Evaluating the Impact of Sidewalk Physical Challenges on Pedestrian Walkability in Adama City: A study of selected arterial Streets

Tesfaye Regasa Gari

A Thesis Submitted to
The Department of Architecture
School of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for the Degree of Master's in Urban Planning and Design

Office of Graduate Studies

Adama Science and Technology University

May, 2024

Adama, Ethiopia

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Approval of Board of Examiners

I, the advisors of the thesis entitled "**Evaluating the Impact of Sidewalk Physical Challenges on Pedestrian Walkability in Adama City:** A study of selected arterial Streets" and developed by **Tesfaye Regasa**, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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Major Advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis by **Tesfaye Regasa** have read and evaluated the thesis entitled "**Evaluating the Impact sidewalk physical challenge on pedestrian walkability in Adama city:** A study of selected arterial Streets" and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in **Urban Planning and Design**.

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

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

Declaration

I hereby declare that this Master Thesis entitled "**Evaluating the Impact of sidewalk physical challenge on pedestrian walkability in Adama city:** A study of selected arterial Streets" is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

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Name of student	Signature	Date

Recommendation

I, the advisor of this thesis, hereby certify that I/we have read the revised version of the thesis entitled "**Evaluating the Impact of sidewalk physical challenge on pedestrian walkability in Adama city:** A study of selected arterial Streets" prepared under my guidance by **Tesfaye Regasa** submitted in partial fulfillment of the requirements for the degree of Mater's of Science in **Urban Planning and Design**. Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

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Major Advisor	Signature	Date

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LIST OF ACRONYMS AND ABBREVIATIONS

AA	Addis Ababa
ASTU	Adama science and technology university
GIS	Geographic Information System
HCM	Highway Capacity Manual
LOS	Level of Service
PF	Pedestrians flow
PFR	Pedestrians flow Rate
PLOS	Pedestrians Level of Service
SAD	Shy Distance
SDG	Sustainable Development Goals
SPSS	Statically Package for Social Science.
TRB	Transportation Research Board
UN	United Nations
We	Effective width

Abstract

The physical condition of sidewalks affected by different factors. Factors such as width, surface quality, presence of obstacles, and accessibility features directly impact pedestrian mobility. Narrow sidewalks, damaged surfaces, obstructions like parked vehicles or street vendors, and a lack of pedestrian-friendly infrastructure contribute to an unfavourable walking experience. These challenges hinder pedestrians' ability to navigate the city on foot and may force them to rely more on motorized transportation options. Adama a rapidly growing conference and industrial, lacks any planned walking environment, and the existing sidewalks are also inaccessible and crowded with obstructions like street vendors. The main objective of the study is to address the unseen physical challenges facing pedestrians on the sidewalk of Adama city and provide effective technical and design recommendations In this study, both quantitative and qualitative methods were used to achieve the intended objectives. The study conducted 384 questionnaire surveys using a purposive sampling method to obtain information related to pedestrian physical challenge and pedestrian pattern, and perceptions of built environment infrastructure. Based on the observation data gathering the Pedestrian level of service and sidewalk walkability indicator results show that in four sidewalk segment surveyed areas resulted 35.7 ped/min/m, 34.84 ped/min/m, 25.7 ped/min/m and 4.13 ped/min/m putting the sidewalks level of service in D, level of service in D, level of service C and level of service A respectively. Based on PLOS the finding analysis indicates that the current physical condition of the sidewalk has inadequate pedestrian facilities and lacks connectivity with many pedestrian movement obstructions which resulted in the reduction of pedestrian walking speed and pedestrian level of service (PLOS). In general, the study developed a strategy and proposed a design for a pedestrian walking environment and a better space where pedestrian can travel without disturbing.

Key words: *walkability, Physical Challenges Evaluation, pedestrian, sidewalk, street*

CHAPTER ONE

1. INTRODUCTION

1.1. Background

Walking was one of the most prevalent means of mobility in both animals and humans, and it was usually slower than running and other types of locomotion. (world health organization, 2013). Walking was the most fundamental means of transportation available to humans. From the earliest human settlements, it had been a factor in the design of communities (Frederick & Kent, 2007). It was just part of our daily lives as humans. As a result, it was a common mode of transportation that was frequently missed. Every single one of us were a walker. Walking was a basic and widespread means of transportation in all communities around the world. Almost every journey began and ended with a walk. On certain journeys, walking was the only mode of transportation, whether it was a long ride or a quick trip to the store (world health organization, 2013).

Pedestrians were generally ignored in urban planning, and walking was not widely seen as a means of transportation. As a result of this disregard for pedestrian movement, there were a general lack of interest in it, as well as pedestrian environment were not comfortable. (Paula Alexandra Sepúlveda Ferreira Da Silva, 2008). This issue was predominantly observed in developing countries like Ethiopia. Recently, there has been a shift in focus towards addressing the challenges stemming from designing communities primarily for motorized transport. This shift has given new meanings to the terms "walkable" and "walkability." Instead of solely focusing on negative health effects caused by sedentary lifestyles, attention has turned to the role of walking in enhancing individuals' health, safety, and well-being. In this context, "walkable" and "walkability" encompass various aspects of community design aimed at encouraging walking. (Frederick & Kent, 2007).

At the macroscale, planners and urban designers had to consider the mix of land uses, as well as site and street network design constraints. At the microscale, walkability requires attention to the details and design of sidewalks, crosswalks, building façades, benches, and other human-scale designed features. (Frederick & Kent, 2007).

Sidewalks were important in transportation because they provided a protected walking path that was isolated from the motorized traffic. They improved road safety by reducing pedestrian-motorized traffic interactions. Sidewalks were usually paired, one on either side of the lane, with motorized vehicles using the middle segment. Sidewalks, like roads, should be designed to accommodate all users. This included children, the elderly, and parents pushing strollers, as well as pedestrians with vision impairments, wheelchair users, and those who use assistive devices (U.S. Department of Transportation, 2014).

Regular exercise, such as walking, running, or skating, lowered obesity, stroke, coronary heart disease, and other related medical problems. Acute health-care expenses would be decreased as a result, and quality of life was improved. Vehicle carbon emissions from short-distance or short-trip driving contributed to climate change (Nwakaire, Chuku, & Udemba, 2017). As a result, rather than being used for automobiles, the usage of sidewalks should be encouraged because sidewalks and walking promote a healthier way of living (Federation of Canadian manucipalities and National research council, 2004).

The practice of diverting traffic away from areas of high pedestrian activity began with the city centre shopping streets. To be fully pedestrianized, a shopping street's shops must have access to non-shopping-street services. Vehicles may use the street to serve the businesses in the early morning and late afternoon, but for the majority of the shopping day, the street is pedestrian only. Residential neighbourhoods have recently been modified to prioritize pedestrians. (Mitchell, 2007)

Based on my observation in Ethiopia pedestrian walkways were not promoted walking and exposed to different physical challenges such as narrowed width, improper placement of street furniture's and poles, vendors occupied the space and other problems were faced pedestrian while walked on sidewalks. This was a common problem for many developing countries. According to the WHO's (World Health Organization) report in 2015 there were around 15 percent of world populations were disabled. Those people with disabilities wants to live as an independent life as other non-disabled people in this world. To support their daily activities, they required technical aids as wheelchairs, guide dogs, tactile paving and many others. In this thesis the researcher wanted to eases their daily movement by studying major problems on pedestrian and finding a better solution. The main purpose of this research work was to provide valuable information on effective design solution for ensuring accessibility of pedestrian walkways for all pedestrians.

1.1.1. Pedestrian sidewalk safety and challenge in Ethiopia

Every journey began and ended on foot. However, in the United States, people 65 and older made just around 8% of their trips on foot, while in Sub-Saharan Africa, walking accounts for 50% of all regular trips for people of all ages. The challenges of pedestrians on the street sidewalks of developing countries were started by the lack of any provision of walkways up to improper design and placement of the sidewalk channel (WorldBank, 2005). These challenges were decreased walking habits of pedestrians, while the problem was more aggravated for disabled and elderly pedestrians. Despite their difficulties, disabled and elderly people were more likely to travel long distances. This issue was worsened by both a lack of accessibility and a high cost. But, for people who walked with a walking aid or a stick, the recommended maximum walking distances were much shorter. Those with impairments were primarily insecure in their daily activities because most developing countries' development does not take disabled people into account as much as it does today. (WorldBank, 2005).

