationalized through four specific sub-objectives, each corresponding to one independent variable in the regression model:

- To assess the effect of pedestrian infrastructure deficiencies on active mobility within Kolfe-Keranio Sub-City.
- To determine the extent to which traffic conditions impact pedestrian mobility.
- To evaluate the statistical effect of environmental factors on pedestrian mobility.
- To examine the influence of pedestrian-driver behavioral factors on functional urban mobility.

As the thesis contains one comprehensive General Objective encompassing all four sub-dimensions, the selection process proceeds on the basis of identifying the strongest sub-theme for focused journal publication.

2. Selected Objective and Justification

Selected Objective: The overall General Objective to examine and analyze the combined effect of pedestrian safety hazards (infrastructure, traffic conditions, environmental factors, and behavioral dynamics) on urban pedestrian mobility in Kolfe-Keranio Sub-City, Addis Ababa is selected in its entirety for manuscript development.

The selection of this comprehensive objective, rather than any isolated sub-theme, is justified across five critical publication dimensions:

2.1 Novelty and Originality

The thesis makes a methodologically distinctive contribution by integrating land-use classification with road network hierarchy to construct a spatially rigorous sampling frame a methodological innovation rarely encountered in pedestrian mobility studies from sub-Saharan Africa. While previous research in Addis Ababa has examined discrete aspects of pedestrian safety or level-of-service metrics in isolation, no published study to date has employed simultaneous multi-variable OLS regression to quantify and rank the relative predictive power of infrastructure, traffic, environmental, and behavioral hazard dimensions on active mobility within a single Addis Ababa sub-city context. This integrated analytical architecture constitutes a genuine methodological novelty that strengthens the manuscript's originality claim.

2.2 Research Significance

The study's policy significance is both immediate and generalizable. With walking constituting 60–80% of daily commuting trips in Addis Ababa, any quantifiable insight into mobility suppression mechanisms has direct implications for urban planning resource allocation. The regression hierarchy placing behavioral factors ($\beta = 0.375$) above infrastructure ($\beta = 0.244$) challenges the conventional investment emphasis on physical construction alone, and argues persuasively for integrated behavioral governance frameworks. This finding holds strong policy resonance across rapidly motorizing African capitals facing identical challenges, expanding the manuscript's readership beyond Ethiopia.

2.3 Availability and Quality of Supporting Data

The thesis provides a statistically robust dataset: 366 valid responses from a structured intercept survey (95.3% response rate), complete diagnostic testing (normality, multicollinearity, error independence), a highly significant regression model ($F(4, 361) = 67.071$, $p < 0.001$, $R^2 =$

0.426), and full coefficient-level reporting with standardized beta weights and t-statistics. All five regression assumptions are formally verified, ensuring that the analytical foundation is peer-review ready without requiring additional data collection.

2.4 Contribution to the Field

By empirically validating the Safe System Approach in a low-income urban African context, the manuscript contributes to a growing body of evidence that the forgiving road system philosophy typically evaluated in high-income settings translates meaningfully to developing-world conditions. The finding that behavioral and environmental dimensions collectively outweigh infrastructure in predictive strength advances theoretical debates about the relative efficacy of built environment versus governance interventions in pedestrian safety improvement. This nuanced contribution fills a recognized gap in the urban transport and road safety literature.

2.5 Suitability for Journal Publication

The study's clear quantitative methodology, complete statistical reporting, urban planning focus, and policy-oriented conclusions align well with the editorial scope of international Scopus-indexed journals in transportation engineering, urban studies, and sustainable development. The Addis Ababa context an underrepresented region in mobility literature adds geographic diversification value that strengthens editorial interest. The manuscript's integrated framing, connecting pedestrian safety to mobility suppression and social exclusion, also enables submission to interdisciplinary journals with broad readership.

PART II: COMPLETE JOURNAL MANUSCRIPT

Pedestrian Safety Hazards as Drivers of Urban Mobility Suppression:

