ADDIS ABABA UNIVERSITY
ADDIS ABABA INSTITUTE OF TECHNOLOGY
SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING
ROAD AND TRANSPORT ENGINEERING STREAM

AN INVESTIGATION OF THE IMPACT OF SIDEWALK VENDORS ON PEDESTRIAN SAFETY AND PEDESTRIAN UTILIZATION OF THE SIDEWALK: A CASE STUDY IN YEKA SUB CITY, ETHIOPIA

By

Abel Seifu Lemma

A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirement for the Degree of Master of Science in Civil and Environmental Engineering
(Road and Transport Engineering Stream)

Advisor
Dr. Getu Segni

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School of Civil and Environmental Engineering

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DECLARATION

This MSc thesis entitled with "AN INVESTIGATION OF THE IMPACT OF SIDEWALK VENDORS ON PEDESTRIAN SAFETY AND PEDESTRIAN UTILIZATION OF THE SIDEWALK: A CASE STUDY IN YEKA SUB CITY, ETHIOPIA" is my original work. This thesis has not been presented for any other university and is not concurrently submitted in candidature of any other degree, and that all sources of material used for the thesis have been duly acknowledged.

Abel Seifu (GSR/1158/14)		March 22, 2024
Candidate	Signature	Date

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LIST OF ABBREVIATIONS

AACRA..Addis Ababa City Roads Authority

AACRTB ....Addis Ababa City Roads and Transport Bureau

AASHTO ....American Association of State Highway and Transportation Officials

CA ....Conjoint Analysis

ERA...Ethiopian Roads Authority

EC ....Ethiopian Calendar

HCM ....Highway Capacity Manual

ITDP..Institute of Transportation and Development Policy

LOS ....Level of Service

M ....meter

NMT..Non-Motorized Transport

OLR …………………………………Ordinal Logistic Regression

PLOS ....Pedestrian Level of Service

PPS ....Pedestrians' preference score

PUV...Part-Worth Utility Value

RI...Relative Importance

SPSS..Statistical Package for Social Sciences

TPMO………………………………Transport Programs Management Office

TUV ....Total Utility Value

WHO ....World Health Organization

ABSTRACT

Ethiopia's can benefit from effective NMT, particularly walking. The city's rapid population growth and migration have led to street vending activities, causing obstructions and pedestrian safety threats. This negatively impacts the city's economy, reducing pedestrian service and increasing delays (Sahani et al. 2017; Bahiru, 2019). Traffic accidents cause 1.19 million deaths annually in the world, with pedestrians, cyclists, and motorcyclists being the most vulnerable (50%). Low- and middle-income countries account for 92% of fatalities, despite having 60% of the world's vehicles (WHO, 2023). Ethiopia's road traffic deaths increased by over doubled between 2007 and 2018 (from 2,161 to 4,597), with Addis Ababa experiencing high pedestrian fatalities (Priti Gautam et al. 2020).

The study investigates the impact of sidewalk vendors on pedestrian safety and Pedestrian Utilization of the Sidewalk in Yeka sub-city of Addis Ababa, Ethiopia. It uses analysis techniques like ordinal logistic regression, Conjoint Analysis, and Pedestrians' Preference Score to understand perceived safety and predict sidewalk usability. Primary data was collected through questionnaires, surveys, and field observations, while secondary data was gathered from various sources, including Addis Ababa city police commission crash data.

The study investigates pedestrian safety in Yeka sub-city sidewalks using an ordered logit regression model, issues vendors and examining relevant inputs. It finds that vendor activity negatively affects safety, while sidewalk adequacy indirectly enhances it. Factors like PLOS and surface condition significantly impact perception, with improved walking surfaces and PLOS variables improving safety. Encroachment on roadways also negatively affects safety, with sidewalks limiting walking opportunities. Factors like sidewalk width, age, frequency, purpose, education, walking distance, and time also influence perceived safety.

The study uses conjoint analysis to generate part-worth utility and relative importance values for each attribute level in a hypothetical profile then Total Utility Value was determined. It uses pedestrians' preference score to measure evasion using sidewalks. Key sidewalk attributes affecting walkability, such as width, flow rates, obstructions, and sidewalk condition, are identified. The survey shows walkable width is the most important attribute, with 1.5m-2.5m desirable.

Keywords: *Walking*, *vendors, pedestrian safety, sidewalk usability, ordinal logistic regression, pedestrians' preference score, Conjoint Analysis*, *Yeka Sub City*

CHAPTER ONE

1. INTRODUCTION

1.1 Background of the study

In the development of one's country, urban economic activities and movements of peoples and goods measured through its primary transport system. The adequate transport system is needed to facilitate a more excellent choice of the peripheral areas if urban transport provided by the nearby authorities. A comfortable environment makes a journey by foot pleasant and enjoyable, which will have positive effects on one's health and the environment. Virtually every trip begins and ends with walking (Tanweer et al. 2000; Hoogendoorn & Bovy, 2004). Ethiopia, like many low-income developing nations, heavily relies on walking for daily travel. In Addis Ababa, walking accounts for over half of daily trips (54%), making it the most popular form of transportation. However, obstructed and small, uneven sidewalks pose safety risks for pedestrians, making it crucial to improve the quality and accessibility of these public transportation options (Jia et al., 2022).

Globally, road fatalities are the leading cause of death, with Addis Ababa having a high incidence of pedestrian fatalities. Approximately 500 individuals in Addis Ababa lose their lives in traffic accidents every year (WHO, 2009). Ethiopia's State Minister of Transport reported a 10.09% decrease in car accident fatalities in the last quarter of 2019-20, with 464 fewer deaths compared to the previous year, but the number of fatalities remains high compared to other African countries (Yonas, 2020). Since road safety interventions in developing countries like Ethiopia are still in their early stages, as rapid motorization is taking place. The primary objective of road safety interventions is to enhance motorist safety over pedestrians, as the literature on pedestrian crashes in developing countries is still in its early stages (Tulu Getu, 2015).

Ethiopia's rapid population growth and migration into cities have led to many individuals engaging in street vending activities, particularly in Addis Ababa, the largest city. These activities create a dynamic environment, but sidewalk vending can decrease walking space, lower pedestrian levels of service, and raise safety threats (Sahani et al. 2017). Addis Ababa city authorities have tried to control street vendors, but this has made the situation worse by making them more mobile on the carriageway, rather than creating a convincing traffic environment (Bahiru, 2019).

In Addis Ababa, vital services, infrastructure, and urban transportation mobility still lag behind the city's growing urbanization. Coordination with planning strategies is lacking in a large portion of ongoing urban growth. Vehicle growth has remained constant in recent years, increasing by 8% annually (Jia et al., 2022). As of 2018, there were a total of 1,071,345 vehicles in Ethiopia (Priti Gautam et al. 2020). Despite the fact that 31% of city inhabitants utilize public transportation and 54% of residents commute on foot, attempts to accommodate the rise of vehicles often place a higher priority on roads and car-related demands than other types of users (Jia et al., 2022).

1.2 Statement of the problem

Traffic fatalities are increasing in low- and middle-income countries, particularly Africa, with pedestrians and cyclists accounting for over 44% of accidents. In Ethiopia, pedestrians account for 37% of fatal crashes annually (WHO, 2018), with higher risk exposure levels. In Addis Ababa, 76% of fatalities are pedestrians, with trucks and taxis responsible for 60% of pedestrian fatalities. Weekend nights have higher rates of fatalities (WHO, 2009). Yeka Sub City experienced 1276 road traffic accidents between 2011 and 2015, with pedestrian-related incidents accounting for 90.28% of these incidents, underscoring the need for improved pedestrian safety measures. Despite these alarming statistics, policymakers in developing countries have not addressed the rising risk of pedestrian crashes, which is worsened by rapid motorization (Tulu, 2015).

The current road infrastructure design, considering vehicle characteristics, contradicts the concept of a complete street, resulting in a lack of pedestrian planning, making it challenging to address city issues (Hediye and Pinar, 2018). Thus, Addis Ababa's pedestrian mobility is subpar, necessitating a comprehensive study and study focuses on enhance the pedestrian walking and the disadvantaged by providing practical recommendations for implementation.

Issues in planning, design, construction, and maintenance lead to poor sidewalks and restricted pedestrian movement. Improper maintenance allows sidewalks to be invaded by garbage, rocks, vegetation, street vendors, parked cars, and loading and unloading activities, leading to risky behaviors among road users and pedestrians (Jia et al., 2022).

Addis Ababa city lacks adequate data and research on sidewalk conditions for pedestrians, as studies focus on roads and intersections instead of a comprehensive analysis of sidewalk conditions and walkability (Jia et al., 2022). Improper sidewalk use by vendors leads to safety issues and traffic jams, necessitating effective measures to establish a pedestrian safety baseline. The Addis Ababa city authority tries to evict street vendors with the notion of making the road accessible and guarantee formal traders. Since it was a campaign work, it suspends street vending operators from vending for a while and then come back into it, so the problem persists. Thus, proper management of street vending activities has to be rethink wisely, else proliferation of these activity discourage walking and may probably jam the vehicle activity and understanding the impact of street vendors and recognizing broader issues is essential before taking action to address these issues.

As a result, efforts will be made in this study to quantify the impact of sidewalk vendors on pedestrian safety and pedestrian mobility on built environment attributes that influence pedestrians' choices to use or avoid sidewalks. Thus, assessing the negative effect of side friction features on pedestrian safety, mobility and the built environment's suitability for walking is important and crucial insights for traffic engineers.

1.3 Research Objective

1.3.1 General Objectives

The general objective of the study is to investigate the impact of sidewalk vendors on pedestrian safety and analyses sidewalk attributes that contribute to the walkability.

1.3.2 Specific Objectives

Specifically, the research is aimed to achieve the following objectives;-

1. To investigate the effect of sidewalk vendors and influencing factors on pedestrian perceived safety in the Yeka sub-city of Addis Ababa.
2. Explore the contributing sidewalk attributes in the pedestrian built environment of the selected study area for walkability and categorize them according to their importance.
3. To evaluate pedestrians’ actual willingness to use the sidewalks and to cluster the sidewalks based on pedestrians’ preference and sidewalk characteristics.

1.4 Research questions

In order to achieve the best results for this proposed thesis the following investigation questions are going to be addressed:

1. How pedestrian safety affected by sidewalk vendors and other influencing factors?
2. What are the contributing sidewalk attributes in the pedestrian built environment of the selected study area for walkability and their importance?
3. What are pedestrians' real willingness to use sidewalks and how can sidewalks be clustered based on pedestrians' preferences and sidewalk characteristics?

1.5 Significance of the research

This study is significant not only for its publication but also for its relevance to the Addis Ababa municipal government's planning and development commission. It will help design public amenities and infrastructure to accommodate population growth, and serve as a reference for improving perceived safety measures. The study investigates current issues affecting pedestrian safety and assesses the service quality of walking facilities in light of pedestrian perception to identify key factors affecting safety and implement engineering countermeasures in cities to encourage walking and reduce fatalities.

The study offers valuable insights for urban planners, street engineers, highway agencies (ERA, AACRA), government officials, policy-makers, and the public to improve pedestrian conditions and accept sidewalk vending as an integral part of infrastructure. It proposes comprehensive street management to accommodate vendors efficiently, considering rapid urbanization and socio-economic challenges. The goal is to create "complete streets" that encourage walking, increase pedestrian safety, and benefit vehicles. The methodology and procedures used in this study can also be used by other researchers for further research on similar activities in other locations.

1.6 Scope of the research

This research focuses on the impact of sidewalk vendors on pedestrian safety and the contributing attributes in the pedestrian built environment. It assesses the negative impacts of sidewalk vendors and existing pedestrian infrastructures on mobility, focusing on built environment attributes that influence pedestrians' choices to make use of or avoid sidewalks and factors contributing to deficiency walking environments. Then study aims to provide possible solutions and improve pedestrian safety. The research, conducted in Yeka sub city of Addis Ababa, focuses on sidewalk vendor activities and deteriorating infrastructure. It evaluates pedestrian safety due to vendors and other factors using data collected from field surveys. The study also evaluates the performance of existing pedestrian walkways and identifies key factors influencing sidewalk evasion using statistical software.

1.7 Limitations of the Study

The investigation faced limitations due to time and data constraints, resulting in surveys conducted in Addis Ababa, a representative area. The study was limited by political unrest in Ethiopia, causing unease among participants and respondents. To address these issues, the researcher presented their university ID and a copy of the Addis Ababa University cooperation letter to respondents. Secondary data from police commissions and city government agencies was difficult to access and organize. The study also examined road traffic accident records, but the data quality was poor and required extensive cleaning.

This study's conclusions are limited to four sidewalk attributes due to the Conjoint Analysis methodology. Comparative studies in other cities are needed to generalize the findings. The study did not consider other physical features like crossing facilities or non-motorized infrastructure. It only evaluated pedestrian safety and physical attributes, leaving room for further research. The study's limitations highlight the need for more comprehensive studies in other cities.

1.8 Organizations of the Thesis

The thesis work is organized into five chapters and associated with Annex. The first chapter is an introduction that includes background, statement of the problem, objectives, and research questions, significance of the study, scope of the research and limitation as well as the overall thesis outline. Chapter two discusses the theoretical framework for the study and review of earlier studies. Chapter three presents the research methodology in detail followed by chapter four which is about results and discussion. And the last chapter, chapter five, is concerned with conclusion and recommendation. Finally, annex in the form of tables and figure that serving as a supporting document to this thesis is attached to make the work a complete one.

CHAPTER TWO

2. LITERATURE REVIEW

To represent an integrated picture of pedestrian facilities, it is crucial to review, compile, and organize the most recent studies that assess pedestrian preference perception, the contributing sidewalk attributes in the pedestrian built environment, and their contributing factors on pedestrian safety. In particular, for this study, the attributes influencing the use of sidewalks are important to investigate. A variety of walkability assessment techniques, investigational and measurement techniques, and sidewalk walkability will all be looked at in this review. The literature review's primary focus is a study of prior research on this subject. Review literatures are used to spot any gaps in the literature and to place each work in the perspective of what it adds to our knowledge of the subject of the research being done.

2.1 Walking as a Mode

Walking is the most fundamental and active mode of human mobility, essential for every trip, whether by car, train, plane, or subway. At some point, everyone's life is lived as a pedestrian. It elicits a wide range of emotions depending on the environment and people you encounter. Walking offers economic advantages, time and money savings, and reduces transportation externalities. It also expands personal mobility alternatives and connects with other transit options like buses (Litman, 2003). The network of pedestrian walkways connects with other transit options while avoiding risks and reducing reliance on cars. The path system encourages walking for leisure, recreation, health, and practical reasons like shopping or work (Southworth, 2005). However, walking has been undervalued in current transportation planning and policy development (Litman, 2003), especially in a number of developing cities.

2.2 Walking in developing cities

The International Road Assessment Programme (iRAP) found that 84% of roads with pedestrians in developing countries lack sidewalks (WHO, 2013b), leading to pedestrians walking along the road. Pedestrians account for 40-60% of modal shares in developing countries (Leather, et al. 2011), including over 54% of Addis Ababa city's modal shares (Jia et al., 2022). The Addis Ababa City road network lacks good interconnectivity and coverage, with poor design standards, shortage of pedestrian walkways, and misuse and encroachment of road spaces according Office for Revision of the Addis Ababa Master Plan. Additionally, the road lacks dedicated service lanes for buses, un-interrupted and safe walkways, and cycle paths. Over 65% of the road network is not pedestrian-oriented, a major drawback of both existing and newly planned roads (Abreha, 2007).

Addis Ababa has disproportionately high pedestrian fatalities compared to the rest of the country. In Addis Ababa nearly 500 people lose their lives due to road accidents each year, 76% of whom are pedestrians (WHO, 2009). The Traffic Police Commission's study reveals that between 2009 and 2013, Ethiopia experienced the highest number of road crash fatalities in respect of road users, sex, and age group. The most vulnerable group were 18-30 year olds, particularly pedestrians, with males being the most vulnerable. The main causes of pedestrian crashes were inadequate parking, poor pedestrian pathways, and enforcement of encroachment on main carriageways (Redi, 2015).

2.3 Walkable environment

The environment for pedestrians often presents obstacles due to poor design, inadequate facilities management, natural terrain features, lacks of sidewalks, uneven surfaces, garbage, dampness, and illegal business activities. These factors limit mobility for people with disabilities, increase vulnerability to infection, and force people to use main roads instead of alternative routes (AASHTO, 2004)

A 2015 study revealed that pedestrians in Ethiopia often walk along or cross roads illegally due to access control. In Addis Ababa, particularly in areas like Merkato, Shiromeda, Kasanchis, Megenagna, Mexico, Saris, Kera, Arat Kilo, and Ayertena, they walk shoulder to shoulder with motorized traffic. These areas have narrow roads without footpaths or insufficient capacity compared to pedestrian demand, causing issues with safety and accessibility (Tulu, 2015). WHO confirmed that about 84% of the road network in developing countries, including Ethiopia, are constructed without pedestrian footpaths (WHO, 2013b).

Although research on walkability analyses of the built environment has expanded considerably in the past decade in fields related to urban planning, geography, psychology, and public health (Brownson et.al. 2009), walkability is still addressed with far less intensity as compared to other modes of transport (Brown et.al. 2009; Southworth, 2005).

2.4 Pedestrian walking behavior

The term pedestrian walking behavior encompasses various actions such as yielding/not to opposite pedestrians, following and bypassing them, creating temporary lanes in crowded areas, weaving pedestrians between cross streams, and encountering various types of individuals (male, female, handicap, child, senior citizen, etc.) and groups (couple, family, friends, and co-workers, etc.) (Gupta, 2005). The narrow pedestrian spaces in cities limit vehicular flow and pose significant danger to pedestrians, as they often walk on carriageways and cross roads at any point. The risk of injuries are high when pedestrians share the road with vehicles at fast speeds, leading to increased injury severity and death. (Segni G., 2013).

The following factors influence the pedestrians walking behavior (Gupta, 2005):

1. Personal Characteristics: Age, gender, size, health, disability, ethnicity, social status, and appearance/attractiveness.
2. Characteristics of trip: Purpose of trip (commuting, shopping, etc.), familiarity of route, luggage, and trip length.
3. Travel companionship: Single or part of a group (couple, family, friends, carrying infant, co-workers, etc.).
4. Properties of infrastructure: Type of pavement, grade, attractiveness of environment, and shelter (protection from weather).
5. Environmental characteristics: Ambient and weather conditions.
6. Function of the location (train station, shopping mall, amusement park etc.)
7. People in the vicinity: Number of people in the surrounding area and type of people.

2.5 Pedestrian Safety

Urban areas are increasingly adopting active transportation methods, such as cycling and walking, to promote sustainability, public health, and reduce greenhouse gas emissions. However, concerns about pedestrian safety persist, especially in metropolitan areas. Issues include crowded sidewalks, vendors selling in the middle of the road, and pedestrians being forced onto the road. These issues are often caused by poor planning, building, upkeep, walkway obstructions, or terrain features. The holiday season has worsened the problem, with vendors still positioned on sidewalks. Despite a decline in road fatalities, non-occupant fatalities have increased (Retting et.al. 2003). Roads are often designed in favor of vehicles, making pedestrians and bicyclists vulnerable. The emergence of autonomous vehicles has heightened attention to pedestrian safety.

The Addis Ababa City Administration Road and Transport Bureau (AACRTB) is implementing the NMT Strategy to enhance pedestrian safety and create a more accessible, inclusive, sustainable, effective, healthy, and attractive city. The strategy identifies walking as the primary mode of transportation in the city and aims to reduce crashes and fatalities due to vehicle-oriented architecture. Each guideline outlines activities to improve pedestrian conditions, taking into account the city context and improvement objectives (AACRTB and TPMO, 2018).

2.5.1 Pedestrian Safety Impacts

Around 1.19 million people die annually in road traffic accidents in world, with pedestrians, cyclists, and motorcyclists being the most common victims. Low- and middle-income nations account for 92% of all road traffic deaths (WHO, 2023). Between 2007 and 2018, Ethiopia experienced a significant increase in road traffic accidents, with the number of fatalities more than doubled. In 2018, there were 1,071,345, with 43 people killed for every 10,000 vehicles. However, the WHO estimated 27,326 road fatalities in 2016, six times higher than the reported number. The government has failed to prioritize road safety in Ethiopia due to lack of awareness, weak political leadership, and difficulty in acquiring long-term funding. Passengers were the most vulnerable road users, accounting for 52% of all fatalities in 2018. Fatal crashes were more prevalent on paved roads, accounting for 79.9% of all fatal crashes. Buses and commercial vehicles were involved in a disproportionately high number of road traffic deaths (Priti Gautam et al. 2020).

In Ethiopia, road traffic accidents result in significant financial and human loss, with 15,086 accidents reported in fiscal year 2007/8, causing 2,161 deaths and property damage exceeding ETB 82 million. The social cost of these accidents is difficult to estimate, but the economic expenses significantly impact the national economy. The WHO reports that vehicle crashes and injuries cost 1% of the GDP in low-income countries like Ethiopia, making it difficult to quantify every human sacrifice and suffering (ECA, 2009). Ethiopia has lost an estimated $1.3 billion over the last 11 years from 2007/08-2017/18 due to traffic accidents, which accounts for 0.9% of the country's annual budget loss (Debela, 2019).

2.5.2 Pedestrian Safety Issues in Addis Ababa

A study in Ethiopia aimed to address pedestrian safety concerns and fatality reduction using models for rural two-way two-lane highways and roundabouts in the capital city. The study identified risk factors and spatial variables affecting pedestrian safety, including site characteristics and highway geometry (Tulu, 2015). Although crash data can indicate risks, the study did not consider user perception, environment, and sidewalk features. The research focuses on vehicle safety and crash data, highlighting the need for more comprehensive understanding of pedestrian safety in Ethiopia.

A study in Addis Ababa collected data from 20 midblock locations and created Poisson and Negative Binomial regression crash models using 2596 crashes. The study found a strong correlation between road cross-sectional design dimensions and traffic accident frequency (Tulu, 2018). It focused on pedestrian safety factors related to crashes, but did not cover other safety issues or pedestrian perceptions. Every year, vehicle accidents in Addis Ababa result in over 500 deaths, with 76% of fatalities being pedestrians. Trucks and taxis are responsible for 60% of pedestrian fatalities, with weekend nights having higher rates (WHO, 2009). The 2017/2018 TPMO Annual Report listed the death toll of pedestrians as 82% of all recorded deaths in 2017.

A study on pedestrian injuries in Addis Ababa was conducted with the intention of examining current issues with pedestrian safety in the Kirkos sub-city. Both drivers and pedestrians participated, and the results were categorized into four categories: pedestrian-related, driver-related, vehicle-related, and road and environment-related. The study comes to the conclusion that Addis Ababa needs to take strategic mitigation measures for urban safety management (Eguale, 2015).

2.6 Complete Streets Design Concept

Cities need streets accessible to all, regardless of age, transportation mode, or physical ability, to improve quality of life. However, many roads are designed for car drivers, leading to congestion. Complete Streets, first implemented in North America, aims to promote active transportation modes like biking and walking, reducing vehicle traffic and promoting safety, health, and economic benefits by providing safe, comfortable, and attractive access for pedestrians, cyclists, motorists, and public transportation users (Burlacu Alina, 2012).

Figure 2. 1 Complet streets concept

Source: Complete Streets Conference, LA, 2011

A complete street design consists of various components, including pedestrian infrastructure like sidewalks, crosswalks, and accessible pedestrian signals. It also includes traffic calming measures like road diets, center medians, and staggered parking. Bicycle accommodations, such as dedicated lanes or wide shoulders, are also included. Mass transit accommodations, such as bus pullouts or special bus lanes, are also considered. These design principles help create a safe and accessible environment for all users (Burlacu Alina, 2012).

Therefore, complete streets design focuses on creating enjoyable, safe, and useful environments for all users, incorporating narrower lanes, reduced motor vehicle speeds, and a landscape with trees and greenery to maintain balance through various movement and modes, rather than just focusing on cars.

2.7 Sidewalk design standards

Sidewalks are elevated, paved surfaces along roads or streets separated by curbs (Toole et al. 1999). They are essential components of any city's public space, devoted to pedestrians. Pedestrians share public spaces with other forms of transportation, such as motor vehicles and cyclists, but are the ones most likely to be hurt in accidents. To design streets that prioritize sidewalks over other forms of transportation, the city must have the necessary tools (Jia et al., 2022).

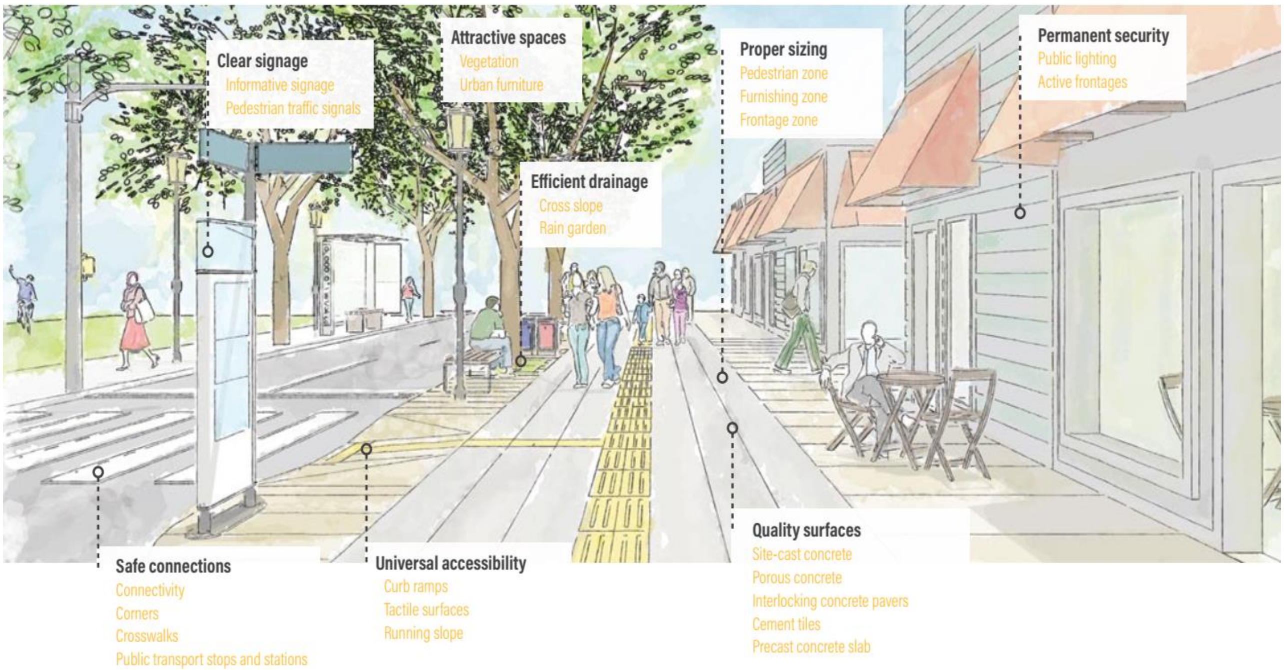


Figure 2. 2 The Eight Principles of the Sidewalk and its elements

Source: WRI Brasil- The 8 Principles of Sidewalks, 2019

2.7.1 Sidewalk width

Urban sidewalk width standards are provided by several manuals depending on the country.