Based on my observation Most of pedestrian walkways of Ethiopia cities/towns where they actually exist were exposed to different physical problem such as narrow width, damaged pavement, improper placement of utility poles, vendors encroach the walkway, uneven level change, stalls encroach the space, car parked on walkways and other related challenges were made sidewalk environment insecure, representing discomfort and lack of safety for pedestrians in general and for the disabled in particular. A preliminary evaluation of these sidewalks indicates that most of them were unsuitable for proper circulation because of the presence of obstacles, their precariousness, or the unsuitability of the materials used in their construction and lack of street furniture's on the walkways. Most of street in our towns and cities had lack of walkway beside the street and those having walkways even did not secure those who remains with healthy abled bodies. Those part of society with disability are left unchecked in case of our country.

Accessibility for all pedestrian including disabled and older people did not only mean physical access to vehicles and walkways. It includes information in forms that were useable by everyone, training of transport staff to understand the needs of all pedestrian, and design and layout of urban areas to enable people to move about safely and confidently (Rahaman, 2005).

1.1.2. Contextual background

Adama, positioned in the central part of Ethiopia's Oromia Region, lies within the East Shewa Zone, approximately 99 km southeast of the capital, Addis Ababa. Nestled between an escarpment to the west and the Great Rift Valley to the east, Adama thrives as a bustling economic and conference hub. It boasts a diverse population comprising individuals from various nations and ethnic backgrounds. Additionally, the city serves as a pivotal center for numerous zonal and regional offices. In the city, different facilities and infrastructure were developed. Streets were among the basic infrastructure priorities for the city administration, as they serve as a lifeline for both humans and freight. Most of the streets were narrowed compared to the structural plan prepared and had a grid pattern. The street escape environments were not walkable, and the pedestrian walkways beside the street were narrow, not well designed, and had different obstacles that challenged pedestrian walkability.

A convenient, accessible, and comfortable pedestrian environment makes a journey by foot pleasant and enjoyable. According to a World Bank report in 2005, walking accounts for 50% of all our regular trips for people of all ages in sub-Saharan Africa. However, based on my simple observation in Adama city, more than 50% of trips were made on foot every day, but the pedestrians were facing many problems while using the walkways. Narrowed width, broken pavement, uneven level change of walkways, street vendors occupying the space, and other related problems were among the pedestrian challenges that hindered the walkability of the sidewalk. A lot of research work is being conducted to assess the pedestrian level of service in developed nations, but in developing countries like Ethiopia, it is not a significant one for transport planners.

1.2. Problem Statement

Street walkability is an indicator of the suitability of the built environment for walking. A walkable street is one where walking is safe and enjoyable, where people wanted to walk, and where fast and widespread car traffic is not a concern (Quednau, 2018). The walkability of any street will improve if pedestrians have access to safe, comfortable, and accessible infrastructure (Litman T. A., 2015). Sidewalks are the main infrastructure for pedestrian mobility. Studies on the condition of sidewalks and their impact on walkability have garnered considerable attention in developed countries (Shaaban k. , 2019). Walkable cities provided numerous advantages to their residents, such as improved road and personal safety, convenience, accessibility to destinations, multimodal transportation, and a higher level of health (Athanasios, George, & Nikolaos, 2016).

Ethiopia is one of the developing countries with rapid economic development in the horn of Africa. According to the United Nations, a developing country was one with a low living standard, an underdeveloped industrial base, and a moderate-to-low Human Development Index. Basically, Ethiopia shared most of the developing country characteristics that is why the country labelled as developing nation. A key characteristic of the developing country is poor infrastructure. Narrow streets, obstructions, a lack of covered corridors, enticing components, and aggressive driving against pedestrians are only a few of the challenges that inhabitants are exposed to. Improving walkability was a challenging task for government agencies, especially in developing countries like Ethiopia.

In developing country, the issue of pedestrian sidewalk is not primary concern when designing streets and roads. Most of the streets in Ethiopian towns has no pedestrian sidewalk and those having sidewalks are also full of physical challenges that made them inconvenient and inaccessible for all pedestrians and pedestrian in different social group such as children, elders and disabled. A few studies investigating sidewalks walkability were conducted in developing country. Especially the studies focused on accessibility, convenience, comfort, vendors related walkability issue (Christopher Kost, Naomi Mwaura, Advait Jani, Christopher Van Eyken, 2015) (Nwakaire, Chuku, & Udemba, 2017) (Shaaban K. , 2019). Even those studies were conducted the walkability issue of sidewalk was not well addressed. The fundamental gap of these research studies was the insufficient coverage of the walkability indicator related to sidewalks, specifically the physical characteristics of the sidewalks. While many studies may address aspects like the width, surface material, and connectivity of sidewalks, they often fail to investigate deeply into the comprehensive physical features that significantly influence walkability. These features include the presence and condition of curb ramps, the degree of obstructions (such as utility poles or parked cars), the consistency and maintenance of the walking surface, and the presence of amenities like benches and shade.

Adama is one of a city in Ethiopia that has recorded rapid economic development in the past few years. In the last five years the city administration is providing massive infrastructure development. Road construction is among the focus area of city administration. Even the infrastructure development is encouraging and supported, but it is not well planned and designed based on research and feasibility studies. The sidewalk paths constructed and renewed in the city nowadays are not even sustainable and walkable. The sidewalks in Adama city are exposed for a number of issues with poor sidewalk physical character. Some of those character are; Vendors occupied the path space, narrow width, improper placement of utility, uneven level change, stalls encroach walkways, construction material damped along walkway, maintenance of sidewalk, bad odour and germs from dusts on footpath, Discontinuation of the walkway creates problems to the disabled persons for walking conveniently, lack of street amenities and furniture, Illegal vehicle parking on footpath and Poor pavement design and construction materials.

Generally, the sidewalks in this city are face different problems and it is not inclusive for all. The width of the pedestrian sidewalk, pavement and different street furniture's are need to design for disables, elders and children to make them part pedestrian using the routes and encourage walking environment. This study evaluates the physical challenges of sidewalk on pedestrian mobility and its impact on the walkability of pedestrian environment in Adama city. This may give an input for further studies on the title.

1.3. Objective of the study

1.3.1. General objective

The major aim of this research is to address the unseen physical challenges facing pedestrians on the sidewalk of Adama city and provide effective technical and design recommendations that ensure a convenient, inclusive, and walkable pedestrian environment.

1.3.2. Specific objectives

A. To identify types of sidewalk physical challenges that decrease pedestrian mobility on the arterial streets of Adama City.
B. To evaluate the impact of sidewalk physical characteristic on pedestrian walkability and safety.
C. To propose recommendations and interventions for improving pedestrian walkability by addressing the identified sidewalk physical challenges.

1.4. Research Question

A. What types of physical challenges on sidewalks decrease pedestrian mobility on the arterial streets of Adama City?
B. How do the physical characteristics of sidewalks impact pedestrian walkability and safety in Adama City?
C. What recommendations and interventions can be proposed to improve pedestrian walkability by addressing the identified physical challenges on sidewalks?

1.5. Significance of the study

This study holds significant importance as it addresses critical aspects of pedestrian infrastructure in Adama City. By identifying and evaluating the physical challenges on sidewalks, the research aims to enhance pedestrian mobility, safety, and overall walkability. Understanding the impact of these challenges on pedestrian behaviour and safety is crucial for developing effective urban planning and design strategies. This research will assist to tackle critical social, economic, and physical issues that society and marginalized groups face on pedestrian walkways. Ultimately, the recommendations and interventions proposed by this study will inform policy-makers, urban planners, and local authorities, guiding them in creating a more inclusive, accessible, and pedestrian-friendly urban environment in Adama City.

This research can also be used to inform for further research by researchers interested in the topic, as well as provide alternative perspectives regarding the impact of sidewalk physical barriers on pedestrian walkability. The study area's pedestrian level of service and pedestrian walkability index may be used as an initial point for additional research. The result of the measurement is also used for existing local research on the sidewalk studies. On this research the walk score analysis and environmental aspects of sidewalk such as thermal comfort of sidewalk are not covered; this helps other researchers to explore in more in depth on this gap.

1.6. Scope of the Study

This research mainly focused on assessing the physical challenges of the sidewalk and its impact on pedestrian walkability on the selected arterial street segments of Adama. The scope of the study was limited to identifying the challenges of sidewalk physical factors, assessing its impact, and evaluating the sidewalk quality. The study mainly focused on the physical factors such as width, pavement, zoning, curb ramp, uneven walkway level change, path encroachment, street amenities, street vendors, gradient, and cleanliness. The walkability challenge was analysed using PLOS and the Walkability index method.

The spatial scope of the study was limited on Adama city arterial streets. This was on the four (4) selected sidewalk segments of the arterial street at Adama those were Franko, Mebrathayil, 04 kebele and Bole segments. The selected segments were from three zones classified by the researcher.