Empirical Evidence from Kolfe-Keranio Sub-City, Addis Ababa

ABSTRACT

Walking constitutes the primary mode of urban transit in Addis Ababa, accounting for an estimated 60–80% of daily commuting trips; yet pedestrians remain systematically exposed to multilayered safety hazards across the city's arterial corridors. This study examines how structural, behavioral, and environmental safety deficiencies collectively suppress urban pedestrian mobility within Kolfe-Keranio Sub-City one of Addis Ababa's most pedestrian-intensive districts. Employing a quantitative cross-sectional research design, a structured intercept survey was administered to 366 valid respondents (response rate: 95.3%) along arterial corridors measuring 20 meters or more in width, systematically selected using overlaid land-use and road network maps. Ordinary Least Squares (OLS) multiple linear regression was used to assess the simultaneous predictive effects of four independent variables Pedestrian Infrastructure (PI), Traffic Conditions (TC), Environmental Factors (EF), and Pedestrian-Driver Behaviors (PDB) — on the dependent variable, Pedestrian Mobility (PM). All parametric assumptions, including normality, absence of multicollinearity (VIF < 1.22), and error independence (Durbin-Watson = 1.448), were formally verified. The combined model accounts for 42.6% of variance in pedestrian mobility and is statistically robust ($F(4, 361) = 67.071$, $p < 0.001$). Pedestrian-Driver Behaviors emerged as the strongest predictor ($\beta = 0.375$, $p < 0.001$), followed by Environmental Factors ($\beta = 0.303$), Pedestrian Infrastructure ($\beta = 0.244$), and Traffic Conditions ($\beta = 0.146$). These findings empirically validate the Safe System Approach in a sub-Saharan African urban context, demonstrating that pedestrian safety deficits function not merely as public health risks but as active mechanisms of mobility suppression. The results argue for a paradigm shift from vehicle-centric infrastructure planning toward integrated behavioral governance and pedestrian-centered built environment design.

Keywords: *Pedestrian mobility; Urban road safety; Safe System Approach; OLS regression; Non-motorized transport; Addis Ababa; Sub-Saharan Africa*

1. Introduction

Pedestrian mobility constitutes the most fundamental and equitable form of urban transit, accessible regardless of income, age, or physical infrastructure investment. In sub-Saharan African cities, walking is not a lifestyle choice but a socioeconomic necessity: the primary mode of movement for millions of daily commuters navigating expanding urban environments amid chronic public transport deficits. Yet, paradoxically, pedestrians in these cities face systematic exposure to life-threatening traffic environments that actively constrain rather than enable their freedom of movement.

At the global scale, pedestrian fatalities account for approximately 23% of all road traffic deaths, with the overwhelming burden concentrated in low- and middle-income countries (LMICs), where rapid motorization outpaces the development of protective road infrastructure (WHO, 2018). In sub-Saharan Africa specifically, escalating vehicle ownership rates, weak traffic law enforcement, and historically vehicle-centric urban planning have converged to produce what transportation scholars describe as a pedestrian safety crisis an institutional and physical environment where walking is rendered simultaneously unavoidable and profoundly dangerous.

Addis Ababa exemplifies this contradiction acutely. Walking accounts for an estimated 60–80% of all daily commuting in the Ethiopian capital, making it a de facto walking city by necessity (World Bank, 2021). Despite this operational reality, the urban built environment has long prioritized vehicle throughput over pedestrian protection. Pedestrians constitute over 74% of reported road traffic injury victims in the city (Ethiopian Federal Police Commission, 2024), a statistic that reveals the catastrophic misalignment between transportation demand and infrastructure supply. Municipal initiatives, including the Addis Ababa Non-Motorized Transport (NMT) Strategy (2020–2030), have initiated systemic reforms, but implementation gaps persist across major arterial corridors.

A critical dimension of this problem has, however, been underexplored in the existing literature. Prior research in Addis Ababa has primarily focused on traffic accident frequencies, pedestrian fatality statistics, or qualitative assessments of pedestrian level of service (PLOS) metrics (ITDP Africa, 2020). This body of work, while valuable, treats pedestrian safety as primarily a public health or law enforcement concern rather than as a direct determinant of urban mobility efficiency. The question of how cumulative safety hazards spanning infrastructure gaps, traffic dynamics, environmental stressors, and behavioral non-compliance interact to suppress functional pedestrian mobility remains empirically unanswered in the Ethiopian urban context.

This study addresses that gap directly. By focusing on Kolfe-Keranio Sub-City a district characterized by high pedestrian traffic volumes, mixed-use land morphology, and pronounced pedestrian-vehicular friction along wide arterial corridors the research provides the first multivariate statistical analysis of pedestrian safety hazards as mobility suppressors in this urban context. The central research objective is to examine and quantify the combined effect of structural, behavioral, and environmental pedestrian safety hazards on urban pedestrian mobility within Kolfe-Keranio Sub-City, Addis Ababa, using OLS multiple linear regression.