AASHTO

Urban collector roadways in commercial districts should have sidewalks on both sides for pedestrian access to schools, parks, retail centers, and transit stops. Residential zones should have at least one side with sidewalks. Residential sidewalk widths range from 4 to 8 feet [1.2 to 2.4 m], with a minimum of 1.2 meters. Sidewalks less than 5 feet require a passing section every 200 feet [60 m] for accessibility. If provided, a planted strip should be 2 feet [0.6 m] wide for maintenance. Sidewalks covering the full border width are suitable in commercial areas, adjoining multiple-residential complexes, near schools, and restricted border widths (AASHTO 2018).

Sidewalk Standards in Addis Ababa

The AACRA Design Manuals provide guidance on geometry, drainage, road rehabilitation, and other elements of the NMT environment. They should be updated to reflect best practices, including reducing design speeds for roads, clarifying footpath design zoning, and recommending a minimum clear width of 2 m (AACRTB and TPMO, 2018).

There must be sidewalks for pedestrians on either side of arterial roads, and they should be raised 15-20 cm above the road. The pedestrian capacity on sidewalks should be at least 30 and at most 50 persons per minute per meter wide, lessening around 0.9 meters of dead space in shopping areas and 0.45 meters elsewhere. On one side of a sub-artery route, a pedestrian sidewalk should be 2.5 to 4 meters wide, while along a principal arterial, it should be 3.5 to 5 meters wide (Addis Ababa Norms and Standards, 2002). In areas with significant pedestrian flow, a minimum width of 3m is recommended for pedestrian strips to accommodate at least two people in wheelchairs. For low pedestrian flows, a 1.8m clearance is required for wider movements, such as those by wheelchair or service dogs. The minimum sidewalk width should be proportionate to the road category, with a minimum of 4.0m on principal or sub-arterial streets and 3.2m on collector and local streets (Jia et al., 2022).

Table 2. 1 Sidewalk standards used in Addis Ababa

Type of Street	Width (in both side of the street in meters)
Principal Arterial (PAS)	7 m - 10 m
Sub-arterials (SAS)	5 m - 8 m
Collector Streets	Less than 2 m
Local Streets	Should be decided based on local condition

Source: Norms and Standards of the Addis Ababa structure plan, 2002

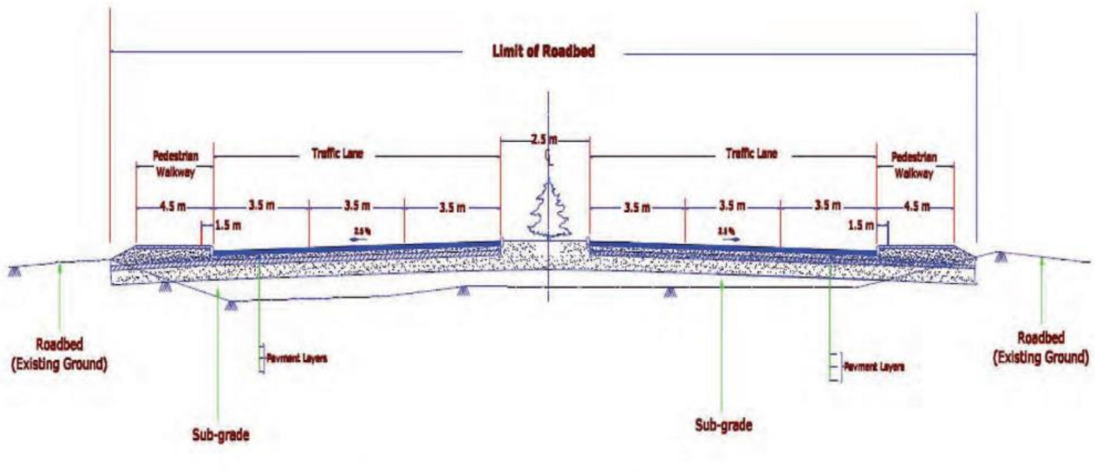


Figure F-13: Divided Three Lane (Addis Ababa) Typical Town Section

Figure 2. 3 Divided three lane (Addis Ababa) Typical town section ERA (2013).

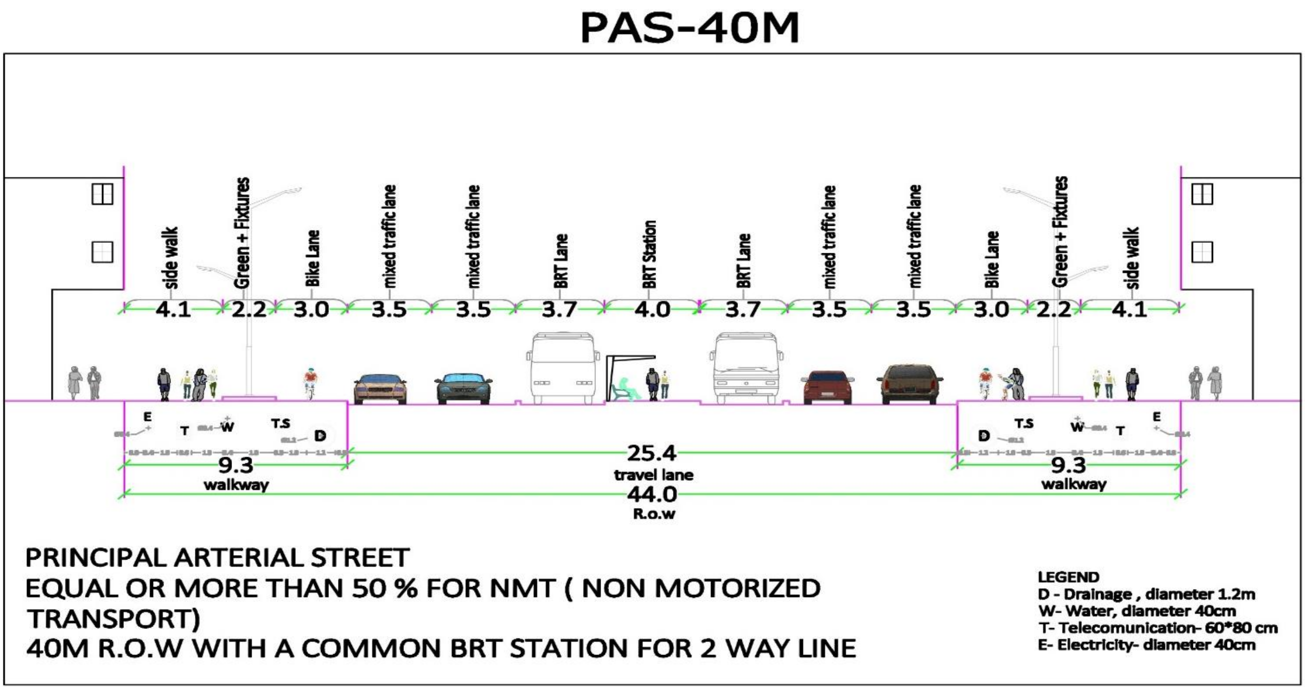


Figure 2. 4 Principal Arterial Street (PAS-40m) Typical Addis Ababa town section.

Source: Addis Ababa plan and development commission.

ERA Manual

Based on the governmental administrative system, ERA divides urban areas of our country's metropolitan areas into kebele, wereda, zonal, and regional seats. There are no rules that specify the type of town in terms of population, economy, or social structure. The diagram below shows the typical part for each classification.

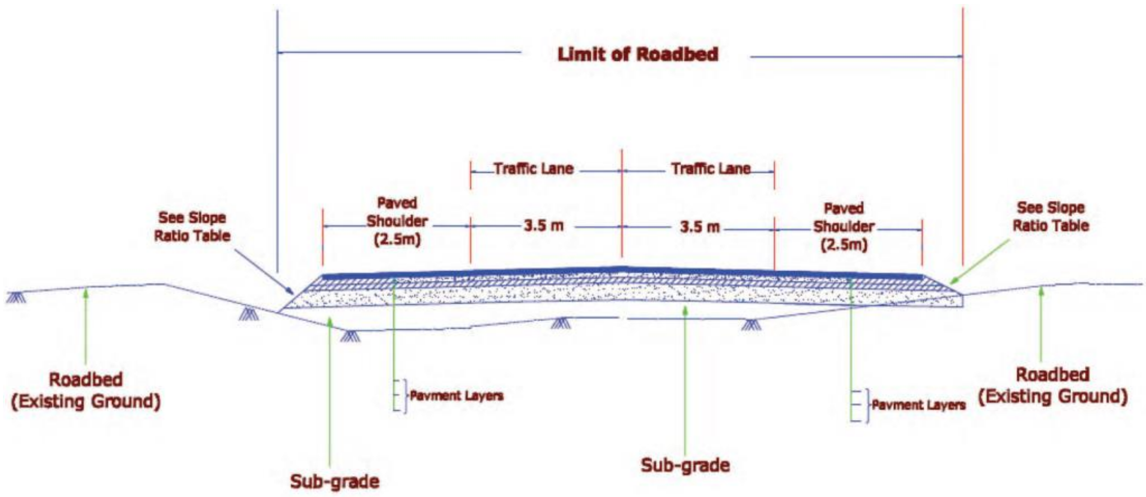


Figure F-9: Divided Lane (Kebele Seat) Typical Town Section

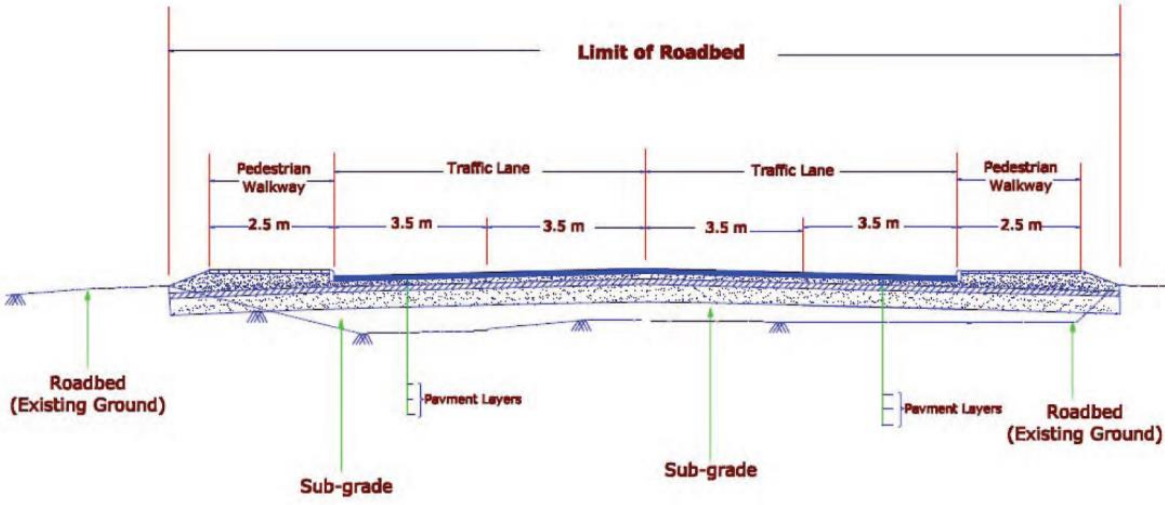


Figure F-10: Divided Two Lane (Wereda Seat) Typical Town Section

Figure 2. 5 Ethiopia urban typical road section for Kebele and Wereda ERA (2013).

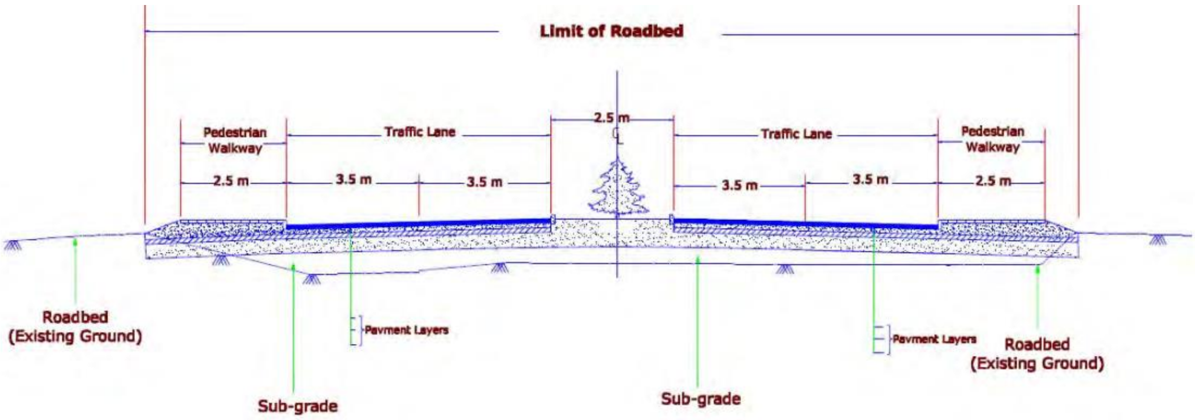


Figure F-11: Divided Two Lane (Zonal Seat) Typical Town Section

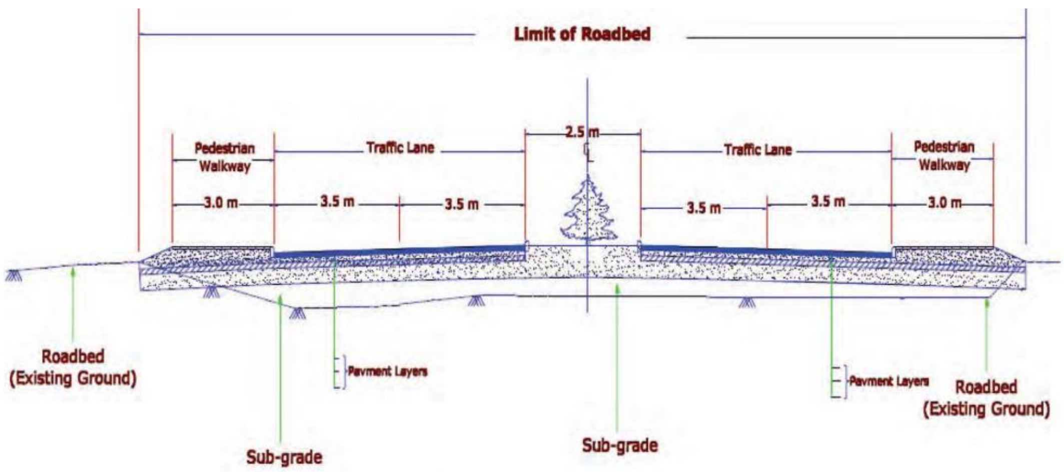


Figure F-12: Divided Two Lane (Regional Seat) Typical Town Section

Figure 2. 6 Ethiopia urban typical road section for Zonal and Regional seat ERA (2013).

2.7.2 Sidewalk materials and universal accessibility

The materials used in pedestrian walkways should be suitable for wheelchair users, canes, and crutches, and should be continuous, firm, level, and slip-resistant. Sand and gravel should not be used in these areas. Construction materials affect the appearance, usability, longevity, and sustainability of urban roadways and pedestrian infrastructure. Different pavement structures and surface materials should be applied to central areas and outer zones for pedestrian movement (Jia et al., 2022).

Materials shall include:

- Concrete tiles, Cement tiles and Mixed terrazzo
- Dressed, semi-dressed and cobble stones
- Roughly dressed granite cobble stones (in high standard city centers).

Street design should prioritize pedestrian safety, ensuring independence and equity for residents. Accessible infrastructure, such as ramps, tactile paving, and audible traffic lights, bridge sidewalk-roadbed gaps, provide a gentle slope for wheelchairs and strollers, and support women's unique mobility needs, as per the World Bank Handbook (Jia et al., 2022).

2.8 Impact of Roadside Frictions for Traffic Characteristics

Street vendors and informal activities in Ethiopia negatively impact traffic characteristics, speed flow, road capacity, and safety for commuters. The study highlights the importance of effective asset management in Addis Ababa's urban roads, particularly in relation to pedestrian safety, emphasizing the need for better planning before constructing new infrastructure such as widening roads or pedestrian bridges.

2.8.1 Street Vendors

A street vendor sells goods or services without a permanent structure, using a temporary static structure or mobile stall. They carry their goods on push carts, bicycles, baskets, or inside moving buses, ensuring accessibility for the public. Addis Ababa city authorities have been attempting to control street vendors' use of roads, but this has increased their mobility. A study evaluating their impact at three potential sites found that street vendors negatively impact the city's economy, affecting pedestrian service, delay relationship, and queue development, following the HCM procedure (Bahiru, 2019).

2.8.2 Sidewalk vendors and pedestrian level of service

A study conducted in five cities of India showed that an increase in the percentage of vendors results in the decline of PLOS in shared traffic (Sahani et al. 2017). The study used pedestrian satisfaction survey and field measurements to develop a regression model that links pedestrian perceived satisfaction of walking experience to geometric and operational characteristics of infrastructure. Sidewalk vendors, as well as other fixed objects (such as trees, poles, sidewalk furniture), are treated as physical obstacles that reduce the effective width and hence reduce PLOS (Kibret et al. 2020).

A study in Addis Ababa found that high vendor activity around intersections negatively impacts pedestrian and vehicle traffic performance (Bahiru, 2019). The study found that increased vendor activity during evening peak periods worsens operating conditions, leading to LOS reaches to F. However, the PLOS analysis approach may not accurately depict the effects of sidewalk vending activity, as it cannot accurately depict physical obstacles reducing walkway width (Kibret et al. 2020).

2.8.3 Debate for Space

Public spaces are open, indiscriminate spaces that should be sustainable. Streets are essential for societal needs, including vending activities. Scholars have debated whether street vendors have the right to sell on roads. A difficult balance must be found between access to public spaces, the need to move around, and the right of street vendors to work and earn a living.

Scholars from the mere transport engineering argue urban roads were built under the motto of “time is money”, reducing the time spent to cover a given distance has been the main aim though the accessibility of roads was undeniable. But other scholars argues, streets were also be designed for activities which go beyond transport purposes, other activities represent a significant part of urban life including commercial places for street vendors.

Ethiopia's capital, Addis Ababa, has a significant informal sector, with 75% of the population working in the formal sector. This sector is crucial for poverty alleviation and job creation (CSA, 2014). However, planning trends suggest removing vendors from public spaces to create more welcoming spaces, which negatively impacts their livelihoods and the city's economic vibrancy.

2.8.4 Policy Measures to Regulate Street Trade

Policies and laws are crucial for setting standards in public goods and services, protecting consumers, investors, and the public. By-laws ensure safety in urban areas. However, local authorities in Africa face challenges in developing informal sector activities like street vending due to outdated restrictive policies. The Ethiopian Government is promoting micro and small-scale enterprises in rural and urban areas by legalizing street vending and allowing them to operate in public spaces. However, current policies do not acknowledge the growing vending activities in urban centers and their significant benefits for urban poor dwellers and the state. A revise of policy measures towards street vending in urban areas is needed (Mitullah, 2003).

2.9 Reconstructing the City?

The refurbishment of streets in Addis Ababa, Ethiopia, may be uneconomical but still demonstrates modal segregation. The roads were originally designed for cars, but now they are used by street vendors, bikes, and skateboards. This raises questions about whether city arterial roads should be segregated for specific activity types. A 2016 project by a cross-disciplinary team called Project for Public Spaces highlighted that governments are now recognizing the role streets can play in public spaces like commerce, socialization, community celebration, and recreation.

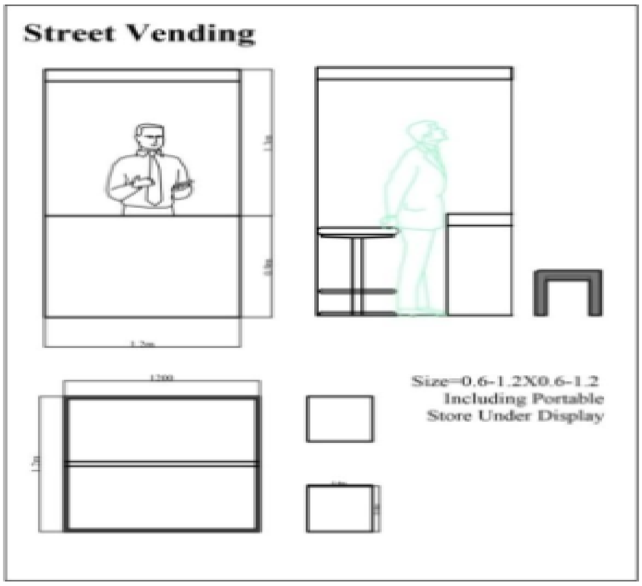


Figure 2. 7 Design Standard for street vendors

Source: Street design standards for urban Ethiopia

The Ethiopian Ministry of Urban Development and Housing has created a manual called Street Design Standards for Urban Ethiopia in 2017 to standardize street design in urban centers. The manual outlines vendor locations, suitable roads, and furniture requirements, including movable, wheel-mounted furniture, 2-4 stools per vendor, and placement in pedestrian walkways, curb corners, intersections, and mid-blocks with spacing of 50-100m.

2.10 Assessment of pedestrian sidewalk facilities

There are many tools and techniques developed for the evaluation of sidewalks at the road level. But most of the tools have mistreated the significance of making an allowance for pedestrians' perception in assessing the PLOS of sidewalks. Research regarding walkability assessment is ample, and sidewalk assessment forms an integral part thereof. Existing sidewalk assessment tools have been developed in various forms, such as LOS methods (Asadi-Shekari et al., 2014; Dandan et al., 2007; Muraleetharan et al., 2005), audits (Clifton et al., 2007; Lee & Talen, 2014), and questionnaires (Kihl et al., 2005; Saelens et al., 2003). These approaches and tools are further discussed in the following sections.

1. Pedestrian Level of Service

Level of Service (LOS) methods are widely used to assess transport infrastructures, including sidewalks (Tanvir et al., 2016). LOS approaches consider factors like sidewalk width, slope, surface material, and barriers (Asadi-Shekari et al., 2013, 2014; Dandan et al., 2007; Dowling et al., 2009). PLOS measures the perceived comfort of pedestrians using pedestrian infrastructure. The analysis of PLOS impacts investments in pedestrian infrastructure, planning, design, and policy decisions (Sahani et al. 2017). LOS is typically expressed as levels A through F, with A indicating high comfort and capacity availability, and F indicating system congestion and significant delays. This approach significantly impacts planning, design, and policy decisions in the transportation sector (Hediye and Pinar, 2018).

Studies analyzed pedestrian perception of safety and comfort in roadside environments, focusing on performance measures, quality aspects, and perceived safety or comfort (Landis et al. 2001). It provided guidance on designing pedestrian environments based on sidewalk presence, lateral separation between vehicles, motor vehicle volume, and speed. A PLOS model was developed to assess sidewalk infrastructure, considering pedestrian needs. It identifies 10 sidewalk qualities that meet diverse needs based on land use. This method can identify road network and sidewalk infrastructure deficiencies, promoting inclusive and efficient public spaces (Bivina et al. 2018).

Several techniques take sidewalk continuity and presence into account. Likewise, there aren't many techniques that take the presence of disabled pedestrians into account. Some approaches took into account separating pedestrians and vehicles (Asadi-Shekari et al., 2013, 2014; Landis et al., 2001). Though some attributes are considered by existing PLOS methods, none of them cover the full range of PLOS (Muraleetharan et al., 2003). For instance, the HCM's PLOS depends mostly on capacity and available space (HCM, 2010). Additionally, emphasise that the lack of accurate data collecting measures is a critical flaw in the current PLOS approaches (Asadi-Shekari et al., 2014).

2. Audits

Walkability audits are a popular method for assessing the built environment's encourager of walking (Maghelal & Capp, 2011). They consider factors like obstructions, tree count, driveway cuttings, sidewalk type, surface quality, cleanliness, and lighting (Pikora et al., 2002). The Irvine-Minnesota Inventory (IMI) is a widely used tool that evaluates subjective and objective aspects of the built environment, including sidewalk design, presence, continuity, condition, maintenance, and buffering (Boarnet et al., 2006).

The Analytical Audit Tool is a tool that evaluates factors related to sidewalks, such as presence, continuity, location, condition, width, levelness, and obstructions (Brownson et al., 2004). Aghaabbasi et al. (2017) also assessed two additional tools: Microscale Audit of Pedestrian Streetscapes (MAPS) and Path Environment Audit Tool (PEAT). MAPS uses positive and negative subscales to rate sidewalks, while PEAT considers aspects of sidewalk design, accessibility issues for disabled individuals, and amenities like benches and drinking fountains (Troped et al., 2006). A summary table of audit assessment techniques is provided in the annex section.

3. Questionnaires (Surveys)

Questionnaires are a common method for gathering data on people's perceptions of sidewalks and walking environments (Peterson, 2000). They can be used to examine perceptions, combine them with objective measurements, and compare measured results to perceptions (Kihl et al., 2005; Brownson et al., 2009; Coughenour, 2013). Studies like the Neighborhood

Environment Walkability Survey (NEWS), Liveable Communities, and Neighborhood Sidewalk Assessment Tool (NSAT) have evaluated perceptions of sidewalks and walking environments (Leather et al., 2011; Saelens et al., 2003). NEWS investigates factors like sidewalk presence, tree availability, shade, pedestrian signals, crosswalks, lighting, and buffers between pedestrians and vehicles. Liveable Communities assesses sidewalks in terms of maintenance, width, bicycle presence, traffic signals, amenities, and curb cuts. NSAT uses two questionnaires to evaluate sidewalk factors, helping researchers understand and improve the walking environment (Aghaabbasi et al., 2017).

Summary of approaches and tools

In an effort to overcome some of the drawbacks identified in the earlier approaches, such as the auditors' bias when conducting audits, (Clifton et al., 2007), and the absence of reliable ways to gather data for LOS methods (Asadi-Shekari et al., 2014), some researchers are looking at a technique known as Conjoint Analysis (CA). Using the CA technique, for instance, Muraleetharan et al. (2003) were able to identify the LOS of a pedestrian path as well as the factors that contribute to high or low LOS.

Recent work to create an unbiased methodology that can assess key factors influencing pedestrians in Sri Lankan city centers is particularly relevant to this study. CA, a multivariate method, was used to accomplish this (Wicramasinghe and Dissanayake 2017). This marketing research approach is predicated on the idea that consumers choose a product or service by evaluating its pertinent attributes or attribute levels (Green & Srinivasan, 1978). A study utilized an orthogonal fractional factorial design to create hypothetical conjoint profiles based on relevant attributes and levels. These profiles were offered to pedestrians to rank as questionnaires, assessing their utility value and relevance. CA proved reliable for expressing qualitative pedestrian assessments (Wicramasinghe and Dissanayake 2017). However, it could be improved by selecting additional attributes and attribute levels to better reflect the environment.