1.7. Limitation of the study

Regarding the limitations of the study, a few challenges were faced in conducting the research. The major challenges faced during the process of study were the lack of necessary instruments to collect pedestrian walkability index data such as pedestrian walking speed and density analysis. The other was the lack of previous studies on the topic, which has allowed further analysis. The shortage of available documents to the study, the absence of written documents about pedestrian walkways in Adama context, and also determining ways to take total population and sample size for pedestrian oriented research is not clearly stated. Additionally, the current and ongoing political instability in the country created an environment of fear, making people hesitant to participate and share information.

1.8. Organization of the paper

The thesis is organized into five chapters, each systematically and effectively examining the study's content and data. The first chapter of the research contains, an introduction, background of the study, statement of the problem, objectives as general and specific, research question significance, delimitation or scope of the study, limitation of the study, and at last an organization of the research were clearly stated.

In the second chapter border area of the research was examined, evaluated, and stated from different literature within the literature review. It contains an Introduction, basic conceptual definitions, and theoretical and empirical views of the research area were referred carefully. Chapter three discusses the tactic and materials used for this specific research. It explains the research approach, research design, research methods, methods for data collection, types and sources of knowledge and eventually, data analysis and presentation methods were discussed. Result and Discussion may be a chapter that discusses the results of qualitative and quantitative data findings. The subjective qualitative data are analysed and supported by a questionnaire survey, field observation notes, and printed documents from different sectors. The target quantitative data are analysed and supported by field observation, measurements of the physical feature of the walking environment, images, aerial photographs, topographic maps. Conclusion and recommendation are the concluding part of the thesis. The chapter made a conclusion that supported the findings from the literature review, the case study of Adama Street, and therefore the results of the discussions. Additionally, the study recommends the most effective pedestrian friendly sidewalk supported by urban design principles.

CHAPTER TWO

2. LITERATURE REVIEW

This section examines the existing literature on the sidewalk physical factors, their impact on pedestrian walkability and pedestrian safety, and the quality of the pedestrian sidewalk for a walkable pedestrian environment. It aims at acquiring available knowledge and identifying blank spots in relation to our research question. The results of this literature review will serve as the foundation for developing a conceptual framework for the provision of a walkable and inclusive sidewalk environment that serves all pedestrians, including the disabled and elderly.

2.1. Concept and Definition Terms

Walking

Walking is one of the most simple and inexpensive kinds of physical exercise. Walking is important for people's health since it can help them avoid illnesses including heart disease, diabetes, and hypertension (Shaaban K. , 2019). It is the first thing an infant wants to do and the last thing an elderly person wants to give up to taking small steps forward. For two-legged creatures, it means proceeding at a varying pace without running, always keeping one foot on the ground before lifting the other (Langen, 2001).

Walkability

Walkability measures how suitable an area is for walking, whether on a street or within a neighbourhood. The design and construction of a residential neighbourhood significantly impact its walkability. Enhancing walkability involves providing pedestrians with safe, comfortable, and accessible infrastructure (Shaaban K. , 2019).

Sidewalk

sidewalk means property between the curb lines in the lateral line of a roadway and adjacent property, set aside and intended for the use of pedestrians or such portion of private property parallel and in proximity to public highway and dedicated to use by pedestrians. (Revised Code of Washington (RCW), 1995). According to Dr Tom V. Mathew, 2014 Sidewalks are pedestrian lanes that offer people with a safe place to stroll in the public right-of-way, away from traffic. Children can also stroll, run, skate, ride bikes, and play in these areas.

Pedestrian

The term "pedestrian" describes anyone who walk, sit, stand in a public place or uses a wheelchair or stick for mobility. This includes children, youths, adults, elders, people with disabilities, shopkeepers and etc. (Agarwal & Chakravarti, 2014).

2.2. Pedestrian mobility and Sidewalk physical character

2.2.1. Travel or movement of people

Travel is defined as the movement of people between geographically distant locations by foot, bicycle, automobile, rail, boat, airline, or other methods, and can be one-way or round-trip. Short periods of time between movements might also be included in travel (Shaaban K. , 2019). Hillman et al (1973) defined mobility as "the capacity that a person has for getting around", also Tolley, R and B Turton (1995) noted that mobility depends on personal factors such as health and financial resources and upon the range of transport facilities that are available. Hence, mobility is personal and evolves throughout an individual's life, necessitating various types of transport services. Mobility and access are crucial for realizing one's potential in areas such as education, employment, and entertainment.

Why we travel? Humans travel for a variety of reasons, including recreation, tourism, or vacationing, research travel for information gathering, holiday travel to visit people, volunteer travel for charity, migration to start a new life somewhere else, religious and mission trips, business travel, trade, and other reasons such as health care or waging, or simply for the pleasure of travelling. Travel may occur by human powered transport such as walking or with vehicle (Lumsdon & Page(Eds), 2004).

2.2.2. Types of sidewalks

The literature on sidewalk types provides comprehensive insights into various designs that cater to distinct urban environments and pedestrian requirements. Traditional sidewalks, made of concrete or asphalt, are the most common, offering straightforward paths parallel to roads, essential for daily pedestrian movement (Southworth, 2005; Litman, 2013). Pedestrian malls, often found in commercial districts, create vibrant, car-free zones with seating, landscaping, and public art, promoting social interaction and economic activity (Gehl, 2010). Shared use paths are designed for both pedestrians and cyclists, facilitating active transportation in parks and urban connectors (Schlossberg et al., 2007). Raised sidewalks enhance pedestrian safety by providing elevation above street level, useful in areas with heavy traffic or flooding (Jacobsen, 2003).

Brick or paver sidewalks, favoured in historic districts, offer aesthetic appeal and ease of maintenance by replacing individual units as needed (Gallimore et al., 2011). Boardwalks, constructed from wooden planks, are typically found in coastal or park areas, providing a rustic, scenic route for recreational walking (Cervero & Kockelman, 1997). Permeable sidewalks, made from materials like porous concrete, support environmental sustainability by allowing water infiltration and reducing runoff (Zhu & Lee, 2008). Floating sidewalks, built on platforms over water, offer access to natural areas with minimal ecological impact, commonly used in wetlands and along riverbanks (Maas et al., 2009). Temporary or movable sidewalks ensure pedestrian access during construction or events, featuring modular designs for easy adjustment (Litman T. , 2013). Sidewalk cafés integrate dining spaces into urban sidewalks, enhancing street life and social interaction in vibrant city areas (Gehl, 2010).

The diversity of sidewalk types highlights the importance of tailored design approaches to meet the specific needs of different urban environments and user groups. By understanding the various types and their respective features and applications, urban planners and designers can create more effective and pedestrian-friendly urban spaces.

2.2.3. Sidewalk and Characteristics of Pedestrians

Pedestrian sidewalks and trails are more efficient when they are designed to meet the needs of all potential users. In order to create functional transportation networks, those responsible for building public sidewalks and trails must understand the needs of a diverse range of route users. The idea of a "typical pedestrian" is a mistake; in reality, pedestrians' travel speeds, endurance limitations, physical strength, size, and judging ability differ greatly. Children, seniors, families, and individuals with and without disabilities use the sidewalks and trails. (Peter, et al., 1999)

Individuals have different levels of mobility. Some people can climb mountains, while others are unable to cross a room on their own, even with the assistance of crutches or a wheelchair. In general, a person's capacity to reach a destination is determined by his or her speed, coordination, and endurance, as well as the types of obstacles, grades, and cross-slopes encountered along the journey. Accessibility standards, such as ADAAG or UFAS, provide minimal accessibility requirements that suit the needs of the majority of individuals. (Peter, et al., 1999)

Some design strategies may assist one group while restricting access to another. Installing ramps to assist wheelchair users, for example, might make walking more difficult for many cane and crutch users, who may find it simpler to negotiate short steps. Steps and a ramp should be provided whenever practicable to accommodate both usage groups. The needs and capabilities of all potential users should be considered and balanced when designing pedestrian facilities. (Peter, et al., 1999)

1. Older Adults

Improvements in quality of life, nutrition, and health care have increased the number of elderly people in the United States. By 2020, it is expected that 17% or more of the US population (almost one in every five) will be over the age of 65 (Peter, et al., 1999). Although aging itself is not a disability, according to the U.S. Census, in 1990 "most persons aged 75 or older had a disability" (U.S. Department of Commerce, Bureau of the Census, 1994). Many of the characteristics commonly associated with aging might limit mobility. Because the attenuated reflexes and physical limitations of older adults might prohibit them from driving automobiles, they are more likely to rely on public transit or walking than other adults (FHWA and NHTSA, 1996).