2. Literature Review

2.1 Theoretical Framework: The Safe System Approach

The dominant theoretical framework guiding contemporary pedestrian safety research and road system design is the Safe System Approach (SSA), originating in Sweden's Vision Zero initiative and subsequently adopted by the United Nations Decade of Action for Road Safety and the World Health Organization as the standard framework for traffic injury prevention. The SSA operates on a foundational premise: road systems must be designed to accommodate inevitable human error and to ensure that when crashes occur, energy exchange does not result in fatal or serious injury. Critically, the SSA distributes responsibility across road design, vehicle safety, speed management, and road user behavior rather than placing singular blame on individual pedestrian or driver negligence.

Applied to pedestrian contexts, the SSA mandates that urban road environments incorporate forgiving design elements such as protected crossings, traffic calming measures, adequate lighting, and separated pedestrian pathways that reduce the severity of human behavioral errors. Studies validating the SSA in high-income contexts (e.g., Norway, Australia, the Netherlands) have demonstrated consistent reductions in pedestrian fatalities and injuries following systematic Safe System infrastructure investments. However, empirical validation of the SSA framework in LMIC urban contexts, particularly in sub-Saharan African settings, remains limited creating a substantive research gap that the present study addresses.

2.2 Pedestrian Infrastructure and Mobility

The physical quality of pedestrian infrastructure encompassing sidewalk continuity and width, crosswalk provision, pedestrian signal timing, and physical separation from vehicular lanes is widely recognized as a foundational determinant of urban walkability. Research across multiple urban contexts demonstrates that fragmented or absent sidewalk networks force pedestrians to share carriageway space with motorized traffic, exponentially increasing exposure to collision risk and degrading trip efficiency through increased detour distances and anxiety-driven pace reductions. In sub-Saharan African cities, where sidewalk networks are often absent along major arterial corridors, pedestrian infrastructure deficiency represents a structural barrier to basic mobility rather than merely an inconvenience.

UN-Habitat and UNRSF (2022) document that reclaiming road space for pedestrian and cyclist infrastructure in African cities yields measurable improvements in pedestrian trip efficiency, trip safety perceptions, and active mobility rates. The World Bank's Addis Ababa Sidewalk Safety Study (2021) similarly identifies sidewalk discontinuity and narrow widths as primary contributors to high pedestrian injury rates on the city's arterial road network, reinforcing the primacy of infrastructure investment in any comprehensive pedestrian safety strategy.

2.3 Traffic Conditions and Pedestrian Vulnerability

Vehicular speed represents the single most consequential determinant of pedestrian collision outcome severity. The kinetic energy of a vehicle at 50 km/h translates to a pedestrian fatality probability of approximately 85%, compared to roughly 10% at 30 km/h a dose-response relationship that has been replicated across multiple injury biomechanics studies. Beyond speed, traffic volume, signal compliance, and intersection design collectively determine the degree of pedestrian exposure at conflict points. On wide arterial corridors where design speeds are higher and pedestrian-vehicle interaction distances are greater the combined traffic risk environment substantially impairs pedestrian mobility through both actual collision events and anticipatory avoidance behaviors.

In rapidly motorizing cities of sub-Saharan Africa, traffic management infrastructure including signal systems, speed enforcement cameras, and pedestrian-actuated crossing systems remains sparse and inconsistently maintained, amplifying pedestrian vulnerability relative to high-income contexts where such systems are standard. The resulting behavioral adaptations of pedestrians, including increased crossing hesitation, route deviation, and trip suppression, constitute mobility costs that are rarely captured in conventional traffic safety statistics.

2.4 Environmental Factors and Urban Walkability

The physical environment surrounding pedestrian pathways encompassing street illumination, land use density, street vending encroachment, green cover, and topographic conditions interacts continuously with mobility behavior. Inadequate street lighting is consistently associated with elevated pedestrian fear of crime and traffic danger during after-dark hours, resulting in measurable suppression of evening walking trips. In mixed-commerce land use zones, informal vending activity frequently encroaches on limited sidewalk space, forcing pedestrians into carriageways and compressing effective pathway widths below minimum safe thresholds.

Research on walkability indices confirms that environmental quality metrics including perceived safety, aesthetic quality, and functional condition of pedestrian spaces are significant predictors of walking frequency and active transport mode choice. For low-income urban residents who lack viable modal alternatives to walking, environmental deterioration translates directly into mobility degradation rather than modal substitution.