2.11 Conjoint Analysis

Con conjoint analysis (CA) is a multivariate technique used to understand a person's choice for a good or service by balancing the importance of several attributes (Green & Srinivasan, 1978). Hair et al. (2010) suggest CA helps determine the utility values consumers assign to different levels of a product's or service's attributes. CA involves displaying hypothetical profiles to customers or users with relevant attributes and gathering their preferences in the form of rankings (Agarwal et al., 2014). Both historical (Green & Srinivasan, 1978) and recent research (Agarwal et al., 2014) has shown that CA is effective in determining consumer preferences.

CA is a useful tool for assessing pedestrian preferences without bias, showing a linear relationship between total utility values and overall pedestrian-to-vehicle (PLOS) at intersections and walkways (Muraleetharan et al. 2005). Studies have shown that sidewalk evenness outweighs other attributes for transportation walking among older persons (Van Cauwenberg et al., 2016). Conjoint analysis was used to assess the most important factors driving illegal road crossings, with familiarity being the most impacting attribute (Wickramasinghe & Priyankara, 2011). Other sidewalk characteristics that significantly affect carriageway use include sidewalk width, obstructions, opposing pedestrian flows, and safety rails. Nine hypothetical profiles were created to assess pedestrians' resistance to using sidewalks (Wicramasinghe and Dissanayake, 2016).

The CA's results explain the relative weights of each attribute level and each attribute's part-worth utility value (Green and Srinivasan, 1978). To maximize the accuracy of the CA, the most suitable attributes and mutually independent levels for those attributes are selected. The generation of attributes and mutually independent attribute levels, the development of conjoint profiles, the gathering of data, and the estimation of parameters are the four stages of the main issues in the usage of CA (Ozmen et al., 2006).

The World Bank conducted a survey in Addis Ababa to assess sidewalk conditions. Five categories were identified: Urban Life, Sidewalk Condition, Urban Elements, Pedestrian Crossings, and Safety. Urban life includes commercial establishments, bus stops, and office buildings. Sidewalk conditions include narrow (less than 1.5 m wide), unmaintained, tactile pavement, and urban furniture. Pedestrian crossings are crucial for universal accessibility. Safety measures include observed jaywalking, traffic insecurity, and right-of-way use. The findings of the urban inventory assessment on sidewalks are summarized in the annex section (Jia et al., 2022). In order to assess pedestrian preference for sidewalks in the study area, this study used the CA technique. CA is also used to assess and identify attributes that influence pedestrians to walk on the street rather than the sidewalks.

2.12 Ordinal Logistic Regression

Research on dependent variables with multiple logically structured categories requires the use of ordinal analyses for accurate and trustworthy results. Traditional methods like linear regression may generate unrealistic predictions when categories are not normally distributed (Rasca & Saeed, 2022). Ordered logistic regression (OLR) is a statistical technique designed for ordinal dependent variables, evaluating the influence of predictor variables on outcomes. OLR compares an ordinal dependent variable to one or more independent variables, measured using a Likert scale, without losing statistical power (Bellizzi et al., 2018).

Ordinal regression is a statistical approach that involves a series of binomial logistic regressions. In this type of regression, the dependent variable, which has k categories, is cumulatively divided into k-1 binomial variables. Each of these variables is defined differently. For example, the first binomial variable distinguishes the dependent variable's first category (1) from the remaining cases (2, 3, ***, k). The second binomial variable distinguishes the cases in the dependent variable's first two categories (1, 2) from the others (3, 4,..., k). Finally, the last binomial variable (k-1) distinguishes between cases in the dependent variable's first k-1 categories (1, 2, 3, k-1). The variable #j is used to distinguish cases in the first j categories of the dependent variable (1, 2, 3,..., j) from those in the following categories (j+1, j+2,..., k). For each binomial variable, the regression results are as follows: Pj/ 1-Pi = boj + b1 j x, b2 j x,.... + bk j x. Here, Pj represents the probability of the j variable being successful, and b's are the regression coefficients. The end result is a family of (k-1) equations identical to the one above.

The assumption of proportional odds is that the coefficients b1j, b2j, and up to bj are equal for all (k-1) logistic regressions. This family of equations defines regression lines with identical slopes. Therefore, general Conditions (assumptions) for OLR:

1. The dependent variable should be ordinal, and the independent variable should be one or more in number. They should be continuous, categorical, or ordinal, and include dichotomous variables.
2. The assumption of proportionate odds should be validated.
3. The independent variables do not have a high degree of interconnection (multicollinearity).

The study utilized OLR to analyze sidewalk vendors' effect on pedestrian safety perception in the study area.

2.13 Summary of Literature Review

It is possible to draw the following conclusions from the overall literature review:

- A well-functioning transport network acknowledges the importance of NMT, walking, and cycling as crucial components of the system. Most journeys begin and end with a walk, hence it is imperative to provide adequate pedestrian infrastructure. The absence of such infrastructure hinders access to services, commercial and leisure activities.
- Walkability is influenced by socioeconomic status, personal preferences, and built environment, with physical barriers from vendors. To make walking feasible, proper infrastructure, personal safety, and reasonable travel time are required, along with physical barriers from vendors.
- Urban and city planners have been neglecting the standard protocols for sidewalk building and planning in developing nations like Ethiopia for a long time. The established city districts in Ethiopia have been undergoing transformation, land use rezoning, and new construction. However, the infrastructure, particularly for NMT, has not been upgraded to accommodate these changes.
- A lack of suitable sidewalks is caused by insufficient financing and planning. Walkability is given less importance, and roadways need to offer more space for pedestrians. Pedestrian-friendly sidewalks are crucial for walkability.
- Audits, surveys, and pedestrian level of service methodologies are commonly used for sidewalk assessment. However, these methods have drawbacks like data reliability issues and auditor bias. Recently, a market research technique called conjoint analysis has been employed to objectively evaluate sidewalk qualities based on user perceptions, overcoming these limitations.
- There is lack of research on the evaluation of current pedestrian infrastructure, the factors that influence pedestrians' usage or avoidance of these facilities, and their perceived level of safety in Ethiopian urban areas.

CHAPTER THREE

3. RESEARCH METHODOLOGY

3.1 Description of the study areas

Yeka is a sub-city in Addis Ababa, Ethiopia, located in the North East part of the city. It borders with Gullele, Arada, Kirkos, lemikura, Bole, and Oromia at the coordinates: 9”01’30.73” N and 38”48’27.55” E. The sub-city has an 85.98 km square area and is surrounded by four road grading types: asphalt, cobblestone, gravel, and earthen with topography including both gentle and sloppy. Based on Central Statistical Agency of Ethiopia population projection for the year 2022, Yeka Population is estimated 488,537, is predominantly composed of Eucalyptus, auriferous, and acacia trees, with limited access to public green spaces. The majority of the population is female. Due to street vendors and poor surface conditions, pedestrian accessibility is limited in many areas. The geographic location of the case study region is shown in figure below.

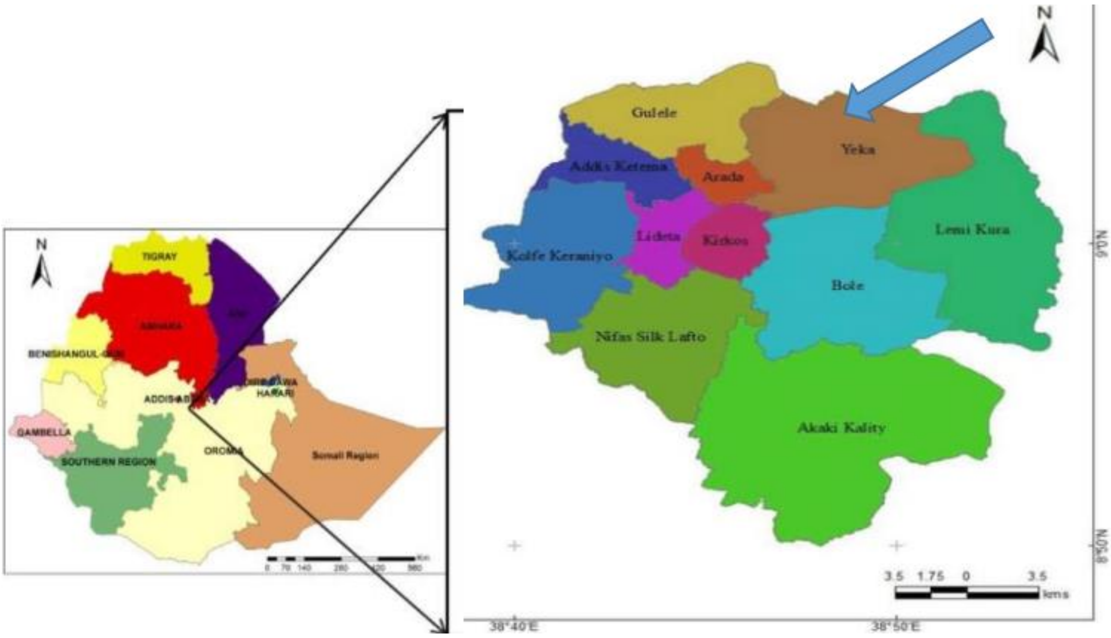


Figure 3. 1 Map showing the study area

Academic research always had restrictions, and one of the biggest ones was the study area's restrictions. In order to represent the entire existing demand, the survey locations required to be carefully selected (Mathew, 2014). This was done by assessing various neighborhoods using on-the-ground inspections and identifying trip generators using GIS data and aerial photography. The places of origin and destination of pedestrian trips serve as the foundation for building pedestrian networks and routes (Keshkamat et al., 2009). Local planning records and maps that show land use, highways, significant residential subdivisions, developments, etc. are the most helpful sources of primary data to make this determination (Vanderschuren et al., 2014). Additionally, according to the NMT Facility Guidelines (Vanderschuren et al., 2014), there will likely be a greater concentration of pedestrians near well-known locations, also known as trip generators. So, the study identified and assessed this destinations that promote travel, including schools, universities, retail stores, churches, retirement neighborhoods, residential residences, public parks, and leisure and amusement centers.

In selecting the pedestrian segments for the research zone, the study took into account a range of facilities and using purposive reasoning. Our study focused on facilities located in areas with both high, medium and low concentrations of street vendors by comparing pedestrian crash occurrence of the areas. The study included business centers and market areas near segments for better analysis and logical results. The study carefully selected facilities from the newly built pedestrian retail district, the historic downtown, and the arterial streets of the investigated Sub City based on majority of crash location of pedestrians which is plotted using ArcGIS. Mapping the crashes on a city map is an effective method to identify high-risk areas. The crash data was obtained from the Addis Ababa city police commission and Yeka Sub-city police commission, and the reported data from 2011 to July 2015 E.C. The total number of pedestrian crashes recorded was one thousand one hundred and fifty-two, which is 90.28% of total crashes. The data was organized by year and severity category, and then sorted based on location. Google Earth Pro was used to discover the coordinates, and then ArcGIS was used to create a crash map of the research region, highlighting locations with high crash prevalence.

Table 3. 1 Total Road Traffic Crashes in Yeka Sub City by Road User Type from 2011-2015

Road user	**Total crashes Years in EC**					**Total**	**5 Year % of Injuries**
	2011	**2012**	**2013**	**2014**	**2015**		
Pedestrian	239	211	240	216	246	1152	90.28
Passengers	19	14	7	12	15	67	5.25
Driver	17	8	7	11	14	57	4.47
Total	275	233	254	239	275	1276	

Source: Yeka Sub City Traffic Police Commission and organized by Author

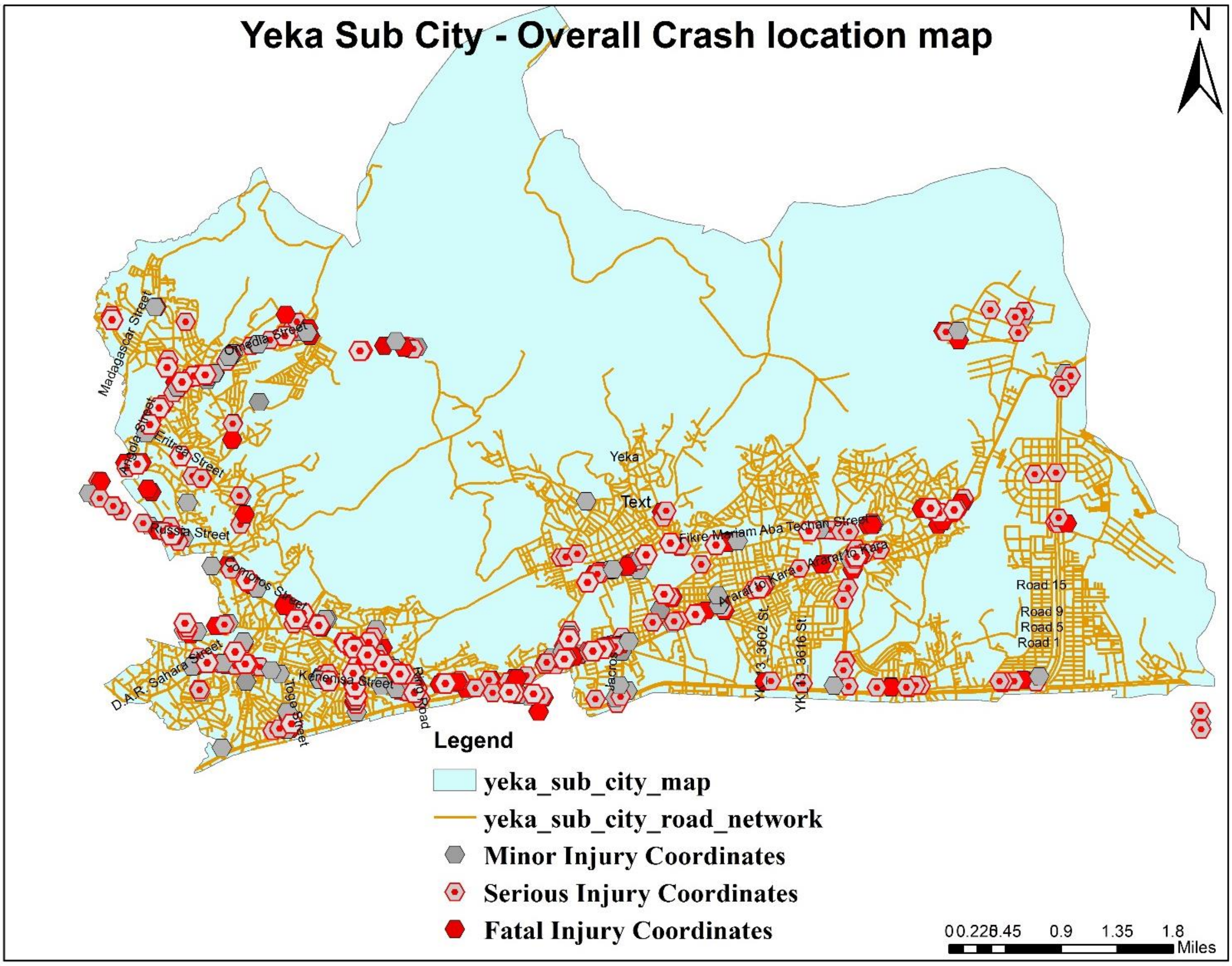


Figure 3. 2 showing Yeka Sub City - Overall Crash location map

Source: Data-Yeka Sub City Police commission and Plot-Author

Based on the field survey findings and the criteria mentioned above, the following Yeka sub-city road segments were chosen:

A. From Israel Embassy- Megenagna (Megenagna Diaspora Roundabout)- British Embassy shola (2.3km). It was identified as where pedestrians using the roadway for walking is quite prominent, in some instances, pedestrians even obstruct the normal flow of motorized traffic. From site observations and measurements, it is evident that little to no facilities exist to accommodate pedestrians. This segment is part of the pedestrian zone that is called the Core Area. It includes many significant employment centers, schools and universities, shopping areas, churches, multi-family housing, immediately surrounds the pedestrian retail center, shola market, Megenagna bus station and taxi stand and natural areas like public parks were found in these segments. In addition, it is located closely to residential homes and the Megenagna (subway) station.

B. From Yeka woreda 9 office Zero hult-Kotebe University of Education -Kotebe Mesalemia St. Maryam & St. George Church (2.8km). The Kotebe area has retail district and pedestrian facilities. While most of the sidewalks network is still being developed, a new network of pedestrian sidewalks has been constructed. These sidewalks feature bigger sidewalks, lower speed limits, and reduced traffic. Additionally, there are plans to add more landscaping buffers, street furniture, and lights. These improvements will make the sidewalks safer and more comfortable for pedestrians, which is expected to increase the number of people using them. Trip generating destinations like schools and universities, significant employment centers, shopping areas, restaurants, churches, residential homes, and Kotebe 02 Market were found in these segments.

C. From Ministry of Mines & Energy- Lamberet-Addis Ababa Haile Grand, Addis Ababa (2.1km). This segment are considered premier walking areas which accommodate high levels of pedestrian activities and provides a high degree of amenities. This segment in the downtown Pedestrian and Retail District consist of Lamberet bus stations, shopping areas, hotels and restaurants with lacks of street furnishings and amenities and closely located to residential homes, schools and employment centers.

D. From Menelik 2 Referal Hospital-Yared Music School-Kagnew Peace Keeping Roundabout (2.1km).This section also is selected from the traditional near downtown area where there is a main street theme again with a lot of older storefronts. It is located in the Pedestrian and Retail District with the same amenities which consists of many schools including Yared Music School and universities, residential homes, Sunday market on weekends, 6 kilo Fruits and Vegetables sales and closely located to churches and close proximity to numerous important employment centers.

E. From Haya Hulet Roundabout (Golagul Building)-Adwa Bridge (1.6km). This segment, outside the Pedestrian Retail District, features a main street theme with an enjoyable walking experience with good amounts of trees shade, but lacks sidewalk presence in some part and street furnishings. It consists of residential homes, gathering facilities, and small construction material shops, and is close to churches and schools. The area experiences a lower volume of pedestrians and vendors compared to other segments.

3.3 Research design and Research Approach

The methodology for this study includes an office and field investigation of the study region, as well as the application of several techniques and procedures for data collecting and analysis, as described below, to reach the state objectives. Data on the safety of pedestrians on sidewalks with vendors have been gathered and analyzed quantitatively.

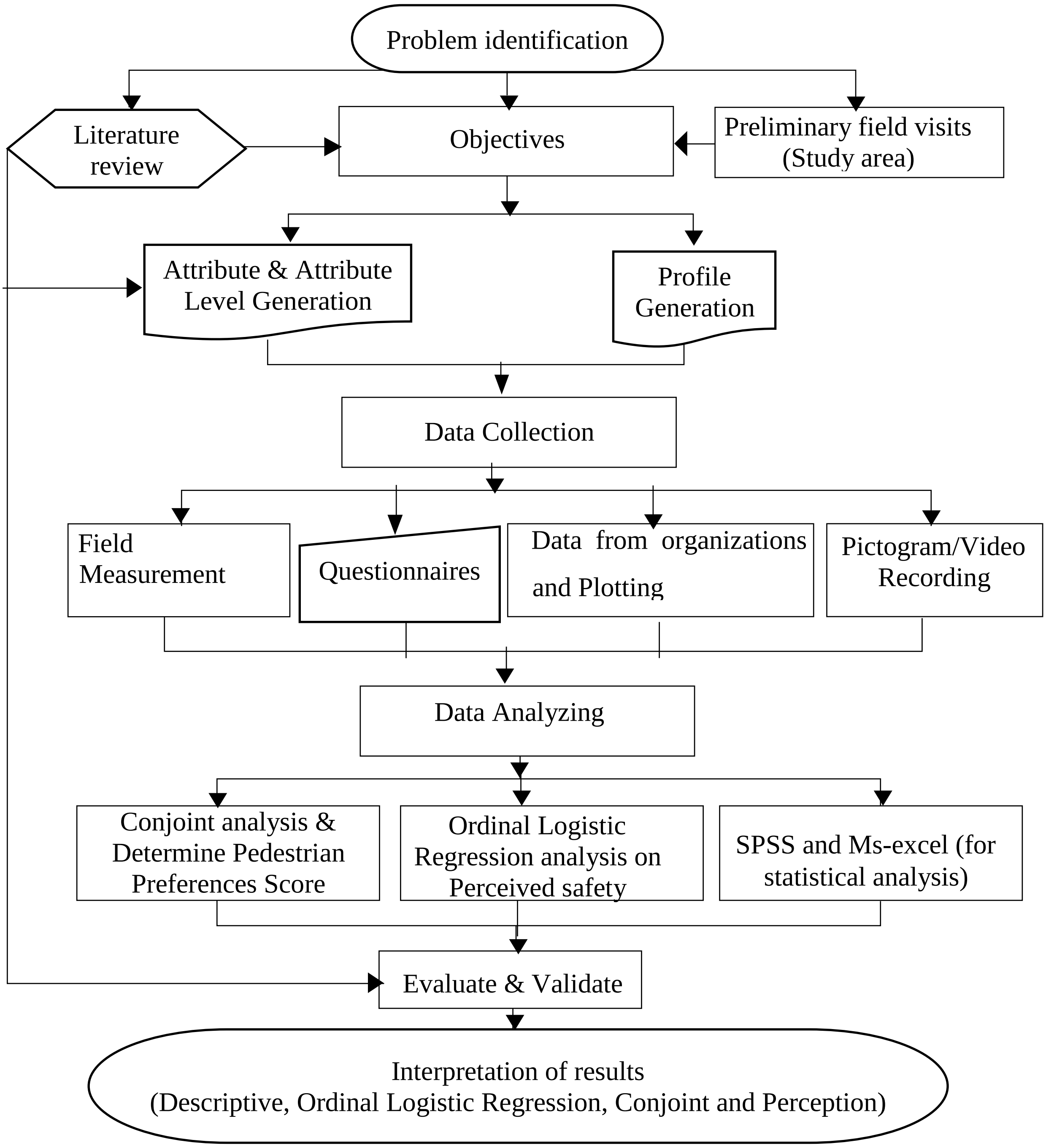


Figure 3. 3 Conceptual frame work
Source: Organized by the author (December 2023)

3.4 Data sources

Primary and secondary data from the study region were gathered expressly for this study in order to meet the objectives of the investigation.

The primary data:- It collected through survey using a questionnaire to the pedestrian, field observation of required infrastructure, and pictogram to observe pedestrian characteristics with presence of vendor and how they utilize sidewalks at selected survey sites.

The secondary data: - The study uses literature and secondary data from various sources, including books, research papers, journals, and articles. The secondary data were gathered from the AACRA, Yeka Sub-city, ERA, Addis Ababa plan and development commission, Addis Ababa city government Road and Transport Bureau and the crash data was obtained from the Addis Ababa city police commission and Yeka Sub-city police commission.

3.5 Sampling Design

3.5.1 Target Population

In order to collect data, the study selected arterial road segments in each specified area that had both high and low street vending activity. The street segments were chosen using purposive reasoning and the criteria outlined in section 3.2. There are sidewalks present in these segments, which makes it practical to observe them. Additionally, there are many pedestrians and street vendors using the sidewalks. The pedestrian segments in Yeka Sub City were thoughtfully planned and included a range of facilities. Unfortunately, due to time constraints, the study were unable to analyze all road segments and pedestrian using it. Therefore, taking samples road segment from the area was a must as stated in section 3.2.

3.5.2 Sample size

Sampling is a method used to determine the quantity and frequency of data collection. In this study, the population of people using sidewalks is either vast or unknown, making it difficult to estimate the sample size for questionnaire survey respondents. The sample size is calculated using Equation following, which includes the total number of people who meet demographic criteria and the margin of error. The confidence interval is used to determine the level of inaccuracy to accept, as no sample will be flawless. Confidence level refers to the researcher's desired level of assurance that the actual means fall within the confidence interval. Three confidence levels are commonly used: 90%, 95%, and 99%. In this investigation, a 95% confidence level was used, with a sample proportion assumption of 0.5 to ensure an accurate prediction because the pedestrian sample proportion approximation could not be known. The maximum error of the estimate is expected to not exceed 5%. Equation 3.1, which is suggested for usage when the population is more than 100,000, was used to calculate the sample size (G.Bluman 2009).

$$n = pq\left(\frac{Z_{\alpha/2}}{E}\right)^2$$ ……………………………………………….Eq 3.1 (Cochran, 1977).

Where:

n= Sample size required for the study,

p=sample proportion of people expected to have the basic knowledge about the problem (i.e. 0.5) because the Morgan table value recommended for 50 percent for the value of" P", q=1-p

α=significance level,

E=margin of error or maximum error of the estimate error that can be tolerated: it is the discrepancy between the sample size and the population. The recommended value is 5% percent (i.e., =0.05).

Z = Critical value (i.e $Z\alpha/2$=1.96) at 95 percent confidence level, the amount of uncertainty that can be tolerated. Most researches recommended 95 percent confidence level.

Therefore: $n = 0.5 \times 0.5\left(\frac{1.96}{0.05}\right)^2 = 384.16$

Taking 15% non-response rate and for accuracy and completeness of returned questionnaire = 15% of 384.16 becomes 57.62. Adding to the previous one it becomes 441.78, approximately 450 is pertinent sample size. This sample size was divided equally for each of the selected section of the road based on quota sampling technique.

3.6 Methods of data collection

The sub city's study region was restricted for the objectives of this study due to data selection. The phases of data collection employed in this study to assess the effects of roadside vendors on pedestrian safety and emphasize on the attributes that influence pedestrians to use the roadway for walking instead of the sidewalks. Generally data collections tools are discussed in the following sections.

1. **Questionnaire survey**

A questionnaire was developed for the chosen sidewalk locations in order to evaluate sidewalk safety, pedestrian preferences, and contributing sidewalk attributes in the pedestrian built environment to gauge the facility's quality based on the opinions of pedestrians. A systematic self-administered questionnaire with closed-ended questions was used for the study's objective. The following constructs were measured by the questionnaire:

- pedestrian profile such as age, gender education level, & occupation
- about trip characteristics like purpose, trip frequency, trip distance, trip time
- Walking Experience of pedestrian and surface condition of the walkway, invading of the major roadway, Safety, comfort, PLOS, presence of street vendors and adequacy of walking environment
- the Conjoint Analysis profile data, and
- the pedestrians' preference

Questionnaire papers were distributed for pedestrians and collected the same day. It was distributed to randomly selected pedestrians of different ages, gender, educational background, etc. Pedestrians rated each variable from Excellent to V. Poor (1. Excellent; 2. V.good. 3. Good; 4. Fair; 5. Poor 6.V.poor) and using the ranking conjoint technique (ordering the profiles from most to least preferred-ordinal scale from 1: most preferred to 9: least preferred), respondents were asked to rank the profiles from most desired to least ones.

2. **Field surveying**

A field investigation was engaged to check the geometric elements of the road. The presence of sidewalk, sidewalk vendor and width of the sidewalk was investigated from the site and collected through pictogram/ recording and using documentation notes.