Older pedestrians are more susceptible than other pedestrians to suffer significant injury or death as a result of falling or traffic incidents. In general, older people require more frequent rest areas and prefer more private locations. Many older pedestrians, according to polls, are concerned about their personal safety. (Peter, et al., 1999)

2. Children

Children have fewer capabilities than adults because of their developmental immaturity and lack of experience. Young people, like elderly people, rely on public transit and walking more than others since they are unable to drive. On routes frequented by youngsters, such as those near schools or playgrounds, simple and easy-to-understand traffic flow patterns should be employed (Peter, et al., 1999).

3. People with Disabilities

According to the United States Census Bureau, one out of every five people in the country has a handicap (U.S. Department of Commerce, Bureau of the Census, 1994). Due to age, sickness, or accident, anybody can develop a temporary or permanent impairment at any time. In reality, 85 percent of Americans who live to their full life expectancy will be disabled for the rest of their lives (Peter, et al., 1999). Elders and disabled people are discouraged from walking long distances without stopping. Walking lengths were studied in depth in the 1980s, and the following are suggested based on the findings of these investigations.

Table 2-1: Recommended distance limit without rest for disabled

Impaired group	Recommended distance limit without rest
Wheelchair users	150m
Visually impaired	150m
Mobility impaired using stick	50m
Mobility impaired without walking aid	100m

Source: (Australian Disability discrimination act, 1995)

2.2.4. Elements of the sidewalk zone

The sidewalk zone is one of three primary street zones. It is typically situated directly adjacent to the edge of the public right-of-way. Sidewalks form the backbone of the pedestrian network, providing crucial access between private properties and streets. They are designed for walking and gathering, supporting a safe and accessible pedestrian environment (Street Design Guideline, 2021). Bicycles may use the sidewalk zone in limited locations outside of business districts or where shared use paths are present. Motor vehicles also may need to travel across the sidewalk zone to access private property via driveways or alleys (Otak, 1997). The sidewalk zone is divided into three main subzones: frontage zone, pedestrian clear zone, and boulevard and furnishing zone, which are described below.

A. Building Frontage Zone

The frontage zone is located immediately adjacent to the edge of the public right-of-way. This zone is essential for providing space for street users to interact with the surrounding environment. It allows for activities such as accessing building entrances, window shopping, and utilizing outdoor seating areas (Otak, 1997). Additionally, the frontage zone acts as a crucial buffer between the pedestrian clear zone and adjacent buildings, structures, or elevation changes. This buffer helps to enhance pedestrian safety by creating a clear separation between walking paths and potential hazards such as door swings, steps, and building projections. The frontage zone also contributes to the overall aesthetic and functional quality of the streetscape by accommodating landscaping, signage, and other elements that enrich the urban experience (Federal Highway Administration, 2010).

Potential uses in the frontage zone include landscaping, transit shelters, retail displays, sidewalk cafes, or other features that make the pedestrian environment more attractive (Street Design Guideline, 2021). Depending on available space inside the right-of-way, the building frontage zone in front of some buildings may become a pedestrian plaza, outdoor café, or meeting spot (Otak, 1997). For streets with commercial uses, it's important to allocate space in the frontage zone for sidewalk cafes, following the guidelines outlined in the Process and Criteria for Sidewalk Café Licenses (Street Design Guideline, 2021).

B. Pedestrian Clear Zone

The pedestrian clear zone is situated between the frontage zone and the boulevard and furnishing zone. This area is designated for pedestrian travel along streets and must remain free of obstructions, vertical discontinuities (such as protruding manhole or utility covers), slippery surfaces (like tree grates or slick metal), and non-compliant cross slopes (Street Design Guideline, 2021). The pedestrian clear zone serves as the Pedestrian Access Route, as defined by the Americans with Disability Act of 1990. The Pedestrian Access Route ensures a minimum passable space for those using mobility devices such as wheelchairs and provides predictability for those using other devices such as canes.

Maintaining a clear and consistent pedestrian clear zone is crucial for providing a safe, accessible, and comfortable walking environment for all users, including children, the elderly, and individuals with disabilities. This zone ensures that pedestrians can move freely without having to navigate around obstacles or uneven surfaces, thereby promoting a more efficient and enjoyable walking experience (Federal Highway Administration, 2010). If the travel way is an accessible route, the minimum required clear space for this zone, free of obstacles and protrusions, is 0.9 meters (3 feet), but it is preferable to provide as much clear space for pedestrian travel as possible, especially in urban areas with higher volumes of pedestrian traffic. A 1- meter (3-foot) wide area is not sufficient for use by more than one person. For this reason, the pedestrian travel zone on downtown streets should typically be 1.8 to 3.0 meters (6 to 10 feet) wide or greater in areas where high volumes of pedestrians are anticipated (Otak, 1997).

C. Boulevard and Furnishing Zone/ Fixtures or planting zone

The boulevard and furnishing zone is situated between the pedestrian clear zone and the bikeway or roadway zone. This area serves multiple purposes, providing space for pedestrians to gather or wait for transit, and accommodating trees, landscaping, and greening. It also includes furnishings, signs, wayfinding elements, streetlights, street signal infrastructure, utility cabinets, bicycle and scooter parking, electric vehicle charging stations, and the curb. Additionally, this zone acts as a buffer, separating pedestrians from motor vehicles to enhance safety (Street Design Guideline, 2021). To minimize obstacles in the pedestrian travel path and enhance the area's aesthetic appeal, it is advisable to consolidate utilities, street furniture, and other features within the boulevard and furnishing zone whenever possible. This approach reduces barriers that could impede pedestrian movement and ensures a clear and unobstructed pedestrian clear zone. By strategically placing items such as benches, trash receptacles, streetlights, utility cabinets, and bicycle racks within this designated area, the overall organization and visual coherence of the streetscape are improved. Additionally, this consolidation helps in maintaining an orderly and visually pleasing environment, making the sidewalk more accessible and enjoyable for all users (Otak, 1997).

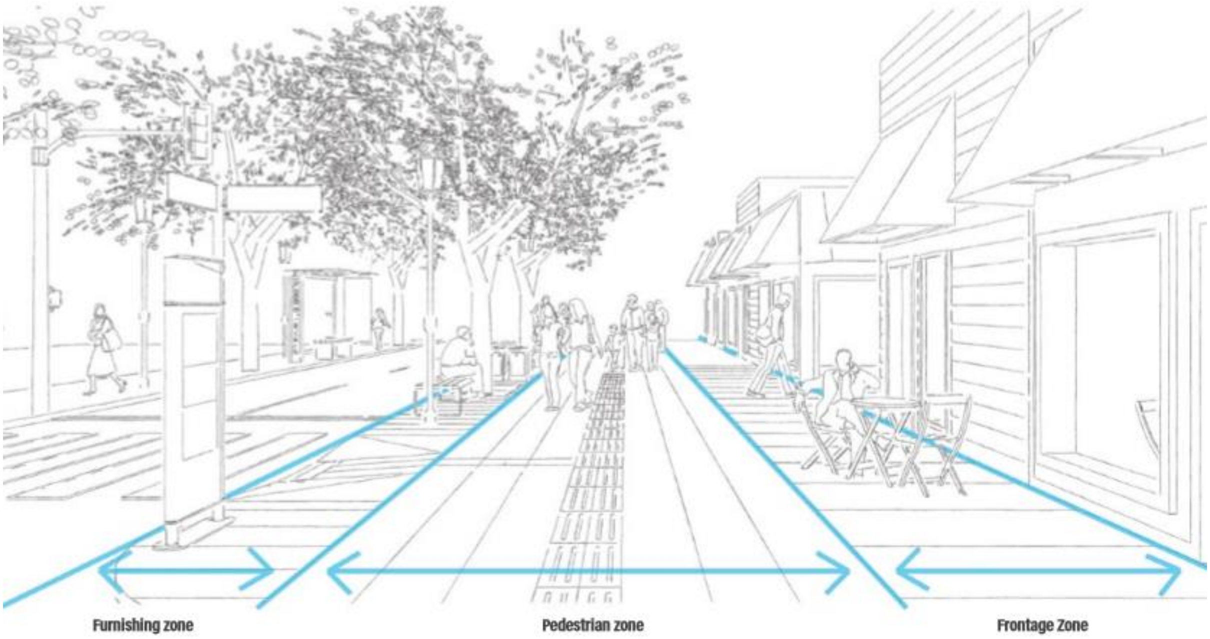


Figure 2.2-1: Zones of Sidewalk Corridor (The 8 principles of sidewalks, 2019)

2.2.5. Sidewalk design consideration

Sidewalk physical design necessitates careful attention to various factors ensuring safety, accessibility, and functionality for all users. Here are key principles to guide the design of sidewalks:

A. Sidewalk width

The width of pedestrian sidewalks is crucial in urban design, impacting safety, accessibility, and the overall pedestrian experience. Adequate sidewalk width allows for various pedestrian activities, fosters social interactions, and ensures adherence to accessibility standards. Research and guidelines from urban planning and transportation authority's emphasize the importance of minimum width requirements for sidewalks. According to the Americans with Disabilities Act (ADA) standards, the minimum accessible route for sidewalks is 1.2 meters (4 feet) to ensure wheelchair accessibility (ADA, 2010). However, this minimum width is often insufficient in high-traffic areas.