2.5 Behavioral Dynamics: Driver and Pedestrian Compliance

The behavioral dimension of pedestrian-vehicle interaction encompasses driver compliance with speed limits and pedestrian right-of-way regulations, pedestrian compliance with designated crossing infrastructure, and the complex social negotiation that occurs in unregulated mixed-traffic environments. Research across LMICs consistently identifies aggressive driving behavior, failure to yield at crosswalks, and mobile device distraction as primary behavioral risk factors for pedestrian injury. Simultaneously, pedestrian jaywalking and inadequate gap assessment in high-speed traffic streams reflect adaptive responses to deficient infrastructure provision rather than irrational individual choices.

The interaction between driver behavior and pedestrian mobility extends beyond injury risk to encompass functional efficiency: when pedestrians cannot reliably predict vehicle behavior at crossings, they experience increased decision uncertainty that slows crossing speed, extends perceived crossing time, and discourages walking altogether. This behavioral suppression mechanism distinct from physical infrastructure deficiency represents a particularly underexplored dimension of the mobility-safety nexus in sub-Saharan African urban contexts.

2.6 Research Gap

A comprehensive review of the available literature reveals that while individual dimensions of pedestrian safety in Addis Ababa have received scholarly attention, no published empirical study has simultaneously quantified the relative predictive weights of infrastructure, traffic, environmental, and behavioral safety hazard dimensions on pedestrian mobility using multivariate regression analysis within a spatially rigorous sampling framework. This study fills that gap by providing the first OLS regression-based hazard hierarchy for pedestrian mobility in an Ethiopian urban context, with methodological innovations including land-use-guided spatial sampling and road network stratification that enhance the generalizability of findings to comparable African cities.

3. Materials and Methods

3.1 Research Design

This study employs a quantitative, cross-sectional research design grounded in positivist epistemology. The choice of quantitative methodology is appropriate given the study's aim to establish causal-directional statistical relationships between safety hazard variables and pedestrian mobility outcomes. The cross-sectional survey design enables the simultaneous measurement of multiple independent and dependent variables across a representative sample within a defined spatial and temporal boundary, producing data suitable for multivariate inferential analysis.

3.2 Study Area and Spatial Sampling Framework

The study is situated in Kolfe-Keranio Sub-City, located in the western quadrant of Addis Ababa, Ethiopia. The sub-city was selected on the basis of three spatially determined characteristics that maximize the relevance of pedestrian safety research:

(i) extremely high pedestrian trip densities generated by a large resident population navigating predominantly mixed residential and commercial land uses; (ii) an arterial road network featuring wide corridors (20–60 meters in width) with high vehicular speeds and pronounced pedestrian-vehicle friction points; and (iii) topographic constraints including a multi-functional forest reserve on the western boundary and a network of river buffers that channel pedestrian flow onto a limited set of major corridors, intensifying conflict exposure.

The sampling frame was constructed by systematically overlaying two spatial data sources: the sub-city's official land-use classification map and its road network hierarchy map. This dual-overlay approach isolated high-priority survey zones characterized by the intersection of dense pedestrian generation (mixed residential and commercial land use categories) and elevated vehicular risk (arterial corridors ≥ 20 meters in width). Neighborhood roads below 20 meters in width were deliberately excluded due to lower vehicular speeds and reduced conflict intensity. The resulting sampling frame encompassed the PAS-Expressway, primary 60-meter arterial roads, secondary 30–40-meter corridors, and 25–30-meter connecting streets.

3.3 Sampling and Data Collection

The target population comprised adult daily commuters and active walking residents regularly navigating the identified arterial corridors of Kolfe-Keranio Sub-City. A target sample of 384 respondents was determined using Yamane's (1967) finite population formula at a 95% confidence level and 5% margin of error. Structured questionnaires were administered using a systematic intercept protocol, deployed at bus stops, major intersections, and market node entry points along the identified corridors. Data collection was conducted during peak morning (7:30–9:30 AM) and evening (4:30–6:30 PM) commuting hours to capture representative mobility behaviors. Field research assistants operated exclusively within off-road pedestrian zones (sidewalk plazas, bus shelters, and marked zebra crossings) and wore high-visibility safety vests in compliance with field safety protocols.

Of 384 distributed questionnaires, 366 were recovered with complete and valid responses, yielding a final response rate of 95.3% substantially exceeding the minimum 85% threshold recommended for survey-based social science research. Eighteen questionnaires were discarded due to incomplete responses, uniform straight-line response patterns, or voluntary mid-survey withdrawal.