3.7 Study Variables

Independent and dependent variables are both used in this study's variables. The table 4.2 below lists the study's independent variables as well as the dependent variables related to sidewalk pedestrian safety and conjoint analyses. Data is gathered from the questioner and entered into statistical software using all relevant procedures.

Table 3. 2 Variable description and type.

Variables	Measure	Description	Type of variable
Age	Ordinal	1) Under 18 2) 18-24 3) 25-34 4)35-55 5)above 55	Auxiliary
Gender	Nominal	1) Female 2) male	Auxiliary
Educational level	Ordinal	A. No B. Primary <8) C. Secondary D. Certificate E. Diploma F. Degree and above	Auxiliary
Occupation	Nominal	1) Government/ private office 2) your own business 3) housewife 4) student	Auxiliary
Neighborhood	Nominal	1) yes 2) no	Auxiliary
Purpose	Ordinal	1) Go to/from work 2) Go to/from school 3) Shopping 4) Recreational 5) Visiting friends/family 6) Others	Independent
Distance	Ordinal	1) Less than 500m 2) 500-1000m 3) 1000-2000m 4) greater than 2000	Independent
Time	Ordinal	1) Morning 2) afternoon 3) evening	Independent
Comfort	Ordinal	1. Excellent 2. V.good 3. Good 4. Fair 5. Poor 6.V.poor	Independent
Safety	Ordinal	1. Excellent 2. V.good 3. Good 4. Fair 5. Poor 6.V.poor	Dependent
Sidewalk surface condition	Ordinal	1. Excellent 2. V.good 3. Good 4. Fair 5. Poor 6.V.poor	Independent
Encroach into the main carriageway	Ordinal	1. Excellent 2. V.good 3. Good 4. Fair 5. Poor 6.V.poor	Independent
General condition of the sidewalk (PLOS)	Ordinal	1. Excellent 2. V.good 3. Good 4. Fair 5. Poor 6.V.poor	Independent
Frequency/ Sidewalk Usage frequency	Ordinal	1) Everyday 2) 2-3 times a week 3) Once a week 4) Sometimes	Independent
Physical Problems Disrupt walking	Nominal	1. Street vending 2. Bicycling on the sidewalk 3. Street retailing 4. Motor vehicles parking on the sidewalk 5. Street shoe shiner 6. Wood, construction materials and metalwork's on the sidewalk	Independent
Street Vendors Existence	Ordinal	1. Very uncomfortable 2. Uncomfortable 3. Slightly uncomfortable 4. Neutral 5. Comfortable 6. very comfortable	Independent
Sidewalk Width Perspective	Ordinal	1. Strongly Agree 2. Agree 3. Slightly Agree 4. Strongly Disagree 5. Disagree 6. Slightly Disagree	Independent

Source: Organized by the author (March 2023)

3.8 Data analysis Tools and Software's

IBM SPSS Statistics (Statistical Package for the Social Sciences) (IBM Corp., 2022), Google earth (Google LLC, 2018), Arch GIS and ArcMap (ESRI, 2021), and the Microsoft Excel (Microsoft Corp., 2016) software's was used in this study. The last two used for data processing and analysis purposes.

3.9 Method of data analysis

The study analyzed pedestrian safety on sidewalks impacted by vendors and identified factors that lead people to walk on the road instead of sidewalks. The study evaluated pedestrians' perceptions of safety by considering trip characteristics, demographic and social profile information such as age, gender, education level, and vendor presence. Data analysis was conducted using tools like ordered logit regression, conjoint analysis, Pedestrians' Preference Score, and descriptive statistics. Errors and incomplete questionnaires were eliminated after comprehensive analysis.

3.9.1 Descriptive Analysis

The study used descriptive analysis to understand pedestrian experiences in research locations. Statistical software was used to determine issues faced by pedestrians. Data was coded and analyzed, and results were obtained. Tools like maps, tables, graphs, figures, charts, and reports were used to interpret data, user impressions, and observations. These tools helped create a clear picture of the data and present conclusions in a more understandable manner.

3.9.2 Ordered logit model

The ordered logit model is a regression model for an ordinal response variable. The model is based on the cumulative probabilities of the response variable, and it assumes that each cumulative probability's logit is a linear function of the covariates, with constant regression coefficients across respond categories. Use a specific model where the pertinent answer variable is ordinal, such as the ordered logit model.

Equation 1 represents the ordered logit model for perceived safety. In this equation, X is a vector of factors that control perceived safety, β is a vector of parameters, and ε is a random disturbance with a mean of 0 and a variance of 1, as noted by Champahom et al. in 2022. The error term in the ordered logistic regression is assumed to have a logistic distribution, as mentioned by Rasca and Saeed in 2022. Y is an ordinal variable that can be described as a function of another unmeasured, continuous latent variable Y*. The observed variable Yi depends on whether or not a specific threshold (ki) was crossed, which may be determined using the following formulas (2)-(4) (Bellizzi et al., 2018). The equations below correspond to three levels.

$$Y^* = \beta X + \varepsilon \cdots\cdots\cdots\cdots (1)$$

$$Y_i = 1 \; if \; Y_i^* \leq k_1 \cdots\cdots\cdots\cdots (2)$$

$$Y_i = 2 \; if \; k_1 \leq Y_i^* \leq k_2 \cdots\cdots\cdots\cdots (3)$$

$$Y_i = 3 \; if \; Y_i^* \geq k_2 \cdots\cdots\cdots\cdots (4)$$

Where k_1, k_2, and k_3 represent the threshold values for the categories.

A crucial assumption underlying statistical modelling is the proportional odds assumption, which states that each input variable affects the outcome variable in a proportional manner. If this assumption is not met, the modelling technique will fail. Therefore, it is essential to address any violation of this assumption during the validation process (McNulty, 2021).

3.9.3 Conjoint analysis

The selection of the most appropriate attributes serves as the basis for the CA, which is then followed by the identification of the independent levels for those attributes (Mackenzie, 1992). The selection of attributes for the pedestrians' sidewalk behavior problem could not be difficult, according to a review of the previously cited studies on pedestrians' sidewalk behavior.

3.9.3.1 Attributes and mutually independent attribute level generation

According to the available literature (see section 2.9 and 2.10), the selection of attributes was done by conducting a comprehensive literature study and evaluation of existing conditions of sidewalk using physical surveys. Previous research showed that sidewalk width, the presence of obstructions, pedestrian flow rate, and safety regarding separation from vehicles were the most appropriate attributes influencing sidewalk avoidance (Muraleetharan et al., 2005; Wicramasinghe et al., 2017). These attributes, however, might not be necessarily the best attributes for the situations in Ethiopia.

According to studies, using appropriate attributes and attribute levels that better reflect the scenario could increase the CA technique's accuracy (Ozmen *et al*., 1992; Wicramasinghe et al. 2017). Thus, the following attributes were chosen for the study after studying Ethiopian literature, assessing the environment, and interviewing manuals and evaluating existing conditions using physical surveys: width of sidewalk, pedestrian flow rates, presence of obstacles, and sidewalk condition were selected as pertinent attributes to evade the sidewalk by pedestrians. Mutually independent three levels for each attribute will be selected as shown in table below for this study. Furthermore, research into current design standards and literature led to the levels for each attribute.

Table 3. 3 Pre- Selected sidewalk attributes and their mutually independent levels

Sidewalk Attributes	**Attribute Levels**		
	Level 1	**Level 2**	**Level 3**
Width of Sidewalk (m)	>2.5 m	2.5 m – 1.5 m	< 1.5m
Number of Obstacles per 50m	No Obstacles	1 to 5 Obstacles	> 5 Obstacles
Two-way Pedestrian Flow Rate (ped/min/m)	< 12	12 to 20	>20
Sidewalk Condition	Good/High- adequate use of pavement materials, presence of continuous pavement, better drainage and presence of tactile pavement	Fair/Medium- unmaintained sidewalk, the presence of non-continuous sidewalk pavement and the presence of non-continuous tactile pavement	Poor/Low-no/lack of sidewalk or deficient construction and design, absence of tactile pavement and pedestrian invasion of the road

3.9.3.2 Generation of conjoint profiles

Hypothetical profiles were created using different combinations of the chosen attributes to evaluate them. However, if the "full profile" design (i.e., one that included all possible combinations of levels and attributes) was used, the generation of all possible combinations of these attributes would result in 81 (3x3x3x3=81) possible hypothetical profiles, some of which would not even be presented in real life but the result of experimental combinations of attributes. These levels are the width of the sidewalk, pedestrian flow rates, the presence of obstacles, and the conditions of the sidewalk. If all possibilities were taken into account, replies would be provided with 81 possible profiles because standard CA uses either a rating or ranking response technique. As the number of characteristics and levels increases, it is clear that the respondents find it challenging to rank or rate all of the options.

The Orthogonal Fractional design (orthogonal array experimental design technique) was used to reduce product configurations, ensuring all attributes are presented equally and uncorrelated. This method assumes negligible interactions. By using statistical software, the original set of 81 profile configurations was reduced to nine product configurations, balancing the independent contributions of all attributes. The results demonstrate the effectiveness of this statistical method in addressing the issue at hand.

Table 3. 4 Nine hypothetical pedestrian sidewalk profiles generated using orthogonal fractional design.

Card ID	Width of Sidewalk	Number of Obstacles per 50m	Pedestrian Flow Rate(ped/min/m)	Sidewalk Condition
1	< 1.5m	1 to 5 Obstacles	>20	Good
2	< 1.5m	> 5 Obstacles	< 12	Fair
3	2.5 m – 1.5 m	No Obstacles	>20	Fair
4	2.5 m – 1.5 m	> 5 Obstacles	12 to 20	Good
5	2.5 m – 1.5 m	1 to 5 Obstacles	< 12	Poor
6	>2.5 m	> 5 Obstacles	>20	Poor
7	>2.5 m	No Obstacles	< 12	Good
8	< 1.5m	No Obstacles	12 to 20	Poor
9	>2.5 m	1 to 5 Obstacles	12 to 20	Fair

3.9.3.3 Visual Representation of Conjoint Profiles

Each hypothetical profile was then constructed into a three-dimensional (3D) model which is used to visualize and presented in annex section. Reasonable care was taken to ensure the uniformity of each profile to minimize any influence other than the attributes being evaluated. To determine pedestrians' preferences, each hypothetical profile was used. Pedestrians are asked to sort the set from the most to the least preferred to make use of the pedestrian sidewalks to travel. Figure 3.3 below provides an example of a hypothetical profile of pedestrian sidewalk (all nine cards can be produced upon request from the authors) and visual representation of the others constructed conjoint profiles are shown in annex F (Annex F Figure F1 to F 9) to visualize.

Figure below shows a sample conjoint profile expressing hypothetical sidewalk which is having width of between 2.5m and 1.5m, no obstacles per 50m, pedestrian flow rate of greater than 20 ped/mim/m and fair sidewalk condition. By assuming respondent has to use this kind of hypothetical sidewalk, respondent is asked to rank the profile according to his/her preference.

Figure 3. 4 Example of a conjoint profile exemplifying a hypothetical sidewalk situation.

3.9.4 Pedestrians' preference score (PPS)

The amount that a pedestrian avoids using sidewalks along a particular street stretch is measured in this instance. The question below in table 3.3 was utilized to determine this type of preference. On a 5-point scale, pedestrians were then asked to indicate whether they preferred to walk on the sidewalk or along a particular stretch of road. The research collected PPS values in five locations in the case study area, focusing on pedestrian preference. The PPS equation was used to evaluate if a pedestrian chose to use sidewalks in a specific location.

Table 3. 5 A model of question which can be used to measure the PPS of each location

Indicate your preference of using the following mentioned sidewalks in Sub City ABC.						
Location 1		1	2	3	4	5
Location 2		1	2	3	4	5
Location 3		1	2	3	4	5

1. Strongly Dislike 2. Dislike 3. Normal
4. Like 5. Strongly Like

3.10 Evaluation and Validation

Model evaluation criteria (Ordered logit model)

The coefficient of determination (R^2) is commonly used to measure the "goodness-of-fit" in models created with the ordinary least squares (OLS) method, which is a linear least squares approach used to determine the unknown parameters in a linear regression model. To evaluate the model's strength, a pseudo-R^2 compares the likelihood of the intercept-only model to the likelihood of the model with predictors. Pseudo-R^2 values can range from zero to less than one, with a higher value indicating a more accurate model. With the best fit model, evaluate the study area of pedestrian safety by taking average values of the independent factor which is collected from questioners for each study area.

Validation of Ordinal Logistic Regression

Goodness-of-fit statistics can be used to verify if the model accurately describes the data using Model Fitting Information and Goodness of Fit statistic; in which they show weather the model demonstrates a good fit or how well the fitted (assumed) model matches the observed data. Using ordinal regression analysis requires meeting the proportional odds assumption, which means that each input variable impacts the different levels of the ordinal output variable in a similar way. This assumption is crucial, and if it is not met, the modelling technique will fail. Therefore, it is considered the primary factor during the validation process.

Validation of the Total Utility Value

The Total Utility Value was plotted against the Pedestrians' Preference Score for each location to validate the index created by the CA approach. There was discovered to be a linear association, which strongly suggests a correlation. Based on the validation, the CA technique's index can be used to identify and classify the utility of sidewalks. The index can also be used to graphically depict the utility by mapping sidewalks. The index's findings were incorporated into the creation of workable planning and design criteria.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1 Questionnaire Responses

The study used surveys to gather data on pedestrian demographics, walking habits, and sidewalk safety perceptions. The questionnaires were distributed in both English and Amharic to enhance comprehension. 450 questionnaires were distributed in the study region, with 430 responses suitable for analysis (See Annexure A for a sample questionnaire). The study aimed to understand the unique perspectives of each pedestrian by rating variables on a scale of 1 to 6 and ranking profiles in order of most to least desirable using the ranking conjoint method. Perceived safety was assigned to six levels, and overall perception ranged from excellent to very poor. The data was then uploaded onto statistical software for analysis.

4.2 Socio-demographic and walking experience analysis

Age and Gender

The survey results show a noticeable difference in gender distribution, with 56.5% of respondents identifying as female and 43.5% as male. Figure 4.1 displays the age distribution of respondents, which is divided into five groups. The most represented age group is those between 25 and 34 years old, accounting for 38.37% of respondents. The second largest group is those between 35 and 55 years old, representing 22.33% of respondents. The remaining age groups are under 18 (11.16%), 18 to 24 (16.51%), and over 55 (11.63%).

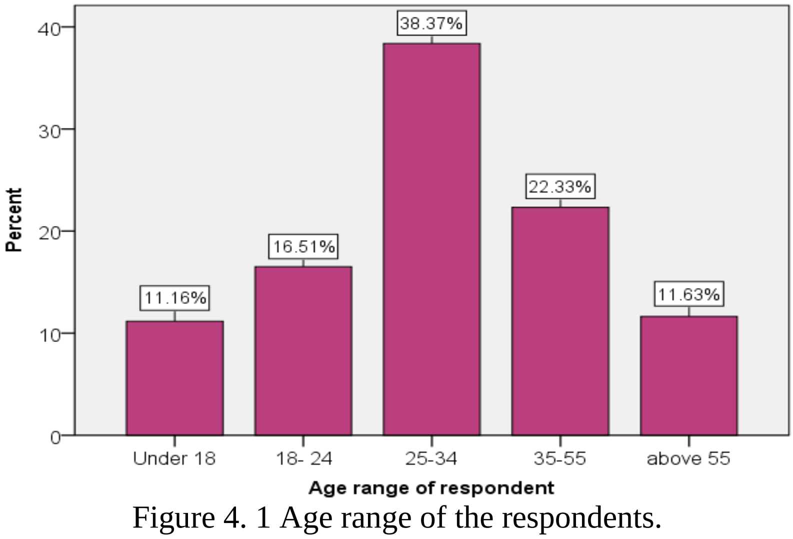


Figure 4. 1 Age range of the respondents.

Education and Occupation

The survey was focused on education and the results are shown in Figure 4.2. The highest percentage of participants (36.51%) had obtained a bachelor's degree or higher, while 20.00% had less than an eighth-grade education. Only 7.44% of respondents reported having no formal education.

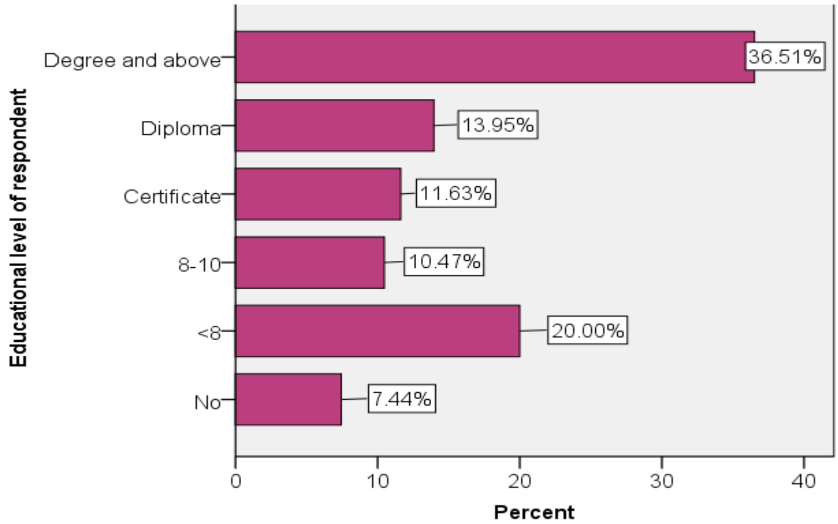


Figure 4. 2 Education level of surveyed respondents.

Figure 4.3 displays the employment status of those surveyed. The results reveal that 38.60% of participants are employed in either government or private offices. Following them are individuals who own their own business (28.60%), students (23.26%), and housewives (9.53%).

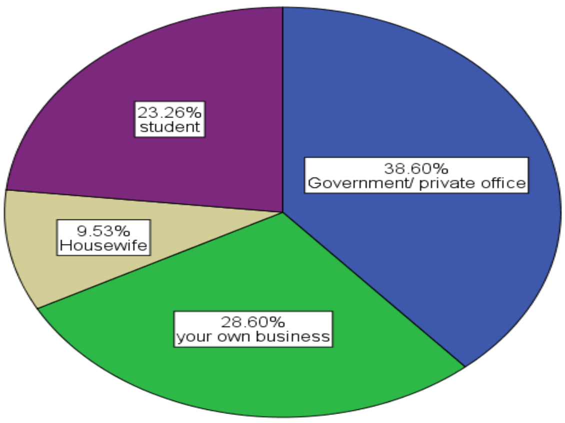


Figure 4. 3 Occupation status of surveyed respondents.

Trip characteristics of pedestrians

A survey was conducted to assess pedestrian perceptions in Yeka sub-city. 55.1% of participants resided in the area, while 44.9% lived outside. The study suggests that the sub-city serves as a passage for other areas or has attractions that attract visitors. When asked about how often they walk, the majority of respondents (58.60%) reported walking daily. A smaller percentage of respondents, 26.98%, said they walk two to three times per week, while 10.23% reported walking occasionally. Only 4.19% indicated that they walk just once per week. See Figure 4.4 for a visual representation of these findings.

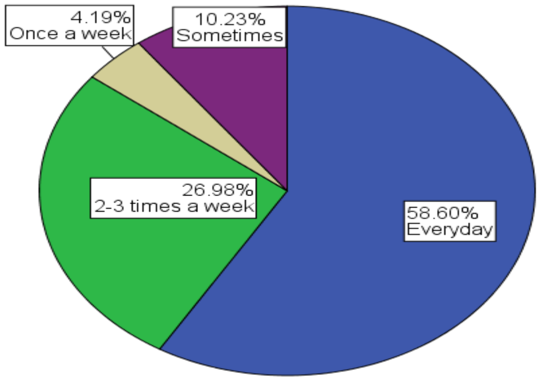


Figure 4. 4 Frequency of respondents walking in the study areas.

The researchers asked respondents about the reasons for their walks in the study areas. As shown in Figure 4.5, 49.53% of the workers reported walking to and from work. Shopping was the purpose for 12.33% of the respondents, while 11.16% walked to and from school and recreational areas separately. Only 5.12% mentioned other activities.

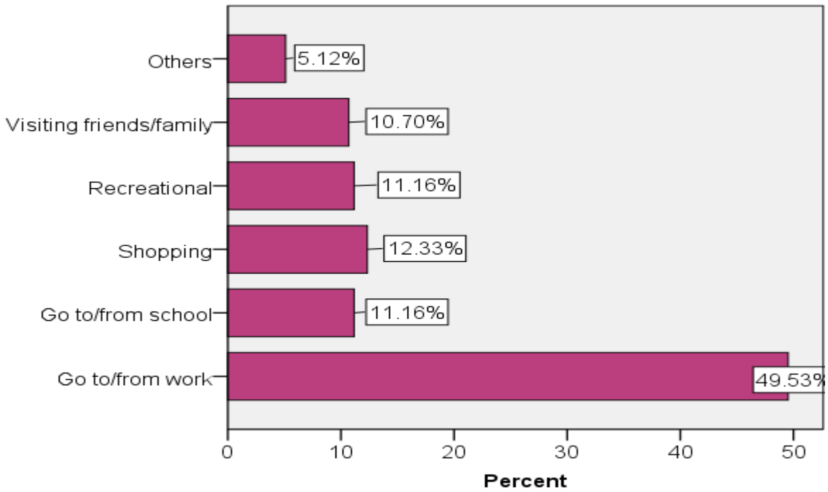


Figure 4. 5 Purpose for walking in the area

The survey asked participants to indicate when they prefer to walk more often. The results revealed that 44.4% of respondents prefer to walk in the morning, 40.20% prefer to walk in the afternoon, and the remaining 15.30% prefer to walk in the evening.

When surveyed about their preferred travel distance to reach points of interest, participants indicated that they would be willing to walk between 1000 and 2000 meters (32.79%), 500 to 1000 meters (28.60%), over 2000 meters (26.98%), or less than 500 meters (11.63%).

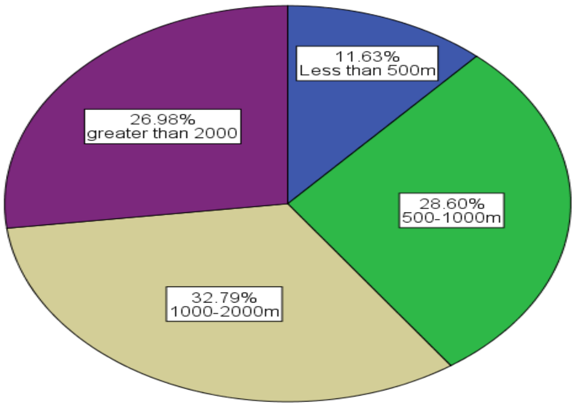


Figure 4. 6 Distance covered by walking in the area.

Walking Experience of pedestrian

After the initial question, respondents were asked what activities on the sidewalk cause discomfort or obstruction for pedestrians. The results are presented in Figure 4.7. The majority of respondents, 46.51%, reported feeling uneasy due to street vendor. 28.60% of respondents occasionally encounter parked cars blocking the sidewalk. 17.67% of respondents stated that debris such as wood, rubbish, holes, or building materials obstruct the sidewalk, while 7.21% identified street shoe shiners as an issue.

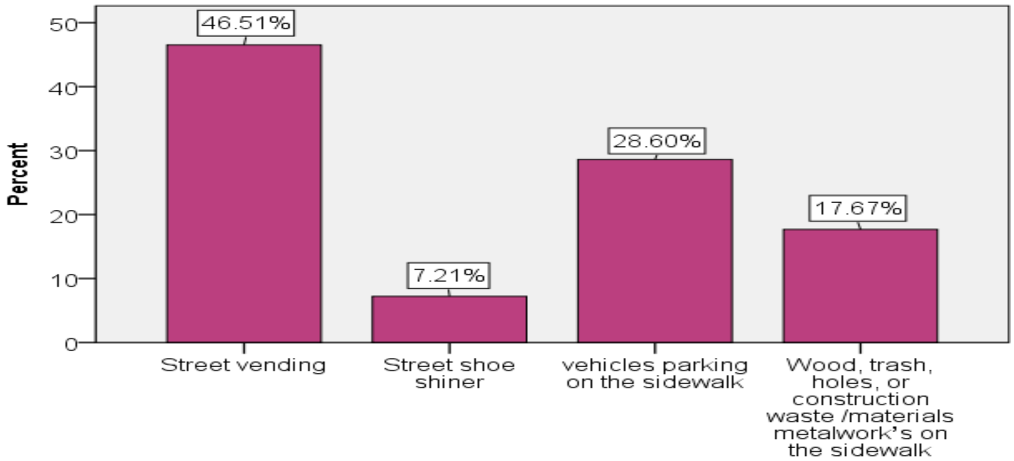


Figure 4. 7 Activities on the sidewalks obstructions to the pedestrians

Participants were asked to rate their agreement on a scale from 1 (Strongly Agree) to 6 (Slightly Disagree) regarding the total width of the sidewalk being satisfactory for pedestrians. Out of the respondents, the majority (54.4%) slightly disagreed with the statement and 15.8% disagreed. 13.5% of people somewhat agreed, 12.3% strongly disagreed, 3.7% agreed and 0.2% strongly agree that the sidewalk's overall width was adequate.

Participants were asked to rate their level of comfort on a scale of 1 to 6 when passing by sidewalk vendors. The majority of respondents (32.56%) reported neutral, 20.23% experiencing some level of discomfort and comfort in their presence. This discomfort was reported while strolling in the company of street vendors, as shown in Figure 4.8.

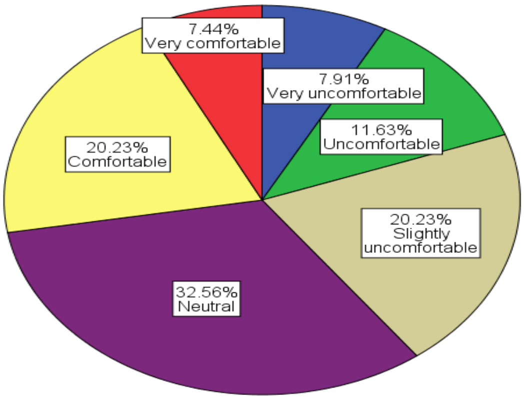


Figure 4. 8 Walking experience on sidewalk in presence of street vendors

The survey revealed that 60.7% of respondents felt congested and preferred walking more frequently on the road, while 37.3% did not feel crowded. This response is closely related to previous concerns. The final section of the questionnaire asked about preferences, including comfort level and sidewalk experience. Figures illustrate how participant perspectives on walking on the sidewalk relate to responses.

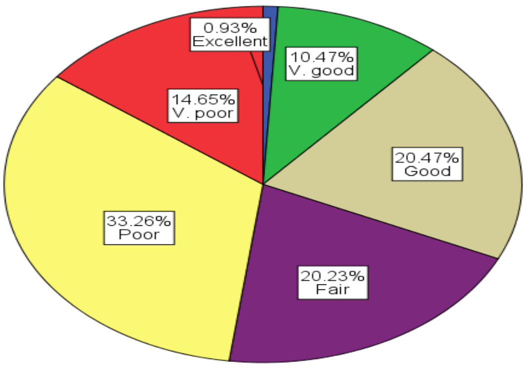


Figure 4. 9 Pedestrians Perceptions about comfort.