Studies suggest that wider sidewalks significantly enhance pedestrian comfort and safety. In urban areas with high pedestrian volumes, widths of 1.8 to 3.0 meters (6 to 10 feet) are recommended (Southworth, 2005). This increased width accommodates multiple pedestrians walking side by side, reduces congestion, and allows for the integration of street furniture and landscaping without obstructing pedestrian flow.

Several factors influence the appropriate width of sidewalks, including pedestrian volume, land use, and street context. High-density commercial districts require wider sidewalks to handle increased foot traffic and activities such as outdoor dining and street vending (Jacobs, 1993). Guidelines for sidewalk zones differ by street type to accommodate the diverse contexts found throughout the city (Street Design Guideline, 2021).

Type of the street	Frontage zone	Pedestrian clear zone	Boulevard and furnish zone
Urban neighborhood	2'+ or (60cm)	6' (1.8m)	5'+ or 1.5m above
Production & processing	2'+ or (60cm)	6' (1.8m)	5'+ or 1.5m above
Mixed use community connector	2'+ or (60cm)	6' – 8' (1.8m-2.5m)	5'+ or 1.5m above
Mixed use commercial zone	2'+ or (60cm)	6' – 10' (1.8m-3m)	6'+ or 1.8m above
Downtown core	2'+ or (60cm)	8' – 10' (2.5m-3m)	6'+ or 1.8m above
Parkway	2'+ or (60cm)	6' – 8' (1.8m-2.5m	6'+ or 1.8m above

Table 2-2: sidewalk zone width at different street type. (source: Street Design Guideline, 2021)

B. Surface material

Selecting the surface material for sidewalks is an important aspect influencing durability, safety, accessibility, and overall pedestrian comfort. This review explores key considerations and recommendations from the literature on choosing suitable surface materials for sidewalks.

Durability is a primary concern in the selection of sidewalk materials. Materials must withstand varying weather conditions, heavy foot traffic, and potential impacts from vehicles. Concrete is widely recommended due to its high durability and low maintenance requirements (FHWA, 2010).

Accessibility standards, such as those outlined in the Americans with Disabilities Act (ADA), require sidewalks to have surfaces that are firm, stable, and slip-resistant. These standards ensure that sidewalks are navigable by all users, including those with mobility aids such as wheelchairs and walkers (ADA, 2010). Tactile paving is often used at crosswalks and curb ramps to aid visually impaired pedestrians. Selecting the appropriate surface material for sidewalks involves balancing durability, safety, accessibility, aesthetics, environmental impact, and cost. Concrete remains the preferred choice for many urban environments due to its durability and low maintenance needs, while permeable and recycled materials are increasingly considered for their environmental benefits.

C. Slope and Cross-slope

Slope and cross-slope are critical factors in sidewalk design, impacting accessibility, safety, and drainage. The Americans with Disabilities Act (ADA) sets specific requirements for sidewalk slope and cross-slope to ensure accessibility. According to ADA standards, the maximum cross-slope for sidewalks is 2% (1:50), which allows water to drain off the surface without posing a challenge to wheelchair users (ADA, 2010). The running slope, or the slope along the direction of travel, should not exceed 5% (1:20) unless the sidewalk is part of a ramp, in which case additional ramp requirements apply. A well-designed slope facilitates effective drainage, reducing the likelihood of ice formation in colder climates and minimizing puddles and slick spots during rain (FHWA, 2010). Furthermore, excessive slopes can make sidewalks difficult to navigate for individuals with mobility impairments, increasing the risk of accidents and falls. According to most rules, an 8 percent slope is the most that may be utilized; anything more than that may pose problems for manual wheelchair users. The majority of guidelines also agree that a drainage rate of 5% is ideal. For many manual wheelchair users, anything less than 2.5 percent is difficult (Highways Agency, 2010). The effects of different gradients are as shown on Table below.

Table 2-3: Effects of gradient on pedestrian

Gradients	Effects
1% (1 in 100)	Never an obstacle.
2% (1 in 50)	Can be managed by most people and also provides good drainage.
2.5% (1 in 40)	Can be managed by many people.
>2.5%	Impossible for many manual wheelchair users.
8% (1 in 12)	Absolute maximum. Not only the physical effort of getting up a steeper gradient beyond many wheelchair users, but also there is a risk of the wheelchair toppling over.

Source: Design compliance assessment guide final version, March 2010

Designers must carefully balance slope and cross-slope requirements with the surrounding topography and urban environment. In hilly areas, it may be necessary to incorporate switchbacks or zigzag paths to keep slopes within acceptable limits while ensuring accessibility (Gehl, 2010). Additionally, integrating ramps with appropriate handrails and landings can help manage elevation changes without exceeding the maximum allowable slopes. Slopes greater than 5% can cause difficulties for wheelchair users and those with limited mobility, while cross-slopes exceeding 2% can create a tilting effect that is uncomfortable and potentially hazardous (Jacobs, 1993).

D. Clear path

A clear path on sidewalks is essential for ensuring the safety, accessibility, and comfort of all pedestrians. This review examines the significance of maintaining an unobstructed pedestrian pathway, the standards and guidelines for clear paths, and the challenges and solutions associated with achieving this goal. The concept of a clear path refers to a continuous, unobstructed route that allows pedestrians to walk without encountering physical barriers. A clear path is crucial for the mobility of all users, particularly those with disabilities, the elderly, and parents with strollers (Southworth, 2005).

Accessibility standards, such as those set by the Americans with Disabilities Act (ADA), specify the requirements for clear paths on sidewalks. The ADA mandates a minimum clear width of 0.9 meters (3 feet) for accessible routes, although wider paths are recommended in areas with high pedestrian traffic (ADA, 2010). Clear paths must be free of obstructions, including street furniture, utility poles, and overgrown vegetation. Urban environments present several challenges in maintaining clear paths. Encroachments from businesses, such as sidewalk cafes, street vendor and displays, can obstruct pedestrian routes. Similarly, poorly placed street furniture, utility installations, and inadequate maintenance can create barriers. (FHWA, 2010).

Several strategies can be employed to ensure clear paths on sidewalks. Clearly designate pedestrian zones and use zoning regulations to control the placement of street furniture and commercial encroachments. The frontage zone can be used for activities like outdoor dining, while the pedestrian clear zone remains free of obstacles (ITE, 2010). The other is implementing regular maintenance schedules to address issues such as overgrown vegetation, snow removal, and repair of damaged surfaces. Promptly address any encroachments or obstructions that arise (Southworth, 2005). Increase public awareness about the importance of keeping sidewalks clear. Enforce regulations to prevent businesses and individuals from obstructing pedestrian pathways, which may involve fines or other penalties for non-compliance (Gehl, 2010).

E. Accessibility

Accessibility on sidewalks are crucial for creating inclusive urban spaces that accommodate all individuals, including those with disabilities, the elderly, and parents with strollers. Key features include curb ramps with a maximum slope of 1:12 and a minimum width of 0.9 meters, tactile paving for visually impaired pedestrians, auditory signals and accessible pedestrian signals (APS) for those with visual and hearing impairments, and smooth, non-slip surfaces that meet ADA requirements (ADA, 2010). Additionally, sidewalks should have adequate width and clear paths, with a recommended minimum clear width of 1.2 meters, and proper lighting to enhance visibility and safety, particularly at night (Gehl, 2010). Clear, accessible wayfinding and signage, including braille and raised characters, assist with navigation.

F. Street Furniture and Amenities

Street furniture and amenities play a crucial role in enhancing the functionality, comfort, and aesthetic appeal of urban sidewalks. This review explores the significance of street furniture and amenities, common types, design considerations, and their impact on pedestrian experience. Street furniture and amenities contribute to the overall livability and usability of urban sidewalks. They provide resting places, shelter from the elements, and opportunities for social interaction, enhancing the pedestrian experience and promoting active street life (Gehl, 2010). Street furniture and amenities are integral components of urban sidewalk design, enriching the pedestrian experience and contributing to the vitality of public spaces.