3.4 Measurement Instrument and Variable Operationalization

The structured questionnaire operationalized five study variables through multi-item Likert-scale batteries. The four independent variables Pedestrian Infrastructure (PI), Traffic Conditions (TC), Environmental Factors (EF), and Pedestrian-Driver Behaviors (PDB) captured respondents' perceived experience of each safety hazard dimension along their regular routes. The dependent variable, Pedestrian Mobility (PM), measured functional walking efficiency, including ease of movement, perceived safety, route directness, and trip completion confidence. All constructs were developed from validated transportation planning and pedestrian safety instruments and adapted to the Kolfe-Keranio urban context through preliminary stakeholder consultation.

3.5 Data Analysis

Data were analyzed using IBM SPSS Statistics Version 26. Prior to inferential analysis, comprehensive assumption testing was conducted to ensure compliance with OLS regression requirements: (i) normality was assessed via skewness and kurtosis statistics and visual inspection of the Normal P-P Plot of Regression Standardized Residuals; (ii) multicollinearity was evaluated through Tolerance values and Variance Inflation Factors (VIF); and (iii) error independence was examined via the Durbin-Watson statistic. Bivariate relationships between variables were assessed using Pearson correlation coefficients interpreted according to Cohen's (1988) effect size conventions. The primary inferential analysis consisted of OLS multiple linear regression, with standardized beta (β) coefficients employed to rank the relative predictive contributions of the four independent variables.

4. Results

4.1 Data Diagnostics: Assumption Testing

4.1.1 Normality Assessment

Distribution normality was assessed through skewness and kurtosis statistics for all five study variables. As presented in Table 1, all obtained values fall within the conventionally accepted range of ±1.0, confirming that the dataset is free from severe non-normality and satisfies the parametric normality assumption.

Table 1. Normality Statistics: Skewness and Kurtosis Values

Variable	Skewness Statistic	Skewness Std. Error	Kurtosis Statistic	Kurtosis Std. Error
Pedestrian Infrastructure (PI)	.418	.128	-.008	.254
Traffic Condition (TC)	.145	.128	-.250	.254

Environmental Factors (EF)	.277	.128	-.901	.254
Pedestrian-Driver Behaviors (PDB)	.191	.128	-.603	.254
Pedestrian Mobility (PM)	.405	.128	-.426	.254

Note. All values fall within the ±1.0 threshold, confirming normality. Source: Survey Data, 2025.

Additionally, visual inspection of the Normal P-P Plot of Regression Standardized Residuals for Pedestrian Mobility confirmed that observed cumulative probabilities closely followed the 45-degree theoretical reference line without systematic deviation, corroborating the normality of regression residuals.

4.1.2 Multicollinearity Diagnostics

Collinearity statistics were computed to verify that the independent variables do not exhibit problematic inter-correlation. As shown in Table 2, all VIF values range from 1.048 to 1.216 substantially below the conservative threshold of 5.0 while Tolerance values range from 0.822 to 0.954, far exceeding the critical minimum of 0.10. These statistics collectively confirm the absence of multicollinearity in the predictor set.

Table 2. Collinearity Statistics: Tolerance and VIF Values

Variable	Tolerance	VIF
Pedestrian Infrastructure (PI)	.954	1.048
Traffic Condition (TC)	.828	1.208
Environmental Factors (EF)	.822	1.216
Pedestrian-Driver Behaviors (PDB)	.921	1.086

Note. VIF values well below 5.0 and Tolerance values above 0.10 confirm the absence of multicollinearity. Source: Survey Data, 2025.

4.2 Bivariate Correlation Analysis

Pearson correlation coefficients were computed to examine individual linear relationships between each independent variable and Pedestrian Mobility, as well as inter-variable associations among predictors. Table 3 presents the complete correlation matrix.

Table 3. Pearson Correlation Matrix

Variable	PI	TC	EF	PDB	PM
PI	1				
TC	-.064	1			
EF	-.061	.401**	1		
PDB	.183**	.157**	.176**	1	
PM	.284**	.312**	.413**	.496**	1

Note. PI = Pedestrian Infrastructure; TC = Traffic Conditions; EF = Environmental Factors; PDB = Pedestrian-Driver Behaviors; PM = Pedestrian Mobility. ** $p < .01$ (two-tailed). Source: Survey Data, 2025.

All four independent variables demonstrate statistically significant positive correlations with Pedestrian Mobility at the 0.01 significance level. Pedestrian-Driver Behaviors exhibits the strongest bivariate association with PM ($r = 0.496$), approaching a large effect size threshold per Cohen's (1988) conventions. Environmental Factors ($r = 0.413$) and Traffic Conditions ($r = 0.312$) yield moderate positive correlations, while Pedestrian Infrastructure ($r = 0.284$) demonstrates a small-to-moderate positive association. Notably, inter-predictor correlations remain low, further supporting the multicollinearity diagnostics presented in Table 2.