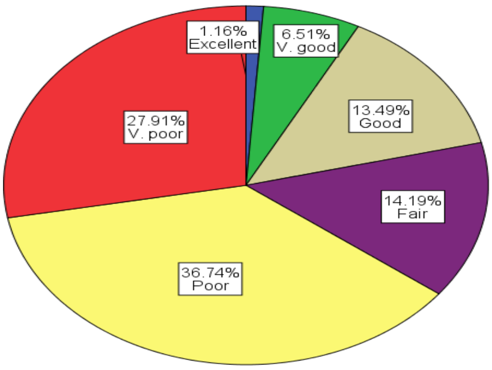


Figure 4. 10 Pedestrians Perceptions on surface condition of sidewalk

When asked about their level of comfort walking on the sidewalk, respondents in the study rated their experience on a scale of 1 to 6 as a shown above in figure 4.9. The results were as follows: 33.26% rated it as poor, 20.47% rated it as good, 20.23% rated it as fair, 14.65% rated it as very poor, 10.47% rated it as very good, and 0.93% respondents rated it as excellent. The results for sidewalk surface condition show a decrease from 36.74% poor to 27.19% very poor, with 14.19% fair, 13.49% good, 6.51% very good and 1.16% excellent as a shown above in figure 4.10.

The survey question asked users to rate how safe they felt when using the sidewalk on a scale of 1 to 6, with 1 being excellent and 6 being very poor. The results showed that 54.42% of respondents rated it as very poor, 15.81% as poor, 13.72% as good, 12.09% as fair, and 3.72% as very good. There were 0.23% responses indicating that the experience was excellent as a shown below in figure 4.11.

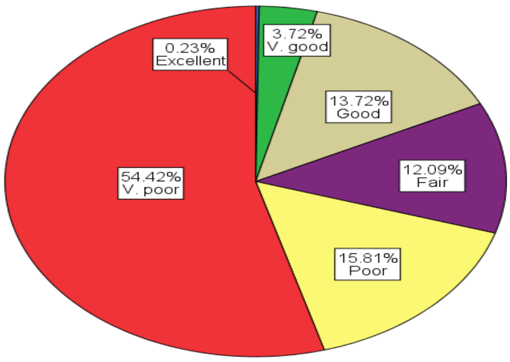


Figure 4. 11 Pedestrians Perceptions about safety

For encroaching into the Carriageway the response from the result of the pedestrian perception is 45.12% very poor, 24.19% poor, 10.93% good, 10.47% fair, 6.74% very good and 2.56% excellent response as a shown below in figure 4.12.

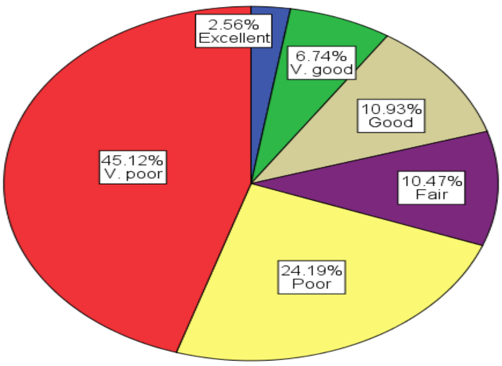


Figure 4. 12 Pedestrians Perceptions about encroaching on carriageway

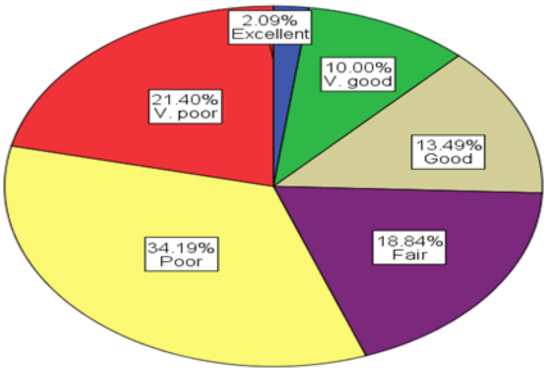


Figure 4. 13 Pedestrians Perceptions about PLOS

According to PLOS, 34.19% of pedestrians perceive the overall sidewalk condition as poor, with 21.4% rating it very poor, 18.84% fair, 13.49% good, 10% very good, and 2.09% exceptional as a shown above in figure 4.13. Based on the survey findings, majority of the factors that pedestrians were asked to evaluate were rated as fair, poor, or extremely poor.

4.3 Ordered logistic regression analysis results

OLR analysis was used in this section and the modeling exercise was conducted using statistical analysis software. The study aimed to identify factors that affect sidewalk pedestrians' perceived level of safety by considering nineteen explanatory variables. The dependent variable, perceived safety, was assessed on a scale of 1-6. Out of the 20 parameters, four were introduced as dichotomous variables: gender, residency in Yeka Sub City, perceived sidewalk crowds, and walking utilization. Additionally, the respondent's occupation status and the sidewalk activities that bother pedestrians were considered as nominal variables. Age, education, how often the pedestrian walk, the purpose, distance pedestrian walking, time pedestrian walk, comfortability of pedestrian walking through sidewalk with the presence of street vendors, pedestrian perception to total width of the sidewalk adequacy, surface condition of the sidewalk, evade the carriageway, pedestrian perceived PLOS, Sidewalk width and pedestrian perception toward safety when walking on the sidewalk, feel secure against potential falls, trips, and vendor risk as well as from oncoming vehicles are provided as ordinal variables.

4.3.1 Ordinal Logistic Regression outcome

Case Processing Summary

The study's output includes a Case Processing Summary, detailing the 430 respondents. The results, including unique responses and marginal percentages, are presented in the appendix section of E in the first part of the OLR analysis results

Goodness-of-fit statistics

Goodness-of-fit statistics can be used to verify if the model accurately describes the data.

1. **Model Fitting Information:** A significant model indicates a notable improvement in fit compared to the null model; thus, the model demonstrates a good fit. The final model and the intercept-only model ought to differ significantly.
2. **Goodness of Fit statistic**: If the significance value is less than 0.05, the goodness of fit statistic shows a poor fit. In this case, the model fits the data well (since $p > 0.05$). In general, a goodness-of-fit test assesses how well the fitted (assumed) model matches the observed data. In this case, an insignificant value would indicate that the assumed model and observed data do not differ significantly (there’re no significant differences).

Table 4. 1 Model fit indices of the ordinal logistics regression analysis

Model Fitting Information				
Model	-2 Log Likelihood	Chi-Square	Df	Sig.
Intercept Only	1107.110	-	-	-
Final	638.942	468.169	54	.000
Goodness-of-Fit				
Pearson	-	4033.335	2091	.000
Deviance	-	638.942	2091	1.00

The results of the ordinary logistic regression model fit indices can be found in Tables 4.1 above. Based on the likelihood ratio test, it is evident that the final model's fit ($\chi2 = 468.169$, $p < 0.05$) is significantly better than the model with only the intercept, and including all predictors. The null hypothesis can be accepted, indicating that the observed data matches the estimated model well according to deviance goodness-of-fit indices ($\chi2 = 638.942$, $p > 0.05$). However, the Pearson goodness-of-fit indices ($\chi2 = 4033.335$, $p < 0.05$) suggest otherwise.

Model Summary - Psuedo R Square

The Psuedo R-Square is shown in the Model Summary. Pseudo denotes that the variation is not scientifically explained. However, the criteria variable can use them as an approximation of variation. R-squared McFadden value will be used in Ordinal Regression. When comparing the current situation to the null model, we can state that the predictor-based result prediction has improved by 42.3 %. In OLR, the value of the pseudo R^2 is utilized, and it can range from 0 to 1. R^2 is determined by comparing the log-likelihood of the model to that of the baseline model (Champahom et al., 2022). According to Cox and Snell, the model's pseudo R^2 in this study is 0.663, or 66.3%. Stated differently, 66.3% of the difference in safety can be explained by the collection of variables.

Table 4. 2 Model Summary - Psuedo R Square

Pseudo R-Square	
Cox and Snell	.663
Nagelkerke	.718
McFadden	.423

Test of Parallel Lines

The assumption of OLR states that the odds of a predictor falling into a higher category on a dependent variable are constant across all categories. This means that all response categories have the same odds of the predictor falling into the higher category. If the P-Value is substantial, Multinomial Logistic Regression can be used. If the Test of Parallel Lines is significant, it means no variation in the predictors' probability of falling into a higher category of the dependent variable.

Table 4. 3 Ordinal Logistic Regression results-Test of Parallel Lines

Test of Parallel Lines[a]				
Model	-2 Log Likelihood	Chi-Square	Df	Sig.
Null Hypothesis	638.942			
General	421.212[b]	217.729[c]	216	.454

4.3.2 Checking proportional odds assumption

The study tested the proportional odds assumption, a prerequisite for ordinal regression analysis, which ensures consistent parameters across outcome variable categories. If this assumption is broken, the modeling technique will fail, and its validity is determined using the Brant-Wald test. If the coefficient fails to meet this assumption, the p-value is low (McNulty, 2021).

Table 4. 4 Proportional odds assumption test result

a. Test of parallel lines					
Model		-2 Log Likelihood	Chi-Square	Df	Sig.
Null Hypothesis		638.942			
General		421.212[b]	217.729[c]	216	.454
b. Goodness of fit					
	Chi-Square		Df		Sig.
Pearson	4033.335		2091		.000
Deviance	638.942		2091		1.000

OLR involves separate intercept terms at each threshold but a single OR for each explanatory variable's effect as specified in section 2.12. Therefore, the proportional odds assumption is satisfied with model's validity is confirmed by a p-value of 0.454, exceeding the 0.05 threshold, and the goodness of fit value is insignificant as shown above in table 4.4, indicating a good fit and validity between the assumed model and observed data.

4.3.3 Checking Multi-collinearity assumption

The correlation coefficient, variance inflation factor, and eigenvalue approach are utilized to detect multicollinearity in regression models, with the variance inflation factor indicating the degree of inflated variance in the presence of correlation. VIF values range from 1 to 10, with difficult values indicating highly linked variables, absence of correlation between the independent variables (VIF = 1), moderate correlations (1< VIF < 5), and multicollinearity (5< VIF < 10). VIF value greater than 10 indicates weakly estimated regression coefficients in multicollinearity, while tolerance is the inverse of VIF value, with tolerances less than 0.1 or VIFs over ten raising red flags (Shrestha, 2020; Fricker, 2001). Table 4.5 displays the results, indicating that all independent variables have tolerance values above 0.2 and VIF values below 5.0, indicating no multi-collinearity issues between the chosen variables. Therefore, all variables were included for further analysis.

Table 4. 5 Multi-collinearity test result

Variables	Collinearity Statistics	
	Tolerance	VIF
Surface	.503	1.989
Encroaching	.644	1.554
PLOS	.435	2.299
Comfort	.399	2.503
Sidewalk width	.587	1.704
Adequacy	.739	1.352
Vendors	.675	1.481
Age	.942	1.062
Educational	.914	1.094
Frequency	.514	1.946
Time	.866	1.154
Distance	.695	1.439
Purpose	.526	1.901
a. Dependent Variable: Safety		

4.3.4 Reliability analysis-Cronbach's alpha

Reliability in statistics refers to the consistency of a measurement, with internal consistency measured using Cronbach's alpha. It measures the degree to which different components of a tool evaluate different aspects of the same trait or construct. The coefficient ranges from 0 to 1, with items assessing an underlying factor having a high alpha value. The number of variables in the measurement impacts Cronbach's alpha (Almquist et al., 2019). Cronbach's alpha is a test of consistency and reliability rather than a statistical test.

Table 4. 6 Rule of thumb for Cronbach's alpha value

Alpha values	Remarks
Between 0.7 and 1.0	Acceptable
Below 0.7	Not Acceptable

The Cronbach's Alpha for the study is shown below which indicate that the factors which in the study analysis are reliable.

Table 4. 7 Cronbach's alpha value for the study

Reliability Statistics	
Cronbach's Alpha	N of Items
.775	7

4.3.5 Interpreting Ordinal Logistic Regression results

Table 4.8 below shows the ordered logit analysis findings for the independent variables. The table indicates that the coefficient estimations have insignificant standard errors. Thus, the coefficient estimations are capable of producing balanced outcomes. The table indicates that all important attributes contribute significantly ($p<0.05$) to the model at the 95% confidence level. Using ordered logit analysis to estimate parameters for independent variables yields the following model. The ordered logistic model is being studied for modelling pedestrian safety perception. To simplify the parameters to be estimated, safety perceptions are recoded into six categories: Excellent, V. good, Good, Fair, Poor and V. poor, so the dependent variable responses are 0, 1, 2, 3, 4, 5. The study found that an increase in independent variables was linked to an increase in perceived safety. The dependent variable indicated the probability of a case falling into a higher or lower category, with a + sign indicating a higher probability and a -sign indicating a lower probability. The Odds Ratio (OR) was used to measure the probability of a dependent variable falling into a higher or lower category with a unit change in the independent variable. A higher OR indicated a higher likelihood of being in a higher category with a unit increase in the predictor.

The study found that comfort and surface condition significantly contribute to perceived safety, with positive values. High comfort and surface quality increase pedestrian safety perception, while low comfort and poor surface quality decrease it. For instance, higher comfort levels have higher odds of higher perceived pedestrian safety on sidewalks, with odds 14.35359 times greater for higher comfort levels of [Comfort=1, Excellent] and lower-quality surfaces have lower odds which have lower perceived pedestrian safety on sidewalks with 6.0436 times lower for lower-quality surfaces of [Surface=5, Poor]. These findings are consistent across the entire category and are presented in table 4.8, along with their corresponding estimates and OR.

Regarding the effect of encroaching on roadway activities, it was significant at a 95% confidence interval and it is categorized in Table 4.8, in which the estimates and OR of perceived pedestrian safety of category increases from the first [Encroaching=1, Excellent] to the second category [Encroaching=2, V. good] but decreases from the second [Encroaching=2, V. good] to the third [Encroaching=3, Good] then increases from the third [Encroaching=3, Good] to the fourth [Encroaching=4, Fair] and again decreases. The chances of a pedestrian feeling safe while stepping into a road are 0.85385 times lower in Category 1 [Encroaching=1, Excellent], 0.96851 times lower in Category 3 [Encroaching=3, Good], and 0.92035 times lower in Category 5 [Encroaching=5, Poor], with the opposite being true for Categories 2 [Encroaching=2, V. good] and 4 [Encroaching=4, Fair]. Similarly this hold true for estimates of perceived pedestrian safety of each category.

The study found that all PLOS variables positively and significantly impact pedestrian safety perception, with increased PLOS categories increasing the likelihood of perceived safety. For instance, when compared to the reference categories, the probabilities of higher perceived pedestrian safety on sidewalks were 9.26274 times higher for PLOS levels in category 5 [PLOS=5, Poor] and when compared to the reference categories, the probabilities of higher perceived pedestrian safety on sidewalks were 25.40637 times higher for PLOS levels in category 4 [PLOS=4, Fair]. This holds true for the general category, as presented in table 4.3, along with their corresponding estimates and odd ratios.

According to the study, the estimated sidewalk width variable showed positive estimate on perceived safety, indicating that people 1.12975 times feel safer by sidewalks widths with 53.05% probability. The impact of sidewalk width on pedestrians' perceived safety has produced contradictory results. The Age variable has a significant impact on perceived safety, with all categories having a negative impact. The negative coefficients indicate that safety perceptions decrease as age decreases. For instance, category 1 [Age=1, Under 18] have lower perceived safety than category 2 [Age=2, 18- 24]. So it shows specifically, young and middle-aged adults have much poorer safety perceptions than elderly people.

The OLR analysis found that pedestrian safety perceptions were not significantly influenced by frequency and purpose categories. However, after controlling for purpose, only three categories had a significant positive impact on perceived safety: walking to work, recreational, or visiting friends or family. These positive coefficients suggest that these factors significantly influence pedestrian safety. For instance, walking for visiting friends or family leads to a higher perceived pedestrian safety of 0.28536 times, with a probability of 22.2%. The study found that education had a significant negative impact on perceived safety, except for category 2 [Education=2, <8], which had a positive effect. After analyzing distance and time, all distance categories, and time category have significant impact on perceived safety. Higher perceived pedestrian safety was found in distance with odds of feeling safe 1.60159 in category 2 [Distance=2, 500-1000m] and 1.32049 times greater in category 3 [Distance=3, 1000-2000m] than the reference group. And perceived pedestrian safety is lower in the afternoon, with odds of feeling safe 0.56722 times lower than the reference category and a 36.19% probability.

The study found that vendors on sidewalks significantly affect pedestrian perceived safety, with all categories having a negative effect. The likelihood of perceived safety declines as vendor activities increase, as shown in Table 4.8. For example, the odds of safety perception on sidewalks are 0.81546 times lower for vendor activities in category 1 [Vendor=1, Very uncomfortable]. The study reveals that sidewalk adequacy significantly influences pedestrian safety, with high-adequacy levels resulting in increased perceived safety and all categories showing a positive effect. For example, sidewalks with assigned adequacy levels of 2 [Adequate=2, Agree] had 3.60745 times higher probabilities of higher perceived pedestrian safety compared to those with low adequacy levels.

Equation 1 is an ordered logit model for perceived safety, involving X is a vector of factors that control perceived safety, β is a vector of parameters, and ε is a random disturbance. Y is an ordinal variable influenced by another unmeasured, continuous latent variable Y*. The observed variable Yi depends on crossing a specific threshold (ki), determined using formulas (2)-(4). Safety perception rankings are based on a linear function for each observation, corresponding to three levels in equations below.

$$Y^* = \beta X + \varepsilon \cdots\cdots\cdots\cdots\cdots (1)$$

$$Y_i = 1 \; if \; Y_i^* \leq k_1 \cdots\cdots\cdots\cdots\cdots (2)$$

$$Y_i = 2 \; if \; k_1 \leq Y_i^* \leq k_2 \cdots\cdots\cdots\cdots (3)$$

$$Y_i = 3 \; if \; Y_i^* \geq k_2 \cdots\cdots\cdots\cdots\cdots (4)$$

Where k_1, k_2, and k_3 represent the threshold values for the categories.

Table 4. 8 Results of OLR analysis parameter estimates and odds ratios: influencing factors on pedestrian perceived safety in the study area.

Variable	Categories	Estimate	Std. Error	Wald	P-value	95% Confidence Interval		Odds ratio (OR=exp(Est))
						Lower Bound	Upper Bound	
Comfort when walking	Excellent	2.664	1.415	3.547	.005	-5.437	0.109	14.35359
	V. good	2.296	0.999	5.284	.002	-4.254	-0.338	9.93437
	Good	2.609	0.948	7.578	.006	-4.466	-0.751	13.58546
	Fair	1.286	0.919	1.96	.002	-3.087	0.514	3.61828
	Poor	1.091	0.885	1.519	.002	-2.825	0.644	2.97725
	V. poor	0[a]	.	.		.	.	
Surface condition of sidewalk	Excellent	6.367	1.087	34.302	.000	-8.498	-4.236	582.30828
	V. good	4.181	0.69	36.711	.000	-5.533	-2.828	65.43125
	Good	3.704	0.605	37.468	.000	-4.89	-2.518	40.60942
	Fair	2.744	0.542	25.625	.000	-3.806	-1.681	15.54906
	Poor	1.799	0.475	14.321	.000	-2.73	-0.867	6.04360
	V. poor	0[a]	.	.		.	.	
Encroaching into the main carriageway	Excellent	-0.158	0.796	0.039	.004	-1.402	1.718	0.85385
	V. good	0.336	0.547	0.379	.005	-1.408	0.735	1.39934
	Good	-0.032	0.439	0.005	.002	-0.829	0.893	0.96851
	Fair	0.964	0.464	4.312	.004	-1.874	-0.054	2.62216
	Poor	-0.083	0.359	0.054	.002	-0.619	0.786	0.92035
	V. poor	0[a]	.	.		.	.	
Pedestrian perception of PLOS	Excellent	5.045	1.165	18.754	.000	-7.329	-2.762	155.24430
	V. good	3.347	0.929	12.991	.000	-5.167	-1.527	28.41735
	Good	3.633	0.936	15.062	.000	-5.468	-1.798	37.82612
	Fair	3.235	0.901	12.897	.000	-5.001	-1.47	25.40637
	Poor	2.226	0.847	6.909	.009	-3.886	-0.566	9.26274

	V. poor	0[a]	.	.		.	.	
Sidewalk Width	Continuous	0.122	0.256	0.229	.032	-0.623	0.378	1.12975
Age range of respondent	Under 18	-1.385	0.64	4.685	.003	0.131	2.639	0.25032
	18 to 24	-1.206	0.585	4.249	.004	0.059	2.353	0.29939
	25 to 34	-0.456	0.504	0.817	.004	-0.532	1.444	0.63381
	35 to 55	-0.461	0.543	0.72	.004	-0.604	1.526	0.63065
	above 55	0[a]	.	.		.	.	
Education level of respondent	No	-0.147	0.548	0.072	.008	-0.927	1.221	0.86329
	<8	0.12	0.422	0.08	.008	-0.948	0.708	1.12750
	8-10	-0.489	0.479	1.043	.003	-0.449	1.427	0.61324
	Certificate	-0.71	0.451	2.475	.001	-0.174	1.594	0.49164
	Diploma	-0.737	0.392	3.524	.005	-0.032	1.506	0.47855
	Degree and above	0[a]	.	.		.	.	
Frequency of pedestrian walking	Everyday	-0.013	0.541	0.001	.981	-1.048	1.073	0.98708
	2-3 times a week	0.694	0.483	2.068	.150	-1.641	0.252	2.00171
	Once a week	0.791	0.826	0.916	.339	-2.41	0.829	2.20560
	Sometimes	0[a]	.	.		.	.	
Purpose of walking	Go to/from work	-0.579	0.727	0.634	.003	-0.846	2.003	0.56046
	Go to/from school	0.694	0.82	0.716	.397	-2.302	0.914	2.00171
	Shopping	0.401	0.81	0.245	.620	-1.988	1.186	1.49332
	Recreational	-1.254	0.762	2.707	.004	-0.24	2.748	0.28536
	Visiting friends/family	0.676	0.782	0.747	.004	-2.209	0.857	1.96600
	Others	0[a]	.	.		.	.	
Distance of walking	Less than 500m	-0.033	0.528	0.004	.010	-1.002	1.068	0.96754
	500-1000m	0.471	0.407	1.335	.002	-1.269	0.328	1.60159
	1000-2000m	0.278	0.381	0.534	.005	-1.025	0.468	1.32049
	greater than 2000	0[a]	.	.		.	.	

Parts of the day time	Morning	-0.076	0.448	0.029	.009	-0.802	0.953	0.92682
	Afternoon	-0.567	0.419	1.833	.002	-0.254	1.387	0.56722
	Evening	0[a]	.	.		.	.	
Walking with the presence Vendor	Very uncomfortable	-0.204	0.676	0.091	.002	-1.12	1.529	0.81546
	Uncomfortable	-0.455	0.617	0.543	.005	-0.755	1.665	0.63445
	Slightly uncomfortable	-0.589	0.601	0.962	.003	-0.588	1.767	0.55488
	Neutral	-0.517	0.572	0.816	.004	-0.605	1.639	0.59631
	Comfortable	-0.55	0.636	0.747	.004	-0.697	1.796	0.57695
	Very comfortable	0[a]	.	.		.	.	
Adequacy pedestrian's walkway	Strongly Agree	0.251	1.94	0.017	.009	-4.053	3.551	1.28531
	Agree	1.283	0.604	4.509	.003	-2.467	-0.099	3.60745
	Slightly Agree	0.6	0.363	2.73	.005	-1.311	0.112	1.82212
	Strongly Disagree	1.201	0.389	9.554	.002	-1.963	-0.44	3.32344
	Disagree	0.388	0.353	1.21	.003	-1.081	0.304	1.47403
	Slightly Disagree	0[a]	.	.		.	.	
Perceived pedestrian Safety Threshold (Intercept)	Excellent	14.776	1.93	58.588	.000	-18.56	-10.992	-
	V. good	11.38	1.602	50.471	.000	-14.519	-8.24	-
	Good	8.689	1.57	30.617	.000	-11.767	-5.611	-
	Fair	6.988	1.554	20.217	.000	-10.035	-3.942	-
	Poor	5.093	1.528	11.108	.001	-8.089	-2.098	-

4.4 Conjoint analysis results

We received 430 valid responses for this section of the questionnaire. Two indices were generated by the conjoint analysis: (1) the part-worth utility value (PUV) of each attribute level and (2) the relative importance (RI) of each attribute. The RI of each attribute is measured by the relative range of utility scores for each attribute, whereas part-worth utility is a value that reflects the importance of a specific level of an attribute. The study used statistical software to calculate the Total Utility Value (TUV) of each hypothetical profile using equation 1 below using the results of the PUVs and RI values, assuming that attribute levels with higher utility values are more preferred and that higher RI values significantly impact pedestrian sidewalk avoidance. The product or attribute with a higher TUV is considered more valuable, as it is considered more valuable (Green & Srinivasan, 1978). The outcomes are presented below.

$$\text{Total Utility Value } U(Xij) = \text{Constant} + \sum_{i=1}^{m} \sum_{j=1}^{k_i} u_{ij} X_{ij} \cdots\cdots\cdots\cdots (1)$$

$U(Xij)$ = Total utility of an alternative

m = Number of attributes

k_i = Number of levels in i^{th} attribute

u_{ij} = Utility associated with j^{th} level of the i^{th} ith attribute

x_{ij} = Dummy variable that takes on 1 if the j^{th} level of the i^{th} attribute is present or 0 otherwise

Model Description

When conducting CA, it's important to have a model that outlines the expected connection between qualities and ranking scores. This analysis assumes that there is a clear link between factors and ranking scores. If using a discrete model, the attribute levels are categorized and there is no predetermined relationship between attributes and ranks (refer to Table 4.9).

Table 4. 9 Conjoint Analysis Model Description

Model Description		
Attributes	**No of Levels**	**Relation to Ranks or Scores**
Width of Sidewalk	3	Discrete
Number of Obstacles	3	Discrete
Pedestrian Flow Rate	3	Discrete
Sidewalk Condition	3	Discrete
All factors are orthogonal.		

Importance Values

Conjoint analysis is a technique used to assess the worth of attributes by determining their RI. It considers the impact of each attribute on a product's overall value and the difference in value generated by each characteristic. The percentage of significance is calculated based on the range of values, with a wider range considered more significant. Figure 4.13 shows how the percentage of significance is calculated based on the range of values. Three types of significance measurements are used: ratio-scaled, relative, and study-specific. Thus, an attribute with 80% importance is twice as valuable as one with 40%.