G. Landscaping

Landscaping plays a vital role in enhancing the aesthetic appeal, environmental quality, and usability of urban sidewalks. Landscaping significantly contributes to the overall ambiance and functionality of urban sidewalks. It provides numerous benefits, including improved air quality, reduced urban heat island effects, increased biodiversity, and enhanced psychological well-being for pedestrians (Gehl, 2010). Additionally, well-designed landscaping can create attractive and inviting public spaces, encouraging more people to walk and engage with their surroundings.

2.2.6. Sidewalk Accessibility features

Accessibility features on sidewalks are essential for creating inclusive urban environments that cater to all individuals, including those with disabilities, the elderly, and parents with strollers. Accessibility features ensure that sidewalks are navigable, safe, and comfortable for everyone. They enable people with mobility impairments to travel independently and safely, thus promoting social inclusion and enhancing quality of life (Southworth, 2005). Accessibility features such as curb ramps, tactile paving, and auditory signals allow individuals with disabilities to navigate sidewalks and intersections independently. This independence is crucial for accessing employment, education, healthcare, and social opportunities (ADA, 2010).

1. Curb Ramps

Curb ramps, also known as curb cuts, are sloped transitions between sidewalks and street crossings that are essential for creating accessible urban environments. Curb ramps are critical for providing accessibility to sidewalks and pedestrian pathways for individuals with mobility impairments, including wheelchair users, the elderly, and parents with strollers. They enable these individuals to navigate transitions between sidewalks and streets safely and independently, thereby promoting social inclusion and equal access to public spaces (ADA, 2010).

Design Standards for Curb Ramps

The Americans with Disabilities Act (ADA) specifies that the maximum slope for curb ramps should be 1:12 (8.33%). This standard ensures that ramps are not too steep, making them manageable for wheelchair users and others with limited mobility (ADA, 2010). Maintain consistent slopes throughout pedestrian pathways to avoid abrupt changes that can create hazards. This provides smooth transitions between different slope grades, particularly at the junctions of sidewalks and curb ramps (ITE, 2010). It also Includes level landing areas at the top and bottom of slopes and curb ramps to allow users to rest and safely maneuver. A variety of curb ramp designs contain some or all of the above components.

Landing – The area at the back of the sidewalk, in the middle of the curb ramp. Landings allow the wheelchair user to move around the intersection corner without using the curb ramp. The recommended minimum landing width is 1.2 meters and maximum grade is 2 percent.

Approach – The area on each side of the landing, extending from the back to the front of the sidewalk.

Flare – The transition area between the curb ramp and the approach areas. It is desirable that the slope on the flare not exceed 8 percent.

Ramp – The sloped transition between the landing and the curb. To meet accessibility guidelines, the curb ramp grade should not exceed 8 percent. The preferred width of the curb ramp should be at least 1.2 meters, not including the width of the flairs (Federal of Canadian Municipality and National Research Council, 2004).

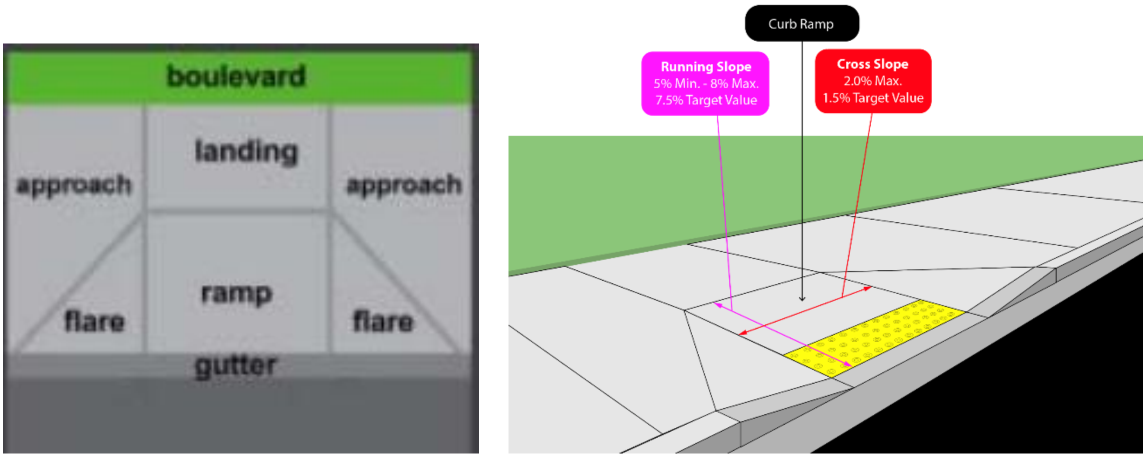


Figure 2-1: Curb ramp components

2. Tactile pavement

Tactile paving, also known as detectable warning surfaces, is a vital component of accessible sidewalk design. These textured ground surfaces provide essential information to visually impaired pedestrians, helping them navigate public spaces safely. Tactile paving plays a crucial role in enhancing the independence and safety of visually impaired individuals by providing sensory cues about their environment. These cues help in identifying key features such as curb edges, pedestrian crossings, and hazards, thereby facilitating safer and more confident navigation through urban areas (Crabb, 2002).

Tactile paving typically features two main patterns: truncated domes for warning of hazards or street crossings, and directional bars for guiding pedestrians along safe paths. These patterns provide distinct tactile feedback that can be easily recognized and interpreted by visually impaired individuals (RNIB, 2011). Tactile paving should have high contrast in color relative to the surrounding pavement to be visible to partially sighted individuals (FHWA, 2013). Tactile paving should be installed at key locations such as pedestrian crossings, transit platforms, and building entrances (TIA, 2005).

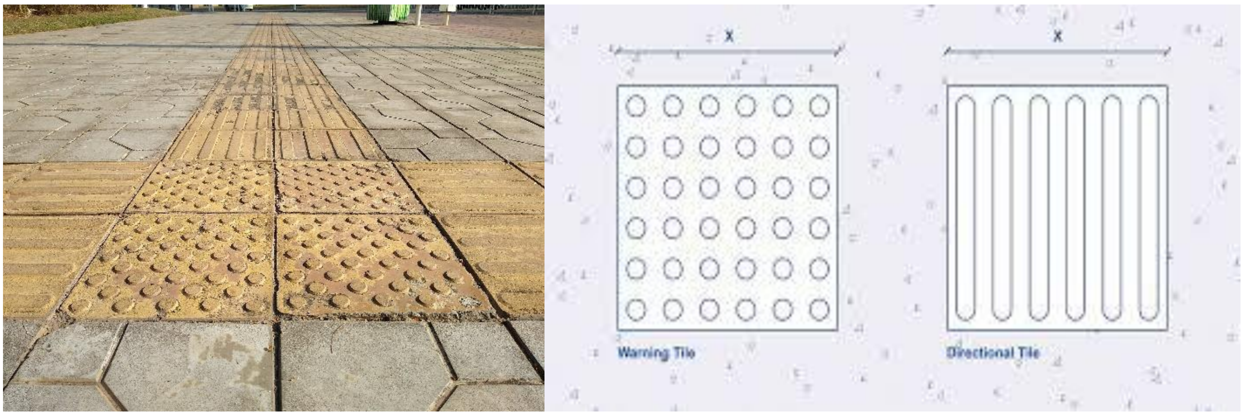


Figure 2-2: Warning tile and directional tile of tactile pavement (Source: Global street design Guide, 2016)

3. Auditory signals

Auditory signals, also known as audible pedestrian signals (APS), are an essential component of accessible urban infrastructure. These devices provide auditory cues to assist visually impaired pedestrians in navigating street crossings and other public spaces. Auditory signals play a critical role in enhancing the safety and independence of visually impaired pedestrians. These signals provide important information about the timing and status of pedestrian crossings, such as when it is safe to cross the street. By doing so, they help reduce the risk of accidents and improve the overall walkability of urban environments for individuals with visual impairments (Bentzen & Barlow, 1995).

2.2.7. Norms and Standards of Addis Ababa

According to the Norms and Standards of the Addis Ababa structure plan from September 2017, pedestrian sidewalks must be provided on both sides of arterial streets and should be elevated 15-20 centimeters above the carriageway. The pedestrian capacity on a sidewalk should range from a minimum of 30 to a maximum of 50 persons per minute per meter of width, after accounting for approximately 0.9 meters of dead width in shopping areas and 0.45

meters elsewhere. The width of pedestrian sidewalks should be 2.5-4 meters on one side of a sub-arterial street and 3.5-5 meters alongside a principal arterial. The gradient of continuous ramps should not exceed 10%, and a minimum height of 2.3 meters should be provided for pedestrian pathways.