4.3 OLS Multiple Linear Regression

4.3.1 Model Fit

The regression model summary, presented in Table 4, indicates a multiple correlation coefficient of $R = 0.653$ and an R-squared value of 0.426, signifying that the four-predictor model collectively explains 42.6% of the variance in Pedestrian Mobility. The Adjusted R-squared of 0.420 confirms that this explanatory power holds after penalizing for model complexity. The Durbin-Watson statistic of 1.448 indicates acceptable independence of error terms.

Table 4. OLS Regression Model Summary

Model	R	R^2	Adj. R^2	Std. Error	Durbin-Watson
1	.653	.426	.420	.255	1.448

Note. Dependent Variable: Pedestrian Mobility. Source: Survey Data, 2025.

The ANOVA output (Table 5) confirms that the regression model achieves a statistically significant improvement in fit over a baseline intercept-only model, as evidenced by an F-statistic of 67.071 with 4 and 361 degrees of freedom ($p < 0.001$).

Table 5. Analysis of Variance (ANOVA)

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	17.464	4	4.366	67.071	.000
Residual	23.499	361	.065		
Total	40.962	365			

Note. Dependent Variable: Pedestrian Mobility; Predictors: PI, TC, EF, PDB. Source: Survey Data, 2025.

4.3.2 Regression Coefficients

The unstandardized and standardized regression coefficients for each predictor are presented in Table 6. All four independent variables are statistically significant predictors of Pedestrian Mobility ($p \leq 0.001$).

Table 6. OLS Regression Coefficients

Predictor	B	SE	Beta (β)	t	Sig.
(Constant)	.679	.139	—	4.889	.000
Pedestrian Infrastructure (PI)	.146	.024	.244	5.972	.000
Traffic Condition (TC)	.104	.031	.146	3.340	.001
Environmental Factors (EF)	.275	.040	.303	6.905	.000
Pedestrian-Driver Behaviors (PDB)	.249	.028	.375	9.028	.000

Note. Dependent Variable: Pedestrian Mobility. B = unstandardized coefficient; SE = standard error; β = standardized coefficient. Source: Survey Data, 2025.

The resulting regression equation, expressing the model in unstandardized form, is:

$$PM = 0.679 + 0.146(PI) + 0.104(TC) + 0.275(EF) + 0.249(PDB)$$

The standardized beta hierarchy reveals the following rank order of relative predictive influence on Pedestrian Mobility: Pedestrian-Driver Behaviors ($\beta = 0.375$, $t = 9.028$, $p < 0.001$) > Environmental Factors ($\beta = 0.303$, $t = 6.905$, $p < 0.001$) > Pedestrian Infrastructure ($\beta = 0.244$, $t = 5.972$, $p < 0.001$) > Traffic Conditions ($\beta = 0.146$, $t = 3.340$, $p = 0.001$). The behavioral dimension thus exerts the strongest independent predictive influence on pedestrian mobility outcomes, even after controlling for the simultaneous contributions of infrastructure, environmental, and traffic variables.

5. Discussion

5.1 Behavioral Governance as the Primary Mobility Lever

The finding that Pedestrian-Driver Behaviors constitutes the strongest predictor of pedestrian mobility ($\beta = 0.375$) is the most substantively significant result of this study, as it challenges the dominant infrastructure-centric paradigm that has historically governed pedestrian safety investment in African cities. When drivers routinely disregard pedestrian right-of-way at crossings and exceed speed limits on wide arterial corridors, they impose two discrete mobility costs on pedestrians: a physical cost manifested as actual collision events, and a psychological cost manifested as anticipatory avoidance increased hesitation, route deviation, and ultimately trip suppression. The behavioral suppression mechanism identified here aligns with conceptual models of pedestrian risk adaptation developed in LMIC traffic safety literature, where inadequate behavioral governance creates a self-reinforcing cycle of reduced pedestrian priority and degraded walkability.

These findings resonate with broader international evidence. Studies from rapidly motorizing cities in South Asia and Southeast Asia similarly document driver non-compliance as a primary pedestrian mobility barrier. However, the magnitude of the behavioral effect identified here substantially larger than the infrastructure coefficient suggests that in the Kolfe-Keranio context, governance failures may be producing mobility suppression effects that infrastructure investment alone cannot overcome. This has important implications for policy prioritization, discussed in Section 7.