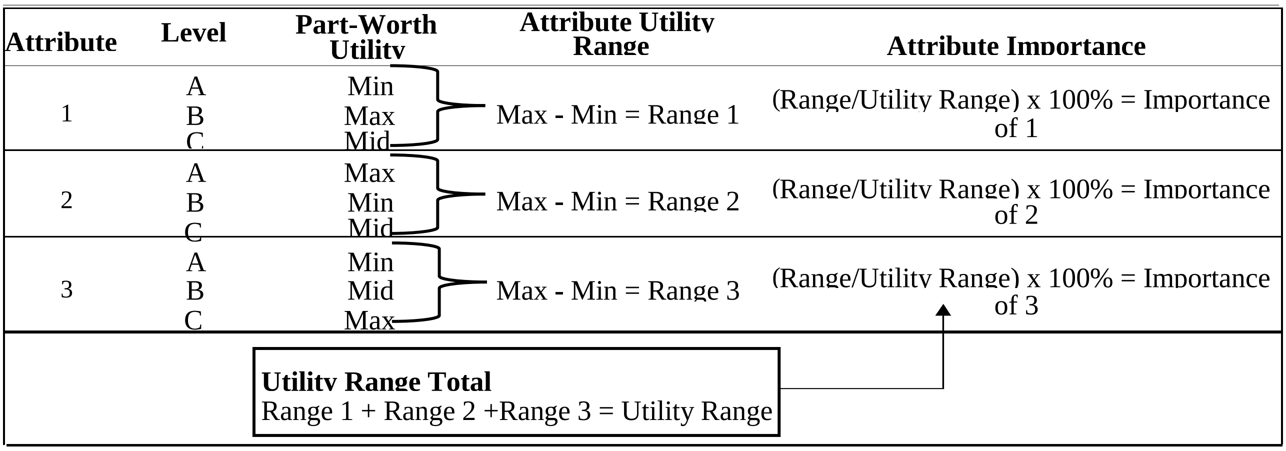


Figure 4. 13 Determination of Attribute Importance

In Table 4.10, the results of the attributes evaluations are presented. As anticipated, the flow rate (35.591%), condition (32.45%), and width (20.795%) of a sidewalk were determined to be highly important. It's noteworthy that obstacles were only found to be of minor significance (11.164%).

Table 4. 10 Conjoint Analysis Results: Importance Values

Attribute	**Level**	**PWU**	**Attribute Utility Range**	**Attribute Importance** (in %)
Width of Sidewalk	1	0.055	1.695	20.795
	2	0.82		
	3	-0.875		
Number of Obstacles	1	0.095	0.91	11.164
	2	-0.502		
	3	0.408		
Flow Rate	1	0.879	2.901	35.591
	2	-1.89		
	3	1.011		
Sidewalk Condition	1	-1.612	2.645	32.450
	2	0.579		
	3	1.033		
Utility Range Total			8.151	

In Figure 4.14, the importance of different attributes for sidewalk usage is summarized. The attribute that was found to be the most important is opposing pedestrian flow rate. The second and third most crucial attributes are sidewalk condition and sidewalk width, respectively. It was observed that good sidewalk condition often leads to improved flow rate. Surprisingly, the study found that flow rate is three times more importance than the number of obstacles. Furthermore, the sidewalk's width was found to be twice as importance as the number of obstacles.

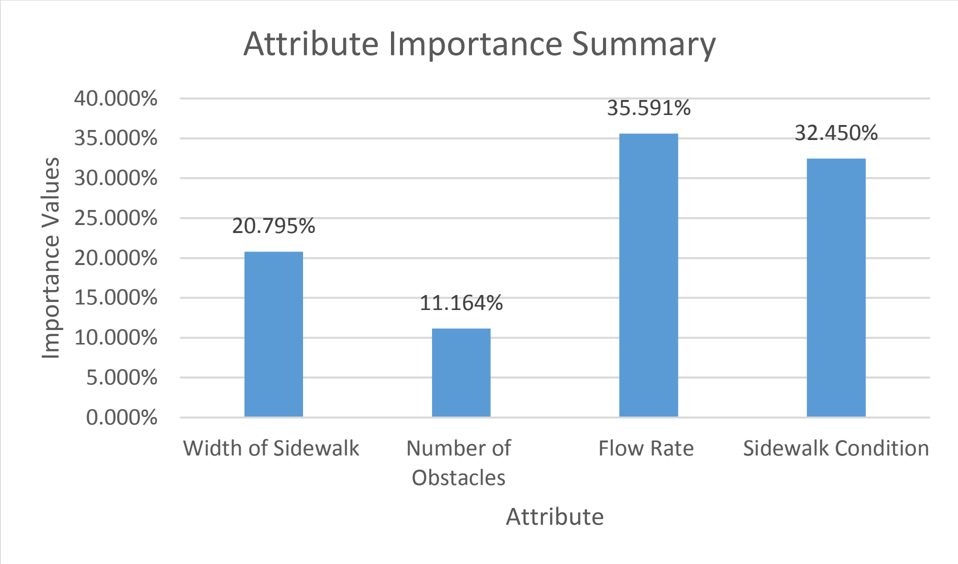


Figure 4. 14 Conjoint Analysis Results: Attribute Importance Summary.

Part-Worth Utilities

Part-worth utilities help in understanding the specific attributes that affect respondents' decision-making process. These utilities assign numerical values to each level of an attribute, indicating the level and attribute's influence on the respondents' decisions. Customers assign higher scores to attribute levels that they prefer and lower scores to those they do not like as much. It is important to keep in mind that the value of a certain attribute may vary. A low utility value (negative value) does not necessarily mean that the attribute level is undesirable. It is possible for all respondents to agree that an attribute level has a negative value. However, if everything else is equal, a higher (positive) value is generally preferred. The CA method utilizes part-worth, which is interval data that has been scaled to a random additive constant for each attribute. As a result, utilities within each attribute are scaled to a total of zero.

In Table 4.11, the walkable width is the most significant attribute, with 1.5m- 2.5m being the most desirable range; width >2.5 m positive value is also generally preferred and less than

1.5m being the least preferred. This range stands out in comparison to the other features. Additionally, it was discovered that the levels of the walkable width attribute have a logical and relative linear relationship.

According to attribute levels, the most significant obstacles are more than five, followed by no obstacles, and then one to five obstacles are the least important, with a logical increase in importance.

Table 4. 11 Conjoint Analysis Results: Part-Worth Utilities

Part-Worth Utilities (PWU)		
Attributes	**Attribute Levels**	**Utility Estimate**
Width of Sidewalk	>2.5 m	0.055
	2.5 m – 1.5 m	0.82
	< 1.5m	-0.875
Number of Obstacles	No Obstacles	0.095
	1 - 5 Obstacles	-0.502
	> 5 Obstacles	0.408
Flow Rate	< 12	0.879
	12 to 20	-1.89
	>20	1.011
Sidewalk Condition	Good	-1.612
	Fair	0.579
	Poor	1.033
(Constant)		5

At first glance, the results of the flow rate may seem strange because flow rates greater than 20 have a slightly higher preference score than flow rates between 12 and 20. This is due to the attributes of the conjoint profiles, which are designed to reflect each attribute level equally and independently. As a result, the combination of attribute levels causes respondents to prioritize their most desired traits over less important ones. For instance, let's take a look at two profile cards: number three and number six. Number three has fair sidewalk quality, a flow rate that is greater than 20, no obstacles and a sidewalk width that falls between 1.5m and 2.5m. On the other hand, number six has a poor sidewalk condition, a flow rate that is greater than 20, > 5 obstacles and a sidewalk width that is more than 2.5m. Out of these two, profile card three is the better choice. Although sidewalk width and flow rate are important factors, they were deemed to be of low importance and therefore not given as much attention as sidewalk condition and the number of obstacles.

Sidewalk condition was even more consistently mentioned as the least significant attribute, much like the flow rate. If you pay close attention, you'll see that poor sidewalk condition obtained a higher significance rating than good sidewalk condition. This is also caused by the mix of attributes in the conjoint profiles that were created, as described under the flow rate. However, since the part-worth utilities for the sidewalk condition are not particularly low, they would not affect the calculation of TUVs.

4.4.1 Calculate Total Utility Value at Selected Locations

In section 3.11.2, Equation (1) was utilized to calculate the TUV of the selected sidewalk locations, using the part-worth utility index obtained from the previous section. As per the CA theory (Green & Srinivasan, 1978), the product (in this case, sidewalk) that receives a higher TUV is considered more valuable than the other products.

Table 4. 12 Attribute levels and TUV of each selected location

Location	**Width of Sidewalk (m)**	**PWU**	**No of Obstacles**	**PWU**	**Flow Rate**	**PWU**	**Sidewalk Condition**	**PWU**	**PWU Sum**	**Constant**	**TUV**
1	>2.5	0.055	>5	0.408	>20	1.011	Good	-1.612	-0.138	5	4.862
2	>2.5	0.055	1 – 5	-0.502	12-20	-1.89	Fair	0.579	-1.758	5	3.242
3	1.5-2.5	0.82	1 – 5	-0.502	12-20	-1.89	Good	-1.612	-3.184	5	1.816
4	1.5-2.5	0.82	>5	0.408	>20	1.011	Fair	0.579	2.818	5	7.818
5	<1.5	-0.875	1 – 5	-0.502	< 12	0.879	Poor	1.033	0.535	5	5.535

Table 4. 13 Example of calculating TUV at a location 2.

Attribute	**Applicable Attribute Level**	**Part-Worth Utility**	**Sum**	**Conjoint Constant**	**TUV**
Width of Sidewalk (m)	>2.5m	0.055	-1.758	+5.00	=3.242
Nr. of Obstacles	1-5	-0.502			
Flow Rate	12-20	-1.89			
Sidewalk Condition	Fair	0.579			

Table 4.14 shows the TUVs for each location and ranks the sidewalks by ascending TUV Rank. In Section 5.7, the PPS is compared and evaluated against the TUV computed for each location.

Table 4. 14 Summary of TUV at each selected location

Location	Street Name	TUV	TUV Rank
1	Israel Embassy- Megenagna - British Embassy shola	4.862	3
2	Yeka woreda 9 office Zero hult-Kotebe University of Education - Kotebe Mesalemia St. Maryam & St. George Church	3.242	4
3	Ministry of Mines & Energy- Lamberet-Addis Ababa Haile Grand	1.816	5
4	Yared Music School- Menelik 2 Referal Hospital -Kagnew Peace Keeping Roundabout	7.818	1
5	Haya Hulet Roundabout (Golagul Building)-Adwa Bridge	5.535	2

4.5 Pedestrians' Preference Score

The last component of the survey was utilized to determine how much a pedestrian avoided utilizing sidewalks along a particular roadway stretch by using their preference score. Five locations within the case study area will have PPS values collected as part of this study, coupled with a 5-point Likert scale. After the information was gathered, equation 2 was used to determine the PPS to utilize the sidewalk at a particular location.

$$\text{Pedestrian Preference Score } (PPS)_j = \frac{1}{n}\sum_{i=1}^{n}(WTC)_{ij} \quad \cdots\cdots\cdots\cdots\cdots\cdots (2)$$

$(WTC)_{ij}$ = Willingness to use at the j^{th} sidewalk by i^{th} respondent

n = Number of respondents

4.5.1 Calculate Pedestrians' Preference Score at Selected Locations

The last section of the survey collected data on pedestrian preference. The responses from 430 participants were analyzed using Equation (2) to obtain the PPS for each sidewalk location. Table 4.15 displays the determined PPS for all sidewalk sites. The PPS Rank column arranges the sidewalks in increasing order of preference, with the most desired at the top (1) and the least desired at the bottom (5). In the following section, the TUVs of each location will be compared and assessed against the PPS.

Table 4. 15 Pedestrians' Preference Score for each location

Location	Street Name	PPS	PPS Rank
1	Israel Embassy- Megenagna - British Embassy shola	3.8535	2
2	Yeka woreda 9 office Zero hult-Kotebe University of Education - Kotebe Mesalemia St. Maryam & St. George Church	2.6349	4
3	Ministry of Mines & Energy- Lamberet-Addis Ababa Haile Grand, Addis Ababa	2.4163	5
4	Yared Music School- Menelik 2 Referal Hospital -Kagnew Peace Keeping Roundabout	4.0070	1
5	Haya Hulet Roundabout (Golagul Building)-Adwa Bridge	3.1047	3

4.6 Evaluate and Validate

The Conjoint Analysis-developed index is validated by comparing the TUV and PPS for each location. The results for all locations are reported in Table 4.16.

Table 4. 16 Summary of TUVs and PPSs for each location

Location	Street Name	TUV	PPS
1	Israel Embassy- Megenagna - British Embassy shola	4.8620	3.8535
2	Yeka woreda 9 office Zero hult-Kotebe University of Education -Kotebe Mesalemia St. Maryam & St. George Church	3.2420	2.6349
3	Ministry of Mines & Energy- Lamberet-Addis Ababa Haile Grand, Addis Ababa	1.8160	2.4163
4	Yared Music School- Menelik 2 Referal Hospital -Kagnew Peace Keeping Roundabout	7.8180	4.0070
5	Haya Hulet Roundabout (Golagul Building)-Adwa Bridge	5.5350	3.1047

As seen in Figure 4.15, a line graph was utilized to compare two sets of data. The graph below shows that both sets exhibit a similar pattern. Location 4 has the highest TUV, while location 3 has the lowest, in descending order. The PPS also reaches its peak at site 4 and its lowest point at location 3, respectively. An interesting observation is that both the peaks and troughs of the PPS have a width of 1.5 to 2.5 meters, or a portion of that width, indicating they are equally ranked.

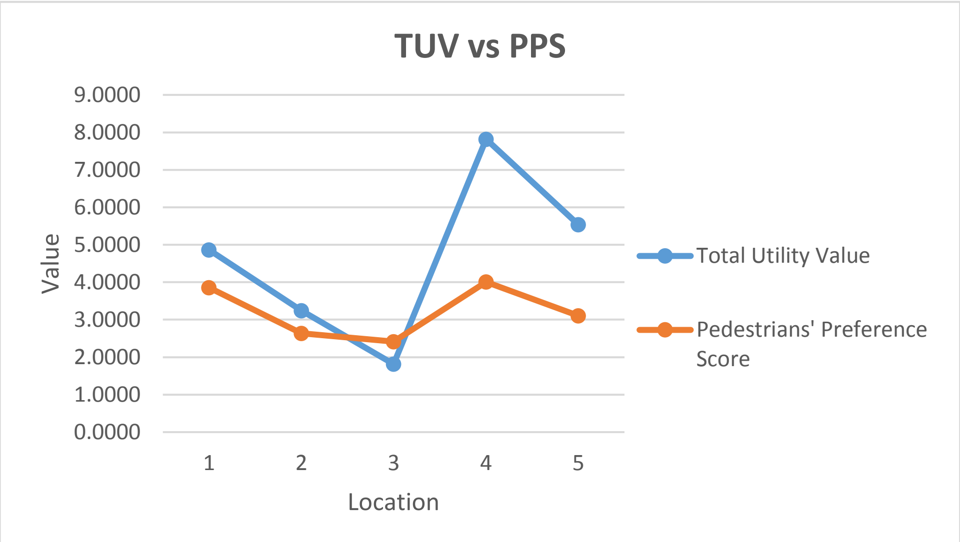


Figure 4. 15 Line Graph of TUV and PPS

The study analyzed the connection between the TUV and PPS for each sidewalk position by conducting a correlation and regression analysis. Figure 4.16 displays a scatterplot graph that shows the TUV and PPS for each site.

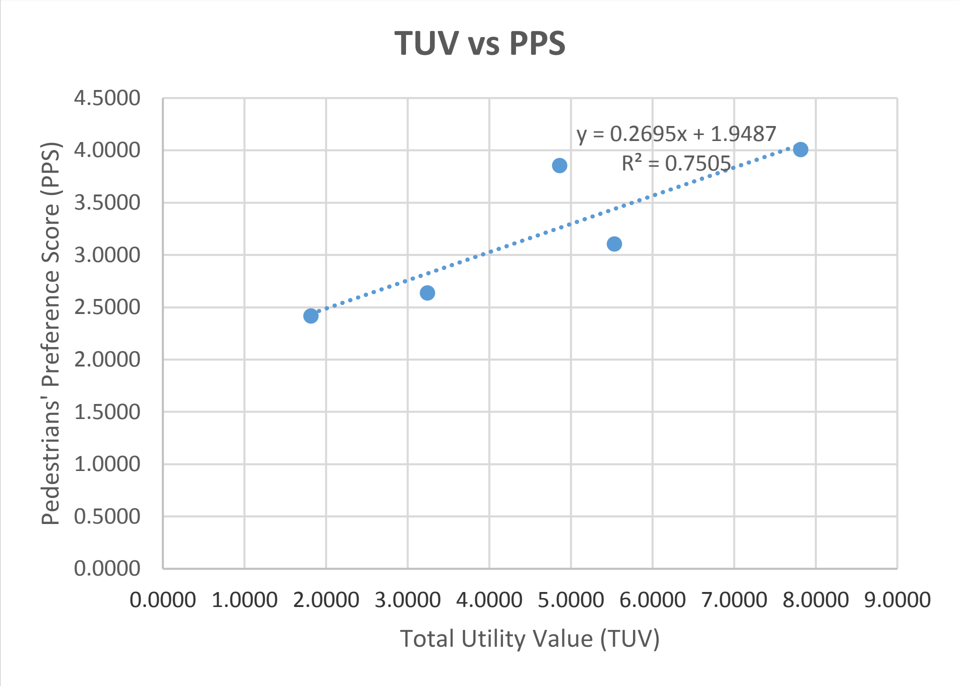


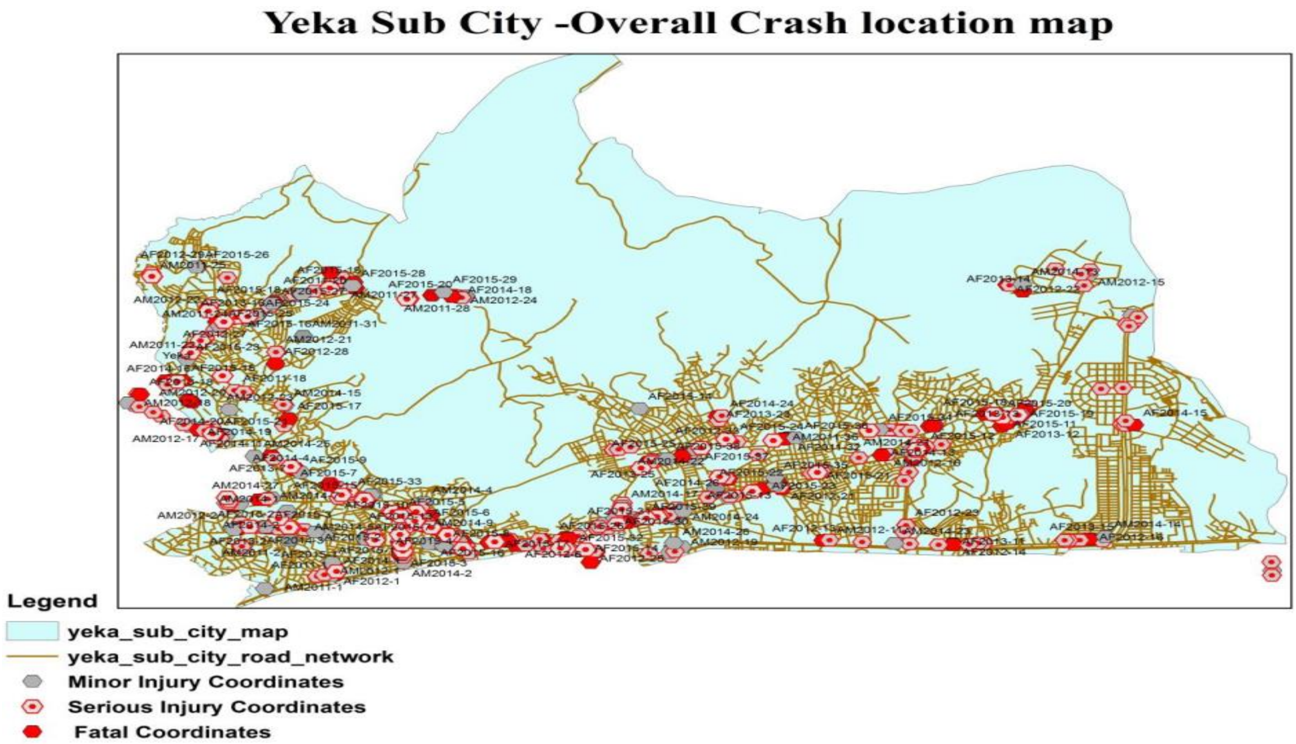
Figure 4. 16 Correlation between TUV and PPS for each of the 5 locations.

The TUV and the PPS have a strong correlation, as demonstrated by their Pearson Correlations (r) data sets. The positive linear pattern of the correlation is significant, with a strength of 0.87, indicating that changes in the TUV will likely result in corresponding changes in the PPS.

After conducting a regression analysis, it was found that the data fit the linear model effectively. The TUV was responsible for 75% (R-squared) of the variation in the PPS. Therefore, the TUV can be utilized to predict the probability of a pedestrian selecting a particular sidewalk based on the linear model.

4.6 Impact of Sidewalk Vendors Activities on Perceived Pedestrian Safety

The study uses a GIS-tool-based methodology for identifying hazardous locations, as most statistical methods cannot display the spatial distribution of crash locations on a map (Chen 2012). GIS allows for spatial referencing, data management, and visualization, enabling the mapping of problem areas and their distribution on the road network (Mendoza et al., 2001; Saccomanno et al., 2001). GIS also enables the creation of spatial statistics based on geographically referenced data (Satria and Castro, 2016), making it a valuable tool for hazardous location identification. The study analyzed pedestrian crashes in Yeka Sub-city, Addis Ababa, and using data from 2011 to 2015 E.C. The data was organized by year and severity category, and sorted based on location. Google Earth Pro was used to discover coordinates, and ArcGIS was used to create a crash map of the research region. The study focused on facilities located in areas with high, medium, and low concentrations of street vendors, comparing pedestrian crash occurrence. Business centers and market areas near the segments were included for better analysis and logical results. The data was organized by year, severity category, and location.



Results showing of OLR analysis parameter estimates and odds ratios of Vendor

Variable	Categories	Estimate	Std. Error	Sig.	Odds ratio
Walking with the presence Vendor	Very uncomfortable	-0.204	0.676	.002	0.8155
	Uncomfortable	-0.455	0.617	.005	0.6345
	Slightly uncomfortable	-0.589	0.601	.003	0.5549
	Neutral	-0.517	0.572	.004	0.5963
	Comfortable	-0.55	0.636	.004	0.5770
	Very comfortable	0^a	.		

Figure 4. 17 Results showing Yeka Sub City - Overall Crash location map and OLR analysis parameter estimates and odds ratios of Vendor

The presence of vendors on sidewalks significantly impacts pedestrian perceived safety. All categories have a statistically significant negative effect on pedestrian safety. As the number of vendors increases, the perceived safety of pedestrians decreases. The likelihood of perceived pedestrian safety for the entire category declines as vendor activities grow. Table 4.8 displays the overall OLR analysis results and OLR analysis parameter estimates and odds ratios of Vendor are shown in figure above. The odds of safety perception on sidewalks for vendor activities in category 1 [Vendor=1, Very uncomfortable] are 0.81546 times lower with probability of 44.92%; category 2 [Vendor=2, Uncomfortable] are 0.63445 times lower with probability of 38.81% and the same for others categories. According to study, the location and width of vending stalls, pedestrian flow, pathway width, and customer interactions all have an impact on pedestrian density (Hagos, 2020). A study in Addis Ababa found that street vendors negatively impact the city's economy, affecting pedestrian service, delay relationship, and queue development (Bahiru, 2019). The study developed a model to assess pedestrian service quality, considering comfort perceptions and vendor activities. This underscores the need for sidewalk design considering pedestrian perceptions. Vendors often occupy sidewalk width, creating obstructions and congested areas. The number of sellers and buyers also exceeds available space (Hidayat, 2011). Therefore, vendor estimations indicate a decreasing perception of safety with increasing vendor activity. This implies decrease in pedestrian perception safety may leads to increase in crash occurrence rate cause in the area.

Based on the study analysis of the sidewalk characteristics affecting walkability, the study reveals that walkable width is the most important attribute, with 1.5m-2.5m being the most desirable range; width >2.5 m positive value is also generally preferred and less than 1.5m being the least preferred. Both for TUV and PPS, Location 4 having the highest value sidewalk and Location 3 having the lowest point sidewalk with sidewalk width of 1.5 to 2.5 meters, indicating equal ranking. The linear association between PPS and TUV implies that CA is a good technique for grouping sidewalk based on pedestrian preferences and characteristics. This demonstrates the utility of TUV as an indicator for clustering sidewalks.

Table 4. 17 Summary of TUVs and PPSs value and their ranks for each location

Location	**Street Name**	**TUV**	**TUV Rank**	**PPS**	**PPS Rank**
1	Israel Embassy- Megenagna - British Embassy shola	4.862	3	3.8535	2
2	Yeka woreda 9 office Zero hult-Kotebe University of Education -Kotebe Mesalemia St. Maryam & St. George Church	3.242	4	2.6349	4
3	Ministry of Mines & Energy- Lamberet-Addis Ababa Haile Grand, Addis Ababa	1.816	5	2.4163	5
4	Yared Music School- Menelik 2 Referal Hospital - Kagnew Peace Keeping Roundabout	7.818	1	4.0070	1
5	Haya Hulet Roundabout (Golagul Building)-Adwa Bridge	5.535	2	3.1047	3

So, TUV can be used to cluster pedestrian sidewalks. A low PPS value and a low TUV were observed at location 3 with TUV of 1.816 and PPS value of 2.4163 and at location 2 with TUV of 3.242 and PPS value of 2.6349 which is for the least used pedestrian sidewalks (small attraction of vendor) which in turn shows low concentrations of street vendors by comparing pedestrian crash occurrence of the areas. A higher values of PPS and TUV were observed at location 4 with TUV of 7.818 and PPS value of 4.0070 and at location 1 with TUV of 4.862 and PPS value of 3.8535 which is for the study for the sidewalks with a high pedestrian flow (high attraction of vendor) shows high concentrations of street vendors by comparing pedestrian crash occurrence of the areas. Based on TUV clustering of sidewalks, therefore, the study conclude that surveyed road segments can be specified for specific sidewalk either for a high pedestrian flow and least used pedestrian sidewalks which can be related to high and low concentrations of street vendors pedestrian sidewalks by comparing pedestrian crash occurrence of the areas. So this can leads to reduction of sidewalk width due to high pedestrian flow and high concentrations of street vendors on the segments which could contribute to high exposure rate of pedestrian crash occurrence.