Additionally, the average width of pedestrian sidewalks varies depending on the adjacent land use according to the Norms and Standards of the Addis Ababa structure plan from 2017. In industrial areas, the sidewalks are typically 1.8 meters wide to accommodate basic pedestrian traffic. In shopping frontages, the sidewalks are wider, ranging from 3.7 to 4.5 meters, to support higher foot traffic and enhance the shopping experience. In business and commercial areas, the sidewalks are designed to be 3 to 5 meters wide, ensuring ample space for pedestrians in bustling commercial districts. Along all-purpose roads, the sidewalks are generally 2.7 meters wide, balancing the needs of various types of pedestrian traffic. These dimensions are designed to ensure safety, accessibility, and comfort for pedestrians in different urban contexts (Addis Ababa structure plan components, 2017).

Table 2-4: Addis Ababa standard size of sidewalk

No	Type of Street	Width in meters of sidewalk
1	Principal Arterial	7 m - 10 m both side
2	Sub-arterials	3.4 – 4m both sides
3	Collector Streets	Should not be less than 2.00m
4	Local Streets	Should be decided based on local condition

Source: (Norms and standards of the Addis Ababa structure plan components, 2017)

2.3. Evaluation of Sidewalk Physical Factors

Introduction

Evaluating the physical factors of sidewalks is crucial for understanding their impact on pedestrian mobility, safety, and overall urban accessibility. This review examines key physical factors, their implications for pedestrian use, and the standards and methodologies for assessing these factors to ensure effective and inclusive sidewalk design.

2.3.1. Sidewalk Physical Challenges

Several studies have focused on identifying and analyzing sidewalk physical challenges in urban areas. Research by Eunyoung Choi, 2012 found that narrow widths, damaged surfaces, and obstructions such as parked vehicles and street vendors significantly impact pedestrian walkability. Furthermore, (Marshall, 2010) noted that uneven surfaces, inadequate lighting, and lack of accessibility features contribute to decreased walkability and safety.

Evaluating the physical challenges of sidewalks is crucial for understanding their impact on pedestrian mobility, safety, and overall urban accessibility. Sidewalks that are too narrow create congestion and limit accessibility, forcing pedestrians to walk on the street, increasing the risk of accidents (Southworth, 2005). Poor surface conditions, such as cracks, uneven surfaces, and potholes, create tripping hazards and discomfort, particularly for the elderly and those with mobility impairments (Gehl, 2010). Obstructions like utility poles, signage, parked cars, and street furniture further reduce the effective width of sidewalks, complicating navigation. Inadequate lighting makes sidewalks less safe at night, increasing the risk of accidents and deterring nighttime walking (FHWA, 2013).

Addressing these physical challenges is essential for enhancing pedestrian mobility, safety, and accessibility. Strategies include widening sidewalks to accommodate higher pedestrian volumes, improving surface conditions through regular maintenance, and removing obstructions by optimizing sidewalk space. Enhancing lighting in high-traffic and high-crime areas, ensuring proper slope design, and incorporating accessibility features like curb ramps and tactile paving are also critical (Marshall, 2010).

2.3.2. Effective Walkway Width

The portion of a pedestrian facility's width that is used for pedestrian circulation is called the effective width. The degree to which single obstructions, such as poles, signs, and hydrants, influence pedestrian movement and reduce effective walkway width is not extensively documented. Although a single point of obstruction would not reduce the effective width of an entire walkway, it would affect its immediate vicinity (Lenters, 2010).

2.3.3. Pedestrian Behavior and Perception

Recent studies have examined the link between perceived walkability and sidewalk quality, mostly counting on non-quantitative pedestrian facility assessment criteria. Sidewalk width, a buffer between sidewalk and street, and therefore the presence of amenities are predictors of pedestrian travel, perceived safety, and quality of the pedestrian environment. Effective sidewalk width, pavement condition, and material composition were important variables for sidewalk accessibility supported perceived importance to wheelchair users (Marshall, 2010).

Understanding pedestrian behavior and perception is essential in evaluating the impact of sidewalk physical challenges. Marshall, 2010 investigated pedestrian behavior in response to sidewalk physical challenges and found that pedestrians often alter their walking patterns to avoid obstacles, resulting in longer routes and potential detours. Moreover, (Gehl, 2010) highlighted the influence of sidewalk conditions on perceived safety and overall satisfaction with the walking experience, emphasizing the need to address physical challenges for improved walkability.

2.4. Pedestrian Walkability Index

Introduction

The Pedestrian Walkability Index (PWI) is a comprehensive measure used to evaluate the walkability of urban environments. Unlike simpler tools, the PWI incorporates multiple factors influencing pedestrian experiences, including infrastructure quality, safety, connectivity, and accessibility. This review examines the components, methodologies, significance, and challenges associated with the Pedestrian Walkability Index, highlighting its role in urban planning and public health.

2.4.1. Pedestrian Level of Service

One of the major methods for evaluating the challenges and accessibility of pedestrian sidewalks is the Pedestrian Level of Service (PLOS). The concept of "Level of Service" (LOS) pertains to an evaluation method that assesses the quality and effectiveness of sidewalks based on various considerations and quantitative measures. The major factors that are included under this category are, inadequate width of walkways, poor sidewalk conditions, and encroachments along the footpaths (Harkey & Zegeer, 2004). Additionally, obstructions on sidewalks, the lack of crossing facilities, and the parking of vehicles on footpaths further impede pedestrian movement (Landis, Vattikuti, & Brannick, 2001). Discontinuities along footpaths and the absence of pedestrian refuge islands also contribute to the challenges pedestrians face, significantly impacting their overall walkability experience. PLOS qualitatively represents the status of these factors for a specific time and location. These conditions are categorized using levels from A to F, where A indicates high levels of comfort and/or available capacity, while F indicates severe congestion and discomfort on that particular section of the sidewalk (Hediye Tuydes-Yaman and Pınar Karataş, 2018).

The other evaluation method is HCM, high way capacity manual. This method is used for analyzing different means of transportation. It is based on the pedestrian traffic flow and the width of sidewalk space. According to HCM, the speed of pedestrian is inversely proportional to pedestrian volume and density. As the density and volume increase, the speed of pedestrian's decline.

Table 2-5: Models of LOS by different researchers

Authors	Indicators LOS	Grade
Sarkar (1993)	(1) Safety, (2) Security, (3) Convenience and Comfort, (4) Continuity, (5) System Coherence, (6) Attractiveness	A-F
Khisty (1994)	(1) Attractiveness, (2) Comfort, (3) Convenience, (4) Safety, (5) Security, (6) System Coherence, (7) System Continuity	A-F
Dixon (1996)	(1) Provision of Basic Facilities, (2) Path Conflicts, (3) Amenities , (4) Motor vehicle LOS, (5) Maintenance Problems, (6) Provision for multiple modes	A-F
Gallin (2001)	(1) Path Width, (2) Surface Quality, (3) Obstructions, (4) Crossing Opportunities, (5) Support Facilities, (6) Connectivity, (7) Path Environment, (8) Potential for Vehicle Conflict, (9) Pedestrian Volume, (10) Mix of Path Users, (11) Personal Security	A-F
Nelson & Zaly Shah (2010)	(1) Amenities, (2) Maintenance, (3) Pedestrian Paths, (4) Conflicts, (5) Pavement Material, (6) Security Perception, (7) Comfort, (8) Traffic Volume In The Adjacent Car Lane	A-F
Asadi-Shekhari & Zaly Shah (2013)	(1) Slope, (2) Elevator, (3) Curb ramp, (4) Wheelchair accessible drinking fountain, (5) Tactile pavement (guiding), (6) Tactile pavement (warning), (7) Ramp, (8) Toilet, (9) Grade, (10) Signal	A-F

Source: (Safizahanin Mokhtar,Tetsuo Shimizu, Nabila Abdul Ghani, 2015)

The Australian model developed by Gallin was chosen for two primary reasons. First, it includes a greater number of factors for determining the level of service. Additionally, all the factors outlined in this model are observable on the pedestrian sidewalks of the selected arterial streets in Adama. This makes it particularly relevant and applicable to the context of this study.