5.2 Environmental Conditions and the Dual Function of Urban Space

Environmental Factors ranked as the second strongest predictor ($\beta = 0.303$), a finding that illuminates the dual function of urban street environments in Kolfe-Keranio: as pedestrian movement corridors and as commercial activity zones. The concentrated mixed-commerce land use pattern in the sub-city's central and southeastern sectors generates chronic sidewalk encroachment by informal vendors, effectively reducing usable pedestrian pathway widths below safe thresholds and forcing pedestrians into carriageways during peak activity hours. Simultaneously, inadequate street illumination on many arterial segments degrades effective pedestrian route availability during evening hours a particularly impactful constraint given that the sub-city's artisanal and market-based workforce operates extended evening commercial hours.

This result echoes findings from UN-Habitat and UNRSF (2022), which identify informal vending encroachment and inadequate lighting as two of the most prevalent environmental barriers to pedestrian mobility across African cities. The present study provides the first regression-based quantification of their combined effect in an Addis Ababa context, enabling evidence-based resource prioritization in environmental upgrade programs.

5.3 Infrastructure Deficiency: Structural Barriers to Mobility

Pedestrian Infrastructure ranked third in predictive strength ($\beta = 0.244$), confirming that structural pathway deficiencies impose significant independent mobility costs even after accounting for behavioral and environmental dimensions. The absence of continuous, paved sidewalks along the PAS-Expressway and primary 60-meter arterial roads forces pedestrians into shared carriageway space with high-speed vehicles, creating constant conflict exposure. The absence of protected pedestrian crossing infrastructure at high-traffic intersections further compounds this structural vulnerability.

Notably, the relatively lower beta weight for infrastructure compared to behavioral and environmental dimensions does not imply lesser policy significance; rather, it reflects the baseline conditions of the study corridor, where infrastructure deficiencies are pervasive and, therefore, shared across the sampled population. In a statistical sense, the lower variance in infrastructure exposure across respondents may limit its marginal contribution to mobility variance relative to the more heterogeneous behavioral and environmental experience. This interpretation is consistent with the World Bank (2021) finding that Addis Ababa's infrastructure deficit is systemic rather than corridor-specific.

5.4 Traffic Conditions: Significant but Contextually Mediated

Traffic Conditions, while demonstrating the smallest beta weight ($\beta = 0.146$), nonetheless exerts a statistically significant and independent predictive influence on pedestrian mobility at $p = 0.001$. This result indicates that vehicular volume, speed dynamics, and intersection control quality contribute meaningfully to mobility outcomes beyond the contributions of behavioral, environmental, and infrastructure dimensions. The relatively attenuated beta coefficient may reflect the fact that traffic condition effects are partly captured by the behavioral variable since driver behavior and traffic speed interact strongly in practice, their respective regression contributions may partially overlap in theoretical space even when multicollinearity statistics remain within acceptable thresholds.

5.5 Validation of the Safe System Approach in a Sub-Saharan African Context

Collectively, the regression findings provide compelling empirical validation of the Safe System Approach in the Kolfe-Keranio urban context. The SSA's foundational premise that effective pedestrian protection requires simultaneous, integrated action across road design, speed management, and behavioral governance is confirmed by the finding that all four safety hazard dimensions exert independent, significant, and positive effects on mobility. No single dimension dominates to the exclusion of others; rather, their combined explanatory power (R^2 = 0.426) substantially exceeds what any individual predictor could achieve in isolation, affirming the framework's emphasis on systemic rather than siloed intervention.

6. Conclusion

This study has demonstrated, through rigorous multivariate empirical analysis, that pedestrian safety hazards in Kolfe-Keranio Sub-City function as active mechanisms of urban mobility suppression rather than merely as public health or law enforcement concerns. The OLS regression model, explaining 42.6% of variance in Pedestrian Mobility across a robustly validated sample of 366 respondents, confirms that all four studied hazard dimensions behavioral, environmental, infrastructural, and traffic-related exert statistically significant and independent negative influences on functional pedestrian mobility.

The study's most consequential finding is the rank superiority of Pedestrian-Driver Behaviors as a mobility predictor (β = 0.375), which challenges the conventional policy emphasis on physical infrastructure construction as the primary lever for walkability improvement. Environmental Factors (β = 0.303) and Pedestrian Infrastructure (β = 0.244) follow as the second and third strongest predictors, while Traffic Conditions (β = 0.146), though significant, contribute most modestly to the model. These findings collectively argue for a policy paradigm shift from vehicle-centric, infrastructure-focused urban planning toward an integrated approach that simultaneously addresses behavioral governance, environmental quality, physical infrastructure provision, and traffic management.