Therefore, the study concluded that with crash clustered area as depicted on GIS shows high concentration of vendors and based on our estimate output as vendor activities increase in specified location leads to decrease in pedestrian perception safety. This indirectly shows decrease in pedestrian perception safety has leads to increase in crash occurrence rate in the area. And based on TUV clustering of sidewalks, the study conclude that surveyed road segments can be specified for specified sidewalk either for a high pedestrian flow and least used pedestrian sidewalks which can be related to high and low concentrations of street vendors on pedestrian sidewalks by comparing pedestrian crash occurrence of the areas. So this can leads to reduction of sidewalk width due to high pedestrian flow and high concentrations of street vendors on the segments which could contribute to high exposure rate of pedestrian crash occurrence also. Sidewalk vendors impede walkways, presenting hazards for pedestrians, particularly those with impairments or mobility challenges. This impediment has an impact on the perceived safety of using sidewalks in which pedestrians feel less safe in their presence. So the allocated pedestrian sidewalk illegally filled by vendors and street hawkers should be avoided and relocated away, since the presence of sidewalk vendors affect how safe pedestrians feel in a given area and leads to highway blockage and vendor encroachment.

4.7 Discussions

The study examines the factors influencing sidewalk users' safety assessment using ordered logistic regression analysis. Results show that increasing independent variables is associated with increased perceived safety. Based on the estimations, Figure 4.18 depicts the connections of the dependent variables with perceived safety.

The study reveals that comfort and surface condition significantly impact pedestrian safety perception. High comfort levels and high-quality surfaces increase perceived safety, while low comfort and poor surface quality decrease it. Higher comfort levels and surfaces are associated with higher perceived safety on sidewalks, with odds 14.35359 times greater for higher comfort levels of [Comfort=1, Excellent] and 40.60942 times higher for higher-quality surfaces of [Surface=3, Good] than reference category. These findings are consistent across categories and are presented in table 4.8. Poor sidewalk conditions can cause obstructions and negatively impact perception (Pejalan, 2017). Sidewalk comfort is crucial for perceived safety. Surface condition, barriers, and presence of sidewalks, landscape buffers, and street trees can affect safety feelings (Arifah, 2021; Kweon, 2021). To ensure a comfortable circulation system, both macro and micro-level pavement comfort ratings are needed in key activity centers (Sarkar, 2003). Therefore, walking surfaces significantly impact pedestrian safety perception, with improved surfaces leading to a higher perceived level of safety on the sidewalk and people who walk comfortably feel safer.

The study reveals that the impact of encroaching on roadway activities increases from the first to the second category but decreases from the third to the fourth category. The negative coefficients suggest that pedestrians with limited chances of walking on the sidewalk feel less safe compared to those who frequently use the sidewalk. This "encroaching into the roadway" is categorized in Table 4.8 with different estimates and odds ratios for each level. As the estimates increase from the first to the second category, the odds of perceived pedestrian safety also increase. The chances of a pedestrian feeling safe while stepping into a road are 0.85385 times lower in Category 1 [Encroaching=1, Excellent], 0.96851 times lower in Category 3 [Encroaching=3, Good], and 0.92035 times lower in Category 5 [Encroaching=5, Poor], with the opposite being true for Categories 2 [Encroaching=2, V.

good] and 4 [Encroaching=4, Fair]. Walking on roadways has a variety of effects. Hutchinson (2011) and Biswas (2022) discuss the barrier effect of arterial highways on pedestrian mobility, while Kang (2018) emphasizes the need for infrastructural and legislative initiatives to improve safety, comfort, and overall walking experience.

The study found that all PLOS variables significantly impact pedestrian safety perceptions at a 95% confidence level. The chances of perceived safety increase as PLOS increases, suggesting that low PLOS may decrease the chances of enhancing safety. For example, higher PLOS levels in category 5 [PLOS=5, Poor] resulted in 9.26274 times higher probabilities of higher perceived pedestrian safety on sidewalks compared to reference categories. This holds true for the general category, as shown in table 4.8. There are various factors that affect the perceived safety of pedestrians on sidewalks, such as the built environment measurements (Bivina, 2019) and pedestrian facilities (Zannat, 2019). The most significant factors that determine the level of service of sidewalks are the concepts of the walking environment. These concepts have the most considerable impact on the PLOS of sidewalks (Bivina, 2019). As a result based on analysis, the odds of perceived pedestrian safety increase with increasing PLOS. This reveals that if the PLOS level is low, the chances of boosting perceived pedestrian safety drop.

According to the study, the estimated sidewalk width variable showed positive estimate on perceived safety, indicating that people 1.12975 times feel safer by sidewalks widths with 53.05% probability. Study shows narrow sidewalks with sufficient greenery can enhance satisfaction and safety (Park, 2023), while research shows that various factors, such as footpath width, affect the perceived safety (Wu, 2020). However, some findings suggest that sidewalk width has no significant impact on pedestrian vigilance (Harrell, 1991), whereas some stresses the importance of safety in sidewalk amenities of any width (Bahari, 2013).

The AGE variable has a significant impact on perceived safety, with all categories having a negative impact. The negative coefficients indicate that safety perceptions decrease as age decreases. Specifically, young and middle-aged adults have much poorer safety perceptions than elderly people. There have been differing opinions on how age affects the perceived safety of pedestrians while walking on sidewalks. Study found that factors like footpath width and vehicle traffic can significantly influence the perceived safety of older pedestrians

(Wu, 2020). In contrast, some study discovered that older pedestrians, especially women, are the safest age group because they can identify potential threats and take precautions (Harrell, 1990). Study also suggested that the built environment, such as parking spaces and green verges, can improve the perception of traffic safety and pedestrian-friendliness for elderly people (Kahlert, 2015) and emphasized the importance of training programs for elderly pedestrians. However, age-related perceptual and cognitive impairments, particularly in judging impending car speed, may continue to be a risk. Based on the analysis, pedestrians who are of higher age have a higher chance of perceiving safety than those who are younger.

After taking the education variable into account, it was found that only three categories have a statistically significant negative impact on perceived safety. The coefficients in these categories are negative, indicating that individuals with lower educational qualifications tend to feel safer on sidewalks when compared to the base category of PG and above. This trend could be attributed to the fact that educated people tend to have a higher awareness of safety issues. Therefore, enhancing safety awareness for pedestrians, including drivers, can create a secure roadside environment. After analyzing distance and time, only two distance categories and one time category have significant impact on perceived safety. Higher perceived pedestrian safety was related to walking distance, with odds of feeling safe 1.60159 for category 2 [Distance=2, 500-1000m]and 1.32049 times greater than the reference group for category 3 [Distance=3, 1000-2000m]. And perceived pedestrian safety is lower in the afternoon, with odds of feeling safe 0.56722 times lower than the reference category and a 36.19% probability.

Based on the OLR analysis, it can be inferred that the perception of pedestrian safety wasn't significantly affected by Frequency categories and certain Purpose categories, at the 95% confidence interval level of significance. Therefore, the results for Frequency and factors that didn't have a significant impact on pedestrian safety perception remain inconclusive at the 95% confidence interval. But the safety of sidewalks is of utmost importance to pedestrians, and it can be influenced by the purpose and frequency of pedestrian travel (Bahari, 2013; Zhuang, 2012). The analysis found that only three categories of Purpose significantly impact perceived safety: walking to work, recreational, or visiting friends or family. These categories have positive and negative coefficients, indicating a significant influence on safety perception. Walking to work is associated with higher perceived pedestrian safety compared to other category, with odds of feeling safe 0.56046 times higher than the reference category. The probability of feeling safe while walking to work is 35.92%. Similarly, people who walk for visiting friends or family also feel safer with a higher likelihood of 1.96600 times greater of having a higher perceived pedestrian safety than the reference category and with chances of 66.28%. It has been observed that individuals who walk for recreational purposes tend to feel less safe with a lower perceived pedestrian safety of 0.28536 times lower than the reference category and probability of approximately 22.2%.

The study examined the impact of sidewalk adequacy on perceived safety. Results showed that sidewalks with high adequacy levels were more secure. As adequacy levels increased, so did the chances of perceived pedestrian safety. For example, sidewalks with assigned adequacy levels of 5 [Adequate=5, Disagree] had 1.47403 times higher probabilities of higher perceived pedestrian safety compared to those with low adequacy levels. The study suggests that improving the condition of all sidewalks could indirectly contribute to a safer and more secure pedestrian environment.

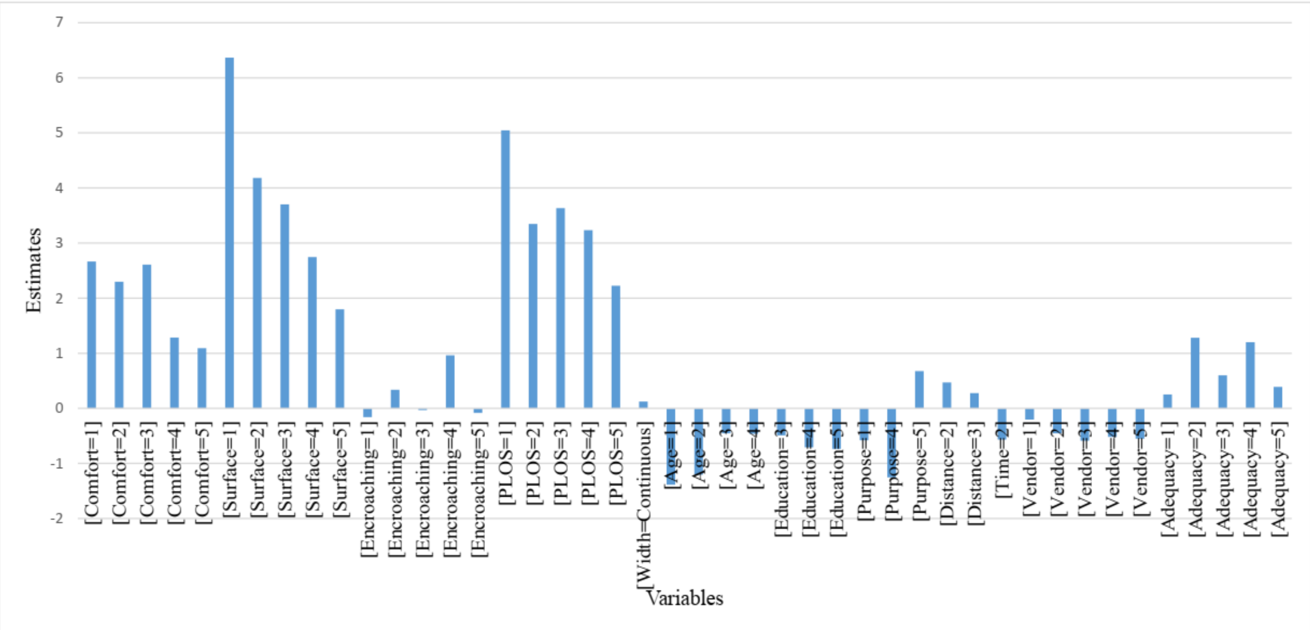


Figure 4. 18 Relative effect of statistically significant variables on perceived safety

The presence of vendors on sidewalks significantly impacts pedestrian perceived safety. All categories have a statistically significant negative effect on pedestrian safety. As the number of vendors increases, the perceived safety of pedestrians decreases. This is because people who have had negative experiences tend to be more vigilant and take extra precautions. The likelihood of perceived pedestrian safety for the entire category declines as vendor activities grow. Table 4.8 displays the results, along with their corresponding estimates and odd ratios For example, the odds of safety perception on sidewalks are 0.81546 times lower for vendor activities in category 1 [Vendor=1, Very uncomfortable]. Therefore, vendor estimations indicate a decreasing perception of safety with increasing Vendor activity.

The study analyzed sidewalk characteristics affecting walkability and developed strategies for pedestrian infrastructure. It identified four key attributes: width, flow rates, obstructions, and sidewalk condition. CA determined their importance values, allowing comparison and evaluation of individual or combined characteristics. The study reveals that flow rate is the most crucial attribute, followed by sidewalk condition and sidewalk width. Good sidewalk condition often leads to improved flow rate, which is three times more important than the number of obstacles and sidewalk width is twice as important as the number of obstacles.

Table 4.11 reveals that walkable width is the most important attribute, with 1.5m-2.5m being the most desirable range; width >2.5 m positive value is also generally preferred and less than 1.5m being the least preferred. The levels of walkable width attribute have a logical and linear relationship, with more than five obstacles being the most significant, followed by no obstacles, and one to five obstacles being the least important, with a logical increase in importance. Obstructions on sidewalks are a significant deterrent for pedestrians, as they are physically impossible to navigate. Once they navigate, they often remain in the roadway, preferring no obstacles. To address this issue, city planners and homeowners must collaborate to create obstacle-free sidewalks areas, ensuring that pedestrians can return to the sidewalk after circumnavigating obstacles.

The flow rate results may seem strange, but they are due to the conjoint profiles that reflect each attribute level equally and independently. This results in respondents prioritizing their most desired traits over less important ones. For example, a profile card 3 with fair sidewalk quality, a flow rate greater than 20, and a sidewalk width between 1.5m and 2.5m with no obstacles was preferred over card 6 a poor one with a flow rate greater than 20, obstacles greater than 5 and a sidewalk width over 2.5m. Sidewalk condition is considered the least significant attribute, with poor sidewalk condition receiving a higher significance rating than good sidewalk condition. This is due to the mix of attributes in the conjoint profiles, but the part-worth utilities for sidewalk condition are not particularly low, so they don't affect the calculation of TUVs. Out of these two, profile card three is the better choice. Although sidewalk width and flow rate are important factors, they were deemed to be of low importance and therefore not given as much attention as sidewalk condition and the number of obstacles. Sidewalk condition is consistently ranked as the least significant attribute, similar to flow rate. Poor sidewalk condition has a higher significance rating than good sidewalk condition due to a mix of attributes in conjoint profiles. However, since PUV for sidewalk condition are not particularly low, they don't affect the calculation of TUVs.

The CA revealed that people prefer walking spaces with an obstacle-free design and a flow rate of 12 or lower. The ideal width for walkable sidewalks is 1.5m-2.5m or greater. However, sidewalk condition and flow rate were not significant factors for flow rates over 20, and the number of obstacles did not significantly impact these factors. The study's findings may have been limited by demographics and the absence of physical disabilities among participants. The study area's actual sidewalks are assessed and validated using calculated part-worth values for each attribute. The line graph comparing two sets of data shows a similar pattern, with Location 4 having the highest TUV and Location 3 having the lowest. The PPS peak at Site 4 and lowest point at Location 3, respectively. Both peaks and troughs have a width of 1.5 to 2.5 meters, indicating equal ranking.

This study successfully applied CA to evaluate individual sidewalk attributes and predict their usability. The results support the hypothesis that this technique can be used to assess walkability attributes. The findings support Addis Ababa's unique challenges and aim to raise awareness about the importance of local walkability research.

The study concluded that the crash clustered region, as displayed on GIS, has a large concentration of vendors, and based on our estimate result, increasing vendor activities in the given location reduces pedestrian perception safety. The study also uses TUV clustering to identify sidewalks with high pedestrian flow and least used sidewalks, which can be related to street vendor concentrations. This can lead to sidewalk width reduction due to high pedestrian flow and high vendor concentrations, potentially increasing pedestrian crash exposure rates. This implicitly demonstrates that a decline in pedestrian perception of safety has resulted in an increase in the area's crash rate exposure.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The study explores the impact of sidewalk vendors on pedestrian safety in Addis Ababa, and identifies factors limiting walkability and suggests that addressing these issues can enhance the region's walking infrastructure. The research uses analysis methods like OLR, CA, and the PPS. Following data analysis, the following conclusions are drawn:

- Yeka neighborhood sidewalks are causing disputes with authorities due to inadequate maintenance, on-street parking, and numerous vendors. The study reveals some road segments lack footpaths and are in disrepair, causing walkway damage and obstructions.
- The study reveals that pedestrian safety perception is significantly influenced by comfort and surface condition. High levels of comfort and quality surfaces increase perceived safety, while low levels and poor surfaces decrease it. Improved walking surfaces improve safety. The study reveals that PLOS variables significantly influence pedestrian safety perceptions, with increased PLOS increasing perceived safety, while low levels decrease it, with walking environment concepts being the most significant.
- The study reveals that the impact of encroaching on roadway has negative effect. The negative coefficients suggest that pedestrians with limited chances of walking on the sidewalk feel less safe compared to those who frequently use the sidewalk.
- A study reveals sidewalk width impacts pedestrian safety, with less than 1.5 meters wide sidewalks causing 20% unsafe feelings. Factors like footpath width also influence perceived safety, with some studies suggesting no significant impact.
- The AGE variable significantly affects perceived safety, with young and middle-aged adults having poorer perceptions than elderly people. The OLR analysis reveals that pedestrian safety perception isn't significantly influenced by frequency, some purpose, or education, but sidewalk safety is crucial for pedestrians.
- The analysis found that walking to work, recreational, or visiting friends or family significantly impacts perceived safety. Overall, walking to work and visiting friends

or family is associated with higher safety perceptions. However, recreational walking results in a lower perceived pedestrian safety, with a probability of 11.2%.

- The study found that individuals with lower education levels feel safer on sidewalks compared to those with higher education, possibly due to increased safety awareness, suggesting that enhancing safety awareness can create a safer roadside environment.
- The study found that perceived safety is significantly influenced by walking distance and time, with higher odds of feeling safe between 500-2000m and lower odds in the afternoon.
- Vendor activity on sidewalks negatively impacts pedestrian perceived safety, with increased activity leading to increased vigilantes. Factors like location, width, and flow affect density, while vendors negatively impact the city's economy and pedestrian service. The study reveals that sidewalk adequacy significantly influences perceived safety, with high levels resulting in more secure sidewalks, suggesting that improving sidewalk condition indirectly enhances pedestrian safety.
- The CA generated RI and PUV for each attribute level, used in determining the TUV and the PPS is calculated for a specific sidewalk location, enabling pedestrian avoidance rates. The study used survey research and CA to identify key sidewalk attributes affecting walkability: width, flow rates, obstructions, and condition. Improved condition leads to improved flow rate, and walkable width and sidewalk conditions are crucial for pedestrian infrastructure improvement.
- Table 4.13 shows walkable width is the most important attribute, with 1.5m-2.5m being the most desirable range. The flow rate results are influenced by conjoint profiles, where respondents prioritize desired traits over less important ones. Fair sidewalk quality, flow rate over 20, and sidewalk width between 1.5m and 2.5m are preferred, with poor sidewalk condition being the least significant. People prefer obstacle-free, flow-rate 12 or lower walkable spaces with 1.5m-2.5m width. However, sidewalk condition and flow rate aren't significant for flow rates over 20, possibly due to demographics and physical disabilities.
- The CA results were compared to pedestrians' genuine willingness to use specific sidewalks, providing utility values to forecast their likelihood to use a specific sidewalk. Section 5.7 assesses the study area's sidewalks using calculated part-worth

values. The line graph shows Location 4 has the highest TUV and Location 3 has the lowest, with PPS peaking at Site 4 and lowest point at Location 3.

- The study utilized CA to assess sidewalk attributes, predicting usability, and highlighting Addis Ababa's unique challenges, thereby promoting the significance of local walkability research.

5.2 Recommendation

The study provides findings, verdicts, and recommendations on sidewalk safety, focusing on street vending and pedestrian sidewalk usage, resulting in reasonable recommendations considering various aspects.

- Street furniture and landscaping can provide protection without compromising width. However, sidewalks must be widened, cleared of cars, vendors, and illegal parking, and repaired promptly.
- To ensure personal safety and maintain sidewalks, street lighting, walkability promotion, and enforcement by local governments are recommended. Regular maintenance, and prohibition of sidewalk construction by firms are also crucial.
- The study suggests that consistent policy implementation, quality standards, and guidelines are crucial for road safety. It suggests that Ethiopian execute measures for street vendors, ensuring impartial management and punishment of violators and address root causes.
- Design recommendations for pedestrian areas include using kerbed pavements to separate them from motorized traffic. Pathways and walkways should be seamless and not abruptly terminate, promoting leisure activities. Some considerations includes:
    - A minimum walkable width of two point five meters is recommended, with more than two point five meters being better.
    - Walkways should have zero obstructions, but if not, shift them to create a straight road.
    - Parklets, which promote pedestrian activity and community interaction, are a quick, cost-effective solution for improving neighborhoods without a permanent concrete foundation.
- Addis Ababa, Ethiopia, needs to improve its urban infrastructure, especially pedestrian safety, by developing a guidebook, creating a comprehensive codebook for

pedestrian facilities, prioritizing public transport infrastructure, and integrating design standards and data into the ERA manual to create safe pedestrian facilities.

- Achieving adequate funding: to enhance walkability in metropolitan areas, local governments should prioritize sidewalk development, allocate funds, organize business corridors, promote NMT, and focus on revenue sources like automated enforcement and reduced claims experience.
- Promoting education, safety awareness, and effective training in schools, workplaces, and media is crucial for enhancing pedestrian safety in sub-cities, fostering a culture of continuous improvement.

As a result, this research enhances understanding of sidewalk vendor interactions on sidewalk utilization and pedestrian safety in Ethiopia. It highlights the need for improved interaction between vendors and pedestrians, and considers operational features of roads.

5.3 Future Study

The study suggests further research on physical environmental criteria, human elements like street vendors and parking, and suggests numerous potential areas for further study. Adjusting sidewalk conditions analysis and incorporating additional variables to enhance pedestrian safety predictions is important. It suggests tailoring the model for different cities, selecting attributes based on country standards, and increasing the sample size for a more comprehensive understanding. Improving the accuracy of model analyzing the accessibility of trip-generating places and other sidewalk attributes can be achieved by using the CA technique. This approach can be applied to additional NMT modes and can enhance the accuracy of transport network impact studies in the area.

To improve Addis Ababa's streets, extensive research is needed on physical limitations and mobility restrictions. Traffic engineers have not resolved issues like cleanliness, odor, ventilation, noise, and vibration on sidewalks, and addressing these is crucial for improving pedestrian safety and the overall road experience.

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ANNEXES

Annex A. Sample of questionnaire survey

ADDIS ABABA UNIVERSTY
SCHOOL OF CIVIL AND ENVIROMENTAL ENGINEERING
አዲስ አበባ ዩንቨርሲቲ
የሲቪል እና ኢንቫይሮሜንታል ኢንጂነሪንግ ትምህርት ቤት

SIDEWALK USE SURVEY IN YEKA SUB CITY AREAS OF ADDIS ABABA CITY, ETHIOPIA.

የእግረኛ መንገድ አጠቃቀም ጥናት በየካ ክፍለ ከተማ አካባቢዎች በአዲስ አበባ ከተማ: ኢትዮጵያ

This survey is voluntary and anonymous. Information will only be used for research purposes.

Instruction: Please circle in the given alternative choice as per requirement of the statement.

1. Age (እድሜ)

1	2	3	4	5
Under 18	18- 24	25-34	35-55	above 55
ከ 18 አመት በታች	18-24	25-34	35-55	ከ 55 በላይ

2. Gender (ፆታ)

1	2
Female	Male
ሴት	ወንድ

3. Educational level (የትምህርት ደረጃ)

1	2	3	4	5	6
No	<8	8-10	Certificate	Diploma	Degree and above
አልተማርኩም	ከ8 በታች	ከ8-10	ሰርተፍኬት	ዲፕሎማ	የመጀመሪያ ድግሪ/በላይ

4. Occupation (ስራ)

1	2	3	4
Government/ private office	your own business	Housewife	student
የመንግስት / የግል ቢሮ	የራስዎ ቢዝንስ	የቤት እመቤት	ተማሪ

5. Do you live in yeka sub city? (የምትኖረው በየካ ክፍለ ከተማ ነው?)

1	2
Yes	no
አዎ	አይ

6. Did you used walking (የእግር መንገድ ይጠቀማሉ))

1	2
Yes	no
አዎ	አይ

7. How often did you walk? (ምን ያህል ጊዜ የእግር መንገድ ይጠቀማሉ)

1	2	3	4
Everyday	2-3 times a week	Once a week	Sometimes
ሁልጊዜ	በሳምንት 2-3 ጊዜ	በሳምንት 1 ጊዜ	አልፎ አልፎ

8. What is your purpose of walking? (ወዴት ለምሄድ እግር መንገድ ይጠቀማሉ)

1	2	3	4	5	6
Go to/from work	Go to/from school	Shopping	Recreational	Visiting friends/family	Others
ወደ ስራ	ወደ ትምህርት ቤት	ወደ ገበያ	ለመዝናናት	ጥየቃ	ሌላ

9. How much distance/length did you walk? (ምን ያህል ርቀት ይገዛሉ)

1	2	3	4
Less than 500m	500-1000m	1000-2000m	greater than 2000
ከ500 ሜ በታች	ከ500-1000 ሜ	ከ1000-2000 ሜ	ከ 2000 ሜ በላይ

10. In what time you always walk? (የእግር መንገድ በየትኛው ጊዜ ይጠቀማሉ)

1	2	3	4
Morning	Afternoon	Evening	Other
ጠዋት	ከሰአት	ማታ	ሌላ

11. What are the activities on the sidewalk you find discomforting? (በእግረኛ መንገድ ላይ ምቾት የማይሰጡ ተግባራት የትኞቹ ናቸው?)

1	2	3	4	5
Street vending	Bicycling on the sidewalk	Street shoe shiner	vehicles parking on the sidewalk	Wood, trash, holes, or construction waste /materials metalwork's on the sidewalk
የመንገድ ላይ ንግድ	በእግረኛ መንገድ ብስክሌት መንዳት	የመንገድ ላይ ሊስትሮዎች	በእግረኛ መንገድ ላይ የሚቆሙ ተሽከርካሪዎች	እንጨት, ቆሻሻ, ጉድጓድ, ወይም የግንባታ ቆሻሻ / ቁሳቁሶች ና የብረት ስራ በእግረኛ መንገድ ላይ

12. Do you feel comfortable walking through this sidewalk with the presence of street vendors? (የመንገድ አቅራቢዎች/የመንገድ ላይ ንግድ ባሉበት በዚህ የእግረኛ መንገድ መሄድ ምቾት ይሰማዎታል?)