2.4.2. Factors affecting level of service

According to Gallin, 2001 the level of service on pedestrian sidewalks is determined by three major categories of factors: physical factors, location factors, and user factors. Physical factors include elements such as the width and surface condition of the sidewalks. Location factors consider the surrounding environment, including the presence of nearby commercial areas or traffic conditions. User factors involve the characteristics and behaviors of the pedestrians themselves, such as pedestrian density and walking speed. Together, these categories encompass a total of eleven specific elements that need to be studied to comprehensively evaluate the pedestrian level of service.

Design factors (Physical characteristics)

The factors include measurements of the path width available for pedestrians and the surface quality of the path, where excellent quality is defined by a continuous, smooth, but skid-resistant surface. Obstructions are measured by the number of distracting obstructions per kilometer on the path being assessed. This is crucial for determining whether sidewalks are accessible for people with disabilities. Obstructions can be permanent (e.g., poles, signs, chairs) or temporary (e.g., bins, parked cars). Stairs are considered obstructions if no alternative route is available for people with mobility disabilities.

Additionally, crossing opportunities are evaluated by the type and number of facilities provided to assist pedestrians in safely crossing roads and paths. This includes median refuges, pelican crossings, guarded crossings, crosswalks, underpasses, and overpasses, with 'delay in crossing' being a characteristic of this factor. Support facilities refer to the presence of amenities that assist pedestrians during their journey, such as tactile paving, color contrast curbing, rest stops, curb ramps, lane markings, signage, and landings on long ramps (Gallin, 2001).

Location factors

Connectivity is one of the major sub-factors under this category, assessing the extent to which sidewalks provide connections and links to critical points of departure and arrival. The second sub-factor is Path Environment, which measures the quality of the path environment as influenced by its surroundings. The degree of 'pleasantness' often correlates with the distance from the roadway.

The third sub-factor, Potential for Vehicle Conflict, involves counting points where conflicts between vehicles and sidewalks can occur, such as driveways and intersections. This is measured over every kilometer. The potential for pedestrian conflict increases with the frequency of intersections and driveways (Gallin, 2001).

User factors

This factor includes three sub-factors. The first is Pedestrian Volume, which involves counting or estimating the number of pedestrians using the path, expressed as an average daily count. The second sub-factor is the Mix of Path Users, which estimates the various groups using the path as a percentage of the total pedestrian count. These groups include pedestrians, cyclists, roller-skaters, and more. When assessing this factor, it's important to consider different types of pedestrians, including recreational users and those with a purpose, such as people walking to work or shops.

The last sub-factor is Personal Security, which qualitatively measures how safe the path feels for users. This includes considerations such as the provision of sufficient lighting, visual permeability from the surrounding environment, and sight distance. Ensuring these elements can significantly enhance the safety and comfort of the sidewalk for all users (Gallin, 2001).

Table 2-6: Australian method PLOS grading scale

NO	Grade Scale	Description	Conditions
1	A	Factors affecting the pedestrian sidewalk are minimized. This grade level is considered as an ideal condition for pedestrian environment.	Ideal
2	B	This level of grade is considered as standard, in which reasonable pedestrian conditions are present with few number of factors pose impacts affecting the safety and comfort.	Standard
3	C	This grade level shows basic pedestrian sidewalk environment exists making the sidewalk environment with significant amount of factors creating negative impact on pedestrian safety and comfort.	Basic
4	D	This grade level shows poor pedestrian conditions exist with high amount of factors which negatively affects pedestrian safety and comfort. The accessibility of sidewalks and safety of pedestrian's are highly compromised.	Poor
5	E	This grade level shows that all the level of service factors are below acceptable standards making the sidewalk environment unsuitable	Unsuitable

Source: (Gallin, 2001)

The following three tables are assessment sheets for the Australian Model used to determine the Level of Service (LOS) for pedestrians according to the Australian method. The Australian model comprises three assessment sheets, each containing various factors under the main categorical factors. These factors are labeled with their respective weights and point values based on sidewalk conditions.

Table 2-7: Physical/ design factor grading

Category	Factor	Weight	Point 0	Point 1	Point 2	Point 3	Point 4
Design factors	Path width	4	No pedestrian path	0-1m	1.1 - 1.5m	1.6 - 2.0m	more than 2m wide
	Surface quality	5	Uncovered and/ or a lot of cracks	poor quality	moderate quality, i.e. some cracks/ bumps etc	reasonable quality, i.e. acceptable standard	Excellent quality (continuous surface with very few cracks etc.
	Obstructions	3	more than 21 obstructions per km	between 11 and 20 obstructions per km	between 5 and 10 obstructions per km	between 1 and 4 obstructions per km	No obstructions
	Crossing opportunities	4	none provided, difficult to cross	some provided but poorly located	Some are reasonably provided and located but more are required	Sufficient crossing facilities are reasonably provided and located OR none are rendered considering them unnecessary	pedestrian crossing facilities are given at sufficient frequency
	Support Facilities	2	non existent	few provided and poorly located	few provided and reasonably well located	several provided and well located OR absent but unnecessary	many provided and well located

Source: (Gallin, 2001)

Table 2-8: Location factor grading

Category	Factor	Weight	Point 0	Point 1	Point 2	Point 3	Point 4
Location on factors	Connectivity	4	None existent	Poor	Reasonable	Good	Excellent
	Path Environment	2	unpleasant environment, close to vehicular traffic	poor environment, may be within 1m of curb	acceptable environment, between 1 and 2m of curb	reasonable environment, between 2 and 3m from curb	pleasant environment, pedestrians more than 3m from curb
	Potential for Vehicle Conflict	3	unpleasant environment, close to vehicular traffic	poor situation	10 to 15 potential vehicle conflict points per km is moderate	1 to 10 or less conflict points per km is reasonable	pleasant environment, pedestrians more than 3m from curb

Source: (Gallin, 2001)

Table 2-9: User factor grading

Category	Factor	Weight	Point 0	Point 1	Point 2	Point 3	Point 4
User Factors	Pedestrian Volume	3	More than 350 per day	226 to 350 per day	151 to 225 per day	81 to 150 per day	Less than 80 per day
	Mix of Path Users	4	majority of path users are non-pedestrians	approx. 51% to 70% of path users are non-pedestrians	between 21% and 50% non-pedestrian path users	less than 20% non-pedestrians	pedestrians only
	Personal Security	4	unsafe	Poor	Reasonable	Good	excellent security provided

Source: (Gallin, 2001)

The Pedestrian Level of Service is a valuable tool for assessing and enhancing sidewalk physical challenges and the quality of pedestrian environments. By considering factors such as sidewalk quality, width, safety, connectivity, and pedestrian density, PLOS provides a comprehensive measure of pedestrian-friendliness. Despite challenges related to data accuracy, context sensitivity, and resource requirements, PLOS remains essential for urban planning and sustainable development. Continuous refinement and application of PLOS can lead to more inclusive, healthy, and vibrant pedestrian Environment.

2.5. Empirical Literature Review

Pedestrian-friendly and walkable sidewalks are crucial for enhancing urban mobility, safety, and the overall quality of life. This literature review examines one empirical studies that evaluate the characteristics, benefits, and challenges of pedestrian-friendly and walkable sidewalks, emphasizing their importance in urban planning and design.

Walkable Sidewalks in Copenhagen, Denmark

Jensen and Nielsen (2008) conducted a comprehensive study to evaluate the walkability of sidewalks in Copenhagen, Denmark. Utilizing a mixed-method approach, the researchers carried out field surveys to assess sidewalk conditions, including width and surface quality, and conducted pedestrian counts and behavioral observations to gauge usage patterns.

The study found that well-designed and maintained sidewalks, free of obstructions, with green spaces, street furniture, and adequate lighting, significantly enhanced walkability. Safety features such as pedestrian signals, curb ramps, and tactile paving were crucial, particularly for vulnerable groups. Sidewalks integrated with public transport facilities saw increased usage, highlighting the importance of connectivity. Overall, high levels of pedestrian satisfaction were reported in areas with comprehensive sidewalk infrastructure.

2.6. Gaps of literature review

In the literature review, a substantial number of papers were examined, focusing on pedestrian comfort, accessibility, and safety. These studies highlighted various physical challenges of sidewalks, identifying them within their specific contexts. However, there is a notable scarcity of comparative studies between Adama City and other cities in Ethiopia with similar contexts. Furthermore, the impact of cultural and social dynamics on sidewalk physical challenges within the local context of Adama City remains underexplored. By addressing these gaps, these research can provide a significant contribution to the understanding and improvement of pedestrian walkability in Adama City.

CHAPTER THREE

3. METHODS AND MATERIAL

This chapter provides a comprehensive outline of the study area, specifying the types of information required and the sampling techniques employed. It details the methods and tools used for data collection, ensuring a