The empirical validation of the Safe System Approach in this sub-Saharan African context demonstrates the framework's applicability beyond its high-income country origins, providing evidence-based support for its adoption as the guiding framework for pedestrian safety policy in rapidly motorizing Ethiopian and African cities more broadly.

7. Practical Implications

The regression coefficient hierarchy derived from this study provides a statistically grounded basis for investment prioritization in pedestrian safety interventions. The following targeted policy implications are proposed:

1. **Behavioral Governance First (β = 0.375):** Municipal and federal traffic enforcement agencies should implement automated speed enforcement systems and pedestrian right-of-way compliance cameras on all arterial corridors measuring 20 meters or more in width. Mandatory driver re-education programs should specifically address pedestrian interaction protocols. Financial penalty regimes for pedestrian right-of-way violations should be substantially increased to serve as effective deterrents.
2. **Environmental Quality Upgrading (β = 0.303):** The Kolfe-Keranio Sub-City Administration should implement systematic street lighting installation programs targeting identified dark segments of arterial corridors. Regulatory frameworks governing informal vending within pedestrian pathway corridors should be enforced and expanded, with designated vendor zones created off carriageways to eliminate encroachment on pedestrian space.
3. **NMT Infrastructure Investment (β = 0.244):** Priority capital investment should be directed toward constructing continuous, physically separated pedestrian pathways and protected crosswalk infrastructure along the PAS-Expressway and primary 60-meter arterial roads, consistent with the Addis Ababa NMT Strategy (2020–2030). High-volume pedestrian crossings at commercial intersections in Ayertena and Zenebework should be upgraded to pedestrian-actuated signal systems with raised crossing platforms.
4. **Traffic Management Integration (β = 0.146):** Speed management through geometric road design interventions including median reductions at pedestrian crossing points, chicane designs, and junction entry narrowing should complement enforcement measures on wide arterial corridors where design speed currently undermines behavioral compliance.

Beyond Kolfe-Keranio, these prioritized intervention sequences offer a replicable model for other Addis Ababa sub-cities and for rapidly motorizing African cities facing comparable pedestrian safety-mobility trade-offs.

8. Limitations

This study must be interpreted within the context of several methodological constraints. First, the cross-sectional survey design captures a point-in-time snapshot of pedestrian perceptions and mobility behaviors, limiting causal inference and precluding the examination of seasonal variation, time-of-year effects, or long-term behavioral change trajectories. Second, the self-reported nature of all study variables introduces social desirability and recall bias risks that cannot be fully eliminated through questionnaire design alone. Third, while the GIS-informed spatial sampling framework significantly enhances the sample's representativeness within Kolfe-Keranio's high-density arterial zones, findings may not directly generalize to lower-density residential corridors, to other Addis Ababa sub-cities, or to cities with fundamentally different urban morphologies.

Fourth, the regression model, while statistically robust and explaining 42.6% of mobility variance, leaves 57.4% of variance unaccounted for by the measured predictors. Unmeasured dimensions including respondents' disability status, trip purpose variability, seasonal infrastructure conditions, and individual risk tolerance may represent significant additional determinants of pedestrian mobility that future research should incorporate. Fifth, the study did not collect GPS-tracked behavioral data or observed mobility measurements, relying instead on subjective self-assessment, which may not fully capture objective mobility constraints.

9. Future Research Directions

Several productive research directions emerge from the findings and limitations of this study. First, longitudinal panel studies that track the same respondents before and after specific infrastructure or behavioral governance interventions would enable causal impact evaluation that cross-sectional designs cannot provide. Such studies would generate direct evidence on the effectiveness of specific Safe System interventions in this urban context.

Second, mixed-methods extensions incorporating qualitative ethnographic observation, pedestrian tracking using wearable GPS devices, and focus group discussions with sub-populations (women, elderly, persons with disabilities, children) would provide richer texture to the quantitative relationships identified here and reveal the experiential dimensions of mobility suppression that surveys cannot capture.

Third, comparative multi-city studies across Ethiopian regional capitals and comparable sub-Saharan African cities applying the same spatial sampling framework and variable operationalization would test the generalizability of the predictor hierarchy identified in Kolfe-Keranio and contribute to the development of context-sensitive Safe System implementation guidelines for African urban environments.

Fourth, structural equation modeling (SEM) approaches would enable examination of mediation and moderation pathways among the study's predictor variables, providing a more nuanced understanding of how behavioral, environmental, infrastructural, and traffic dimensions interact rather than merely co-contribute to mobility outcomes.

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