1	2	3	4	5	6
Very uncomfortable	Uncomfortable	Slightly uncomfortable	Neutral	Comfortable	Very comfortable
በጣም የማይመች	የማይመች	ትንሽ የማይመች	ምንም	ምቹ	በጣም ምቹ

13. Do you agree total width of the sidewalk is satisfying and the number of pedestrians in this sidewalk is too small, not causing this sidewalk to be crowded (adequate pedestrian's walkway)? (የእግረኛ መንገዱ አጠቃላይ ስፋት አጥጋቢ እንደሆነ እና በዚህ የእግረኛ መንገድ ውስጥ ያሉት የእግረኞች ብዛት በጣም ትንሽ በመሆኑ ይህ የእግረኛ መንገድ መጨናነቅን አያስከትልም)

1	2	3	4	5	6
Strongly Agree	Agree	Slightly Agree	Strongly Disagree	Disagree	Slightly Disagree
በጣም እስማማለሁ	እስማማለሁ	ትንሽ እስማማለሁ	በጣም አልስማማም	አልስማማም	ትንሽ አልስማማም

14. Do you feel this sidewalk is crowded? (ይህ የእግረኛ መንገድ የተጨናነቀ እንደሆነ ይሰማዎታል?)

1	2
Yes	no
አዎ	አይ

15. Comfort (የእግረኛ መንገድ ምቾት): The walkway seems comfortable for you as you walk through it without slowing down, enough room to bypass the obstruction, No physical restraints, vendor restraints, or other restrictions shouldn't be present while you move freely,

condition of walking surface, sidewalk cleanliness, odor, ventilation, noise, vibration, and crowding also included. (በእግረኛ መንገድ ላይ ሲገዙ ምቾት አለው፤ካለምንም መሰናክል ይገዛሉ የቆመ ነገር ወይም ለመሄድ እሚያሰቸግር ነገር የለም፤የእግረኛ መንገዱ ፅዱ እና ምቹ ነው)

1	2	3	4	5	6
Excellent	V. good	Good	Fair	Poor	V. poor
እጅግ በጣም ጥሩ	በጣም ጥሩ	ጥሩ	ምንም አይልም	ዝቅተኛ	በጣም ዝቅተኛ

16. Safety (የእግረኛ መንገድ ደህንነት): Whenever you feel safe when walking on the sidewalk, feel secure against potential falls, trips, and vendor risk as well as from oncoming vehicles. (በእግረኛመንገድ ላይ ሲገዙ ደህንነትዎ ተጠብቆ በጥሩ እና በተረጋጋ ስሜት ይገዛሉ ፣መንገዱ አያደነቃቅፍም ከመንገድ ላይ ነጋዴዎች ደህንነት ይሰማህ ፤ለትራፊክ አደጋ አይሰጉም)

1	2	3	4	5	6
Excellent	V. good	Good	Fair	Poor	V. poor
እጅግ በጣም ጥሩ	በጣም ጥሩ	ጥሩ	ምንም አይልም	ዝቅተኛ	በጣም ዝቅተኛ

17. Surface Condition of sidewalk (የእግረኛ መንገድ ሁኔታ): Smooth, level, slip-resistant, comfortable, and secure walking surface (የእግረኛ መንገድ ልባሱ ምቹ እና የተስተካከለ ለስላሳ፣ ደረጃ፣ መንሸራተት የሚቋቋም፣ ምቹ እና ደህንነቱ የተጠበቀ ነው)

1	2	3	4	5	6
Excellent	V. good	Good	Fair	Poor	V. poor
እጅግ በጣም ጥሩ	በጣም ጥሩ	ጥሩ	ምንም አይልም	ዝቅተኛ	በጣም ዝቅተኛ

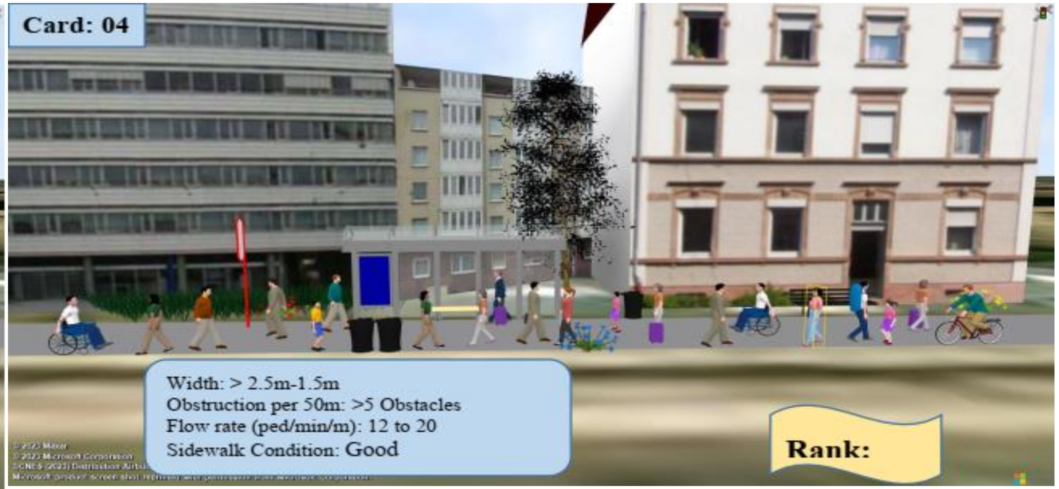
18. Encroach into the main carriageway (እግረኛ ወደ መንገድ የሚገበት): Leaving sidewalk facilities due to inadequate sidewalk width, the presence of obstruction and high pedestrian flow rates leads to evade the carriageway (በቂ ያልሆነ የእግረኛ መንገድ ስፋት ምክንያት የእግረኛ መንገድ መገልገያዎችን መልቀቅ፣ የመስተጓጎል መኖር እና ከፍተኛ የእግረኛ ፍሰት መጠን የመጓጓዣ መንገዱን ያመልጣል።)

1	2	3	4	5	6
Excellent	V. good	Good	Fair	Poor	V. poor
እጅግ በጣም ጥሩ	በጣም ጥሩ	ጥሩ	ምንም አይልም	ዝቅተኛ	በጣም ዝቅተኛ

19. PLOS (የእግረኛ መንገዱ እግረኛውን የማስተናገድ አቅም): The road condition allows for the freedom to walk at any speed, the complete width of the sidewalk allows for easy passing of other walkers and provides a clear view of the bus stop. (የመንገዱ ሁኔታ በማንኛውም ፍጥነት ለመራመድ ነፃነትን ይሰጣል ፤ የእግረኛው ሙሉ ስፋት ሌሎች ተጓዦችን በቀላሉ ለማለፍ እና እነዲገዙ የስችላል ፤ የአውቶቡስ ማቆሚያውን ግልጽ እይታ ይሰጣል.)

1	2	3	4	5	6
Excellent	V. good	Good	Fair	Poor	V. poor
እጅግ በጣም ጥሩ	በጣም ጥሩ	ጥሩ	ምንም አይልም	ዝቅተኛ	በጣም ዝቅተኛ

Please rate the following sidewalk illustrations below on a scale of 1 to 9. (1 = most preferred) (9 = Least preferred) Note: Only use a number once.




Card: 05
Width: 2.5m-1.5m
Obstruction per 50m: 1 to 5 Obstacles
Flow rate (ped/min/m): < 12
Sidewalk Condition: Poor
Rank:


Card: 06
Width: > 2.5m
Obstruction per 50m: > 5 Obstacles
Flow rate (ped/min/m): > 20
Sidewalk Condition: Poor
Rank:


Card: 07
Width: > 2.5m
Obstruction per 50m: No Obstacles
Flow rate (ped/min/m): < 12
Sidewalk Condition: Good
Rank:


Card: 08
Width: < 1.5m
Obstruction per 50m: No Obstacles
Flow rate (ped/min/m): 12 to 20
Sidewalk Condition: Poor
Rank:

Indicate your preference of using the following mentioned sidewalks in the Yeka Sub City						
No	**Sidewalk Location**	1.Strongly Dislike	2. Dislike	3.Normal	4. Like	5. Strongly Like
1.	Israel Embassy- Megenagna - British Embassy shola					
2.	Yeka woreda 9 office Zero hult-Kotebe University of Education -Kotebe Mesalemia St. Maryam & St. George Church					
3.	Ministry of Mines & Energy-Lamberet-Addis Ababa Haile Grand, Addis Ababa					
4.	Yared Music School- Menelik 2 Referal Hospital -Kagnew Peace Keeping Roundabout					
5	Haya Hulet Roundabout (Golagul Building)-Adwa Bridge					

Thank you for your participation.

Annex B. A summary table of audit assessment techniques, was adjusted using information from Lee and Talen (2014) and Albers et al. (2010) and taken from Aghaabbasi et al. (2017).

Tool Name	Authors	Sidewalk Indicators	Limitations
Analytic Audit Tool—St Louis University	(Brownson et al., 2004)	(1) The presence of facilities that provide comfort and aesthetics (such as trees that provide shade, benches, or other features); (2) The presence of obstacles in the way. (3) The presence or visibility of service amenities in the area, (4) Street amenities are present, and destinations are accessible and visible in the segments (driveways). (5) Sidewalk width and accessibility (6) Crosswalks, traffic signals and lighting,	Only a few microscale sidewalk design elements were evaluated.
Irvine Minnesota Inventory(IMI)	(Boarnet et al., 2006)	(1) The quantity of benches, 2) The quantity of trees and the quantity of sidewalks covered by trees, 3) The quantity of discernible driveways on the segment, (4) The segment's incline, (5) The presence of pedestrian signals, and the presence of lights on the stretch	Disability is overlooked as well as sidewalk facilities like trash cans, bollards and water fountains.
Microscale Audit of Pedestrian Streetscapes (MAPS)	(Millstein et al., 2013)	(1) The presence of street amenities (such as drinking fountains and benches), (2) The presence of path obstructions (such as trees), (3) The number of trees on either side of the sidewalk, the order in which the trees were planted and the percentage of the sidewalk that is covered by trees, (4) The number of driveways on the segments, (5) The steepness of the cross slope, (6) The width of the pavement, (7) The presence of a pedestrian signal	Sidewalk amenities like benches, drinking fountains, and tactile paving for the disabled have been disregarded. Sidewalk surveillance is not evaluated.

Path Environment Audit Tool (PEAT)	(Troped et al., 2006)	(1) Benches, seating areas and Bollards on the segments and accessible to those with wheelchairs, (2) Water fountains, (3) their functionality, their cleanliness, and their accessibility for those in wheelchairs, (4) Restrooms along the sidewalk and Toilets their cleanliness and access to wheelchair (5) The segment's slope, (6) Path state, (7) The presence of pedestrian signals signs; and lighting	Can take into account more categories of disability, safety, and criminality are not assessed, and components of visibility like surveillance and sidewalk windows are not assessed.
pedestrian Environment Data Scan (PEDS)	(Clifton et al., 2007)	(1) The presence of street amenities (seat space); (2) The number of trees providing shade; (3) The presence of medium- or high-volume driveways; (4) Path information (5) Sidewalk width, (6) The presence of crossing aids (signs and pedestrian signals), (7) Path obstruction, (8) General cleanliness of sidewalk, (9) Path and road lights	Disability issues are not addressed. Inadequate consideration of microscale elements.
Pedestrian Environmental Quality Index (PEQI)	(San Francisco Department of Health, 2008)	(1) The width of the sidewalk, (2) Sidewalk obstructions, (3) The presence of a curb and Driveway cuts, (4) Trees, Garden, Chairs, and Buffer	Narrow scope, no available applicable evidence
PIN3 Neighbourhood Audit Instrument	(Evenson et al., 2009)	(1) The presence of trees to provide shade for the walking area, and (2) The presence of street lighting	Microscale design and a small number of handicap issues were evaluated.

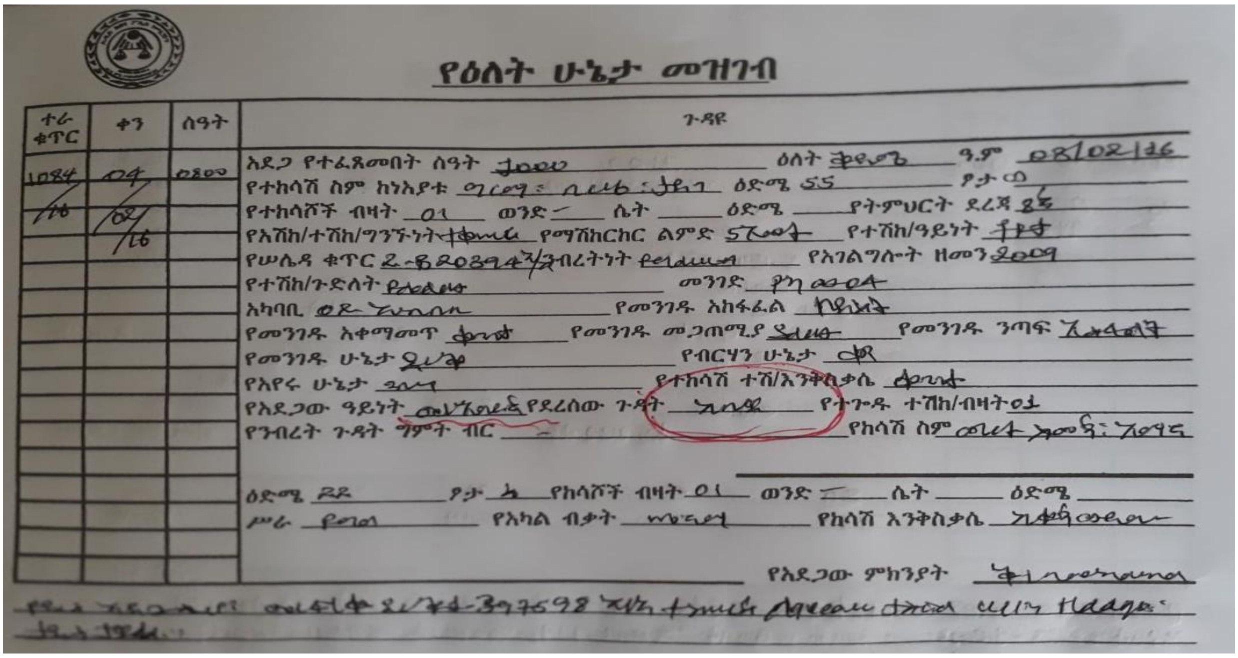
Scottish Walkability Assessment Tool (SWAT)	(Millington et al., 2009)	(1) Location of the path and type of the path, (2) Material (3) Sidewalk width, slope, and Condition, (4) Obstacles, (5) Driveway cuts, (6) The presence of vegetation and Height of the vegetation (7) parking, (8)Street Lighting	limited study area, emphasis on recreation,
South African Pedestrian Environment Assessment Tool	(Albers et al., 2010)	(1) Sidewalk presence and location (2) Material, (3) Obstacles, (4) Conditions, (5) Slope, Drop Off and Curb, (6) Driveway cuts, (7) "trees," "hedges," (8) Fences, (9) Parking restrictions, (10), public seating, (11) Lighting, (12) Public Transportation	Design considerations including sidewalk width and the distance to the closest intersections were excluded. Security concerns for field workers prevented an evaluation of lighting.
Systematic Pedestrian and Cycling Environmental Scan (SPACES)	(Pikora et al., 2002)	(1) The presence of barriers in the path (trees, sign poles), (2) The number of trees and the average height of the trees, (3) Crossovers at driveways(4) The type of path material and the state of the path's surface, (5) Tidiness, (6) The presence of lighting	Disability issues were not taken into account. Inadequate consideration of microscale elements. Limited outcomes for arbitrary factors, lack of a well-defined neighbourhood a lack of variety in the sites.
Walking Suitability Assessment Form (WSAF)	(Emery et al., 2003)	(1) Material, (2) Surface Condition, (3) Sidewalk width, (4) Necessity of installation of pedestrian signals at busy intersection, (5) Availability of curb ramps, (6) Availability of adequate lighting	The study evaluated sidewalk design elements like continuity, material, width, and surface quality, excluding disability-related issues like tactile paving and accessible drinking facilities.

Annex C. Table showing walkability findings of the urban inventory assessment on sidewalks shows results of all factors considered and summary (Addis Ababa Sidewalk Safety and Improvement Study, 2022).

Key Features	Descriptions	Categorization of the indicator	Findings
Permeable Fronts	Street permeability measures pavement accessibility from indoor areas, considering property activity, promoting walking and pedestrian-friendly activities, and enhancing the vibrant environment.	1. Poor/Low, 2. Fair/Medium, and 3. Good/High	Only 15% of the network has fronts with high permeability, while 55% of the network has fronts with low permeability.
Bus stops	Clear bus stops promote safety and encourage the use of public transportation. Visible stops attract more pedestrians.	1. Poor/Low, 2. Fair/Medium, and 3. Good/High	Insufficient bus stops on many routes discourage passengers from using them as their final destination, encourage unauthorized stops, and raise road safety concerns.
Sidewalk Dimensions	Dimensions refer to the space available for pedestrians to circulate.	1. Narrow (poor/low)-width of <1.5 meters (m). 2. an average (fair/medium)- 1.5 m-2.5 m., 3. Optimal (good/high) - > 2.5m.	68% of the pavements in this LRT segment have dimensions that are appropriate, with 39% of the network having pavement widths greater than 2.5m and 29% measuring between 1.5 and 2.5m.
Pavement Conditions	Refers to the adequate use of pavement materials and incorporation of textures to delineate spaces, as well as drainage quality.	1. Very Poor 2. Poor/Low 3. Fair/Medium 4. Good/High	The network's pavements must be prioritised because 50% of them fall into the "poor to very poor" category, including 26% that have no pavement and 23% that have very poor pavement conditions.
Tactile pavement	A surface that has a rough texture to aid visually impaired pedestrians in navigating is called a pod tactile floor. However, it is not recommended to have non-continuous tactile flooring along the	1. presence of continuous tactile pavement-Poor/Low, 2. presence of non-continuous pavement-Fair/Medium,,	There is no tactile pavement for visually challenged users on 54% of the network. Only 24% of the network's freshly constructed stretch has continuous tactile pavement.

	sidewalk.	3. absence-Good/High	
Seating Infrastructur e	The presence of urban furniture including seating is indispensable for users' comfort.	1. Absence-Poor/Low, 2. Inadequate-Fair/Medium 3. Adequate-Good/High	Only 13% of the network has suitable seating infrastructure, and 81% lacks seating items. Furniture is present in the remaining 6%, but it is in poor shape and is therefore useless.
Street Lighting	Adequate lighting in public spaces, especially sidewalks, improves security perception, especially at night and for women	1. Poor 2. Good	More street lighting is needed for better pedestrian safety, especially at night, as only 48% of the street network currently has adequate lighting.
Obstacle	Obstructions on the sidewalk make it hard for pedestrians to use the space and can lead to them crossing into traffic.	1. Poor 2. Good	20% of walkways are blocked by trash, debris, or holes, with 63% caused by these factors and 37% by street vendors. Prioritizing vendor migration is crucial for improving the situation.
Crossing Accessibility	Pedestrian crossings are designed for easy access, with signals, lights, and ramps for those with limited mobility.	1. Poor 2. Good	For persons with reduced mobility (PRM), 65% of crossings are inaccessible. The most hazardous pedestrian habits were found at these intersections.
Improper Crossing	Identifying jaywalking hotspots can reveal inadequate pedestrian crossings, aiding urban planning and identifying areas with improper crossings.	1. Poor 2. Good	In the examined area, there are incorrect crossings on 79% of the network.
Trees	Greenery on pavements provides shade, pollution barrier, and rain protection. Trees are especially effective.	1. Poor/Low, 2. Fair/Medium, 3. Good/High	The new pavement plans account for trees, which are present in 13% (high), 16% (moderate), and 23% (low) density in the area analyzed. 49% of the area has no trees.

Annex D. Figure Daily Crash Data Report Format Used in Addis Ababa



Annex E. Ordered logistic regression analysis results of variables

Case Processing Summary			
		N	Marginal Percentage
Perceived pedestrian Safety	Excellent	1	0.2%
	V. good	16	3.7%
	Good	59	13.7%
	Fair	52	12.1%
	Poor	68	15.8%
	V. poor	234	54.4%
Comfort when walking	Excellent	4	0.9%
	V. good	45	10.5%
	Good	88	20.5%
	Fair	87	20.2%
	Poor	143	33.3%
	V. poor	63	14.7%
Surface condition of sidewalk	Excellent	5	1.2%
	V. good	28	6.5%
	Good	58	13.5%
	Fair	61	14.2%
	Poor	158	36.7%
	V. poor	120	27.9%
Encroaching into the main carriageway	Excellent	11	2.6%
	V. good	29	6.7%
	Good	47	10.9%

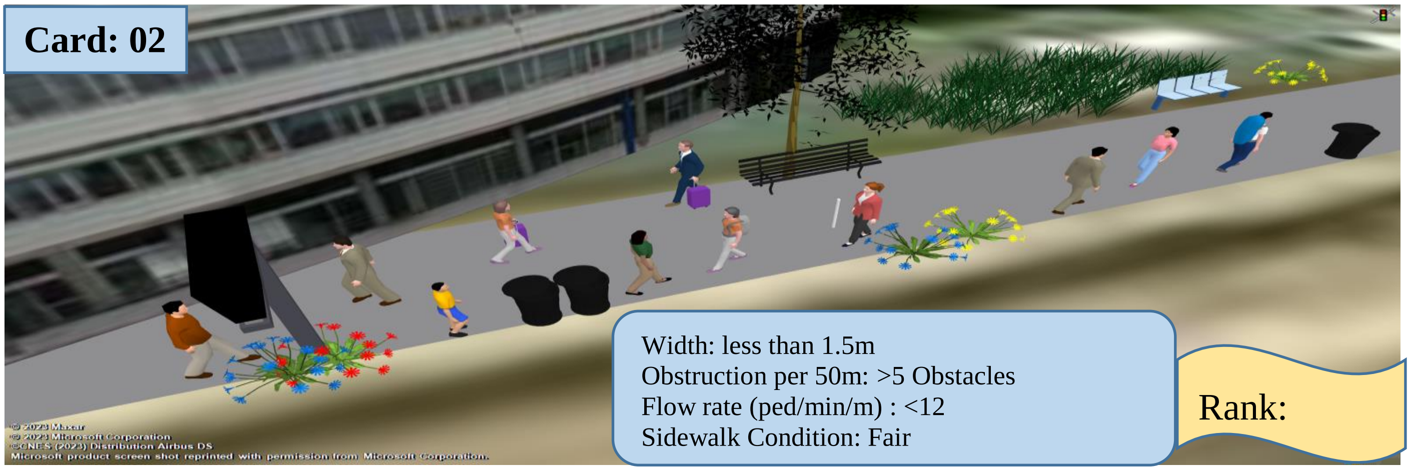
	Fair	45	10.5%
	Poor	104	24.2%
	V. poor	194	45.1%
Pedestrian perception of PLOS	Excellent	9	2.1%
	V. good	43	10.0%
	Good	58	13.5%
	Fair	81	18.8%
	Poor	147	34.2%
	V. poor	92	21.4%
Sidewalk Width	Continuous	-	-
Age range of respondent	Under 18	48	11.2%
	18- 24	71	16.5%
	25-34	165	38.4%
	35-55	96	22.3%
	above 55	50	11.6%
Education level of respondent	No	32	7.4%
	<8	86	20.0%
	8-10	45	10.5%
	Certificate	50	11.6%
	Diploma	60	14.0%
	Degree and above	157	36.5%
Frequency of pedestrian walking	Everyday	252	58.6%
	2-3 times a week	116	27.0%
	Once a week	18	4.2%
	Sometimes	44	10.2%
Purpose of walking	Go to/from work	213	49.5%
	Go to/from school	48	11.2%
	Shopping	53	12.3%
	Recreational	48	11.2%
	Visiting friends/family	46	10.7%
	Others	22	5.1%
Distance of walking	Less than 500m	50	11.6%
	500-1000m	123	28.6%
	1000-2000m	141	32.8%
	greater than 2000	116	27.0%
Day of the time	Morning	191	44.4%
	Afternoon	173	40.2%
	Evening	66	15.3%
Walking with the presence Vendor	Very uncomfortable	34	7.9%
	Uncomfortable	50	11.6%
	Slightly uncomfortable	87	20.2%

	Comfortable	140	32.6%
	Very comfortable	87	20.2%
	6	32	7.4%
Adequacy pedestrian's walkway	Strongly Agree	1	0.2%
	Agree	16	3.7%
	Slightly Agree	58	13.5%
	Strongly Disagree	53	12.3%
	Disagree	68	15.8%
	Slightly Disagree	234	54.4%
Valid		430	100.0%
Missing		0	
Total		430	

Annex F. Visual Representation of Conjoint Profiles

Conjoint Generated Profile sidewalk illustrations using VISSIM software (Each hypothetical constructed profiles were shown in Figures below Annex Figure F1-F9).

Annex F Figure 1. Conjoint Generated Profile: Card 01

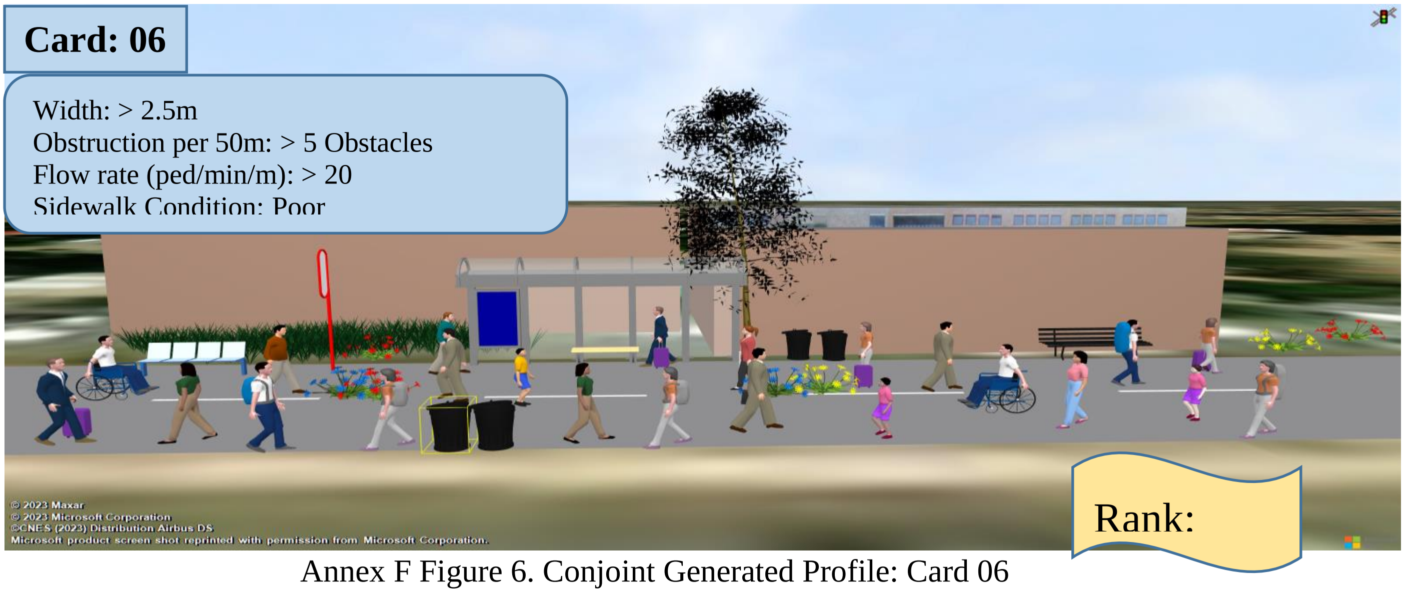


Annex F Figure 2. Conjoint Generated Profile: Card 02

Annex F Figure 3. Conjoint Generated Profile: Card 03

Annex F Figure 4.Conjoint Generated Profile: Card 04

Annex F Figure 5. Conjoint Generated Profile: Card 05



Annex F Figure 6. Conjoint Generated Profile: Card 06

Annex F Figure 7. Conjoint Generated Profile: Card 07

Annex F Figure 8. Conjoint Generated Profile: Card 08

Annex F Figure 9. Conjoint Generated Profile: Card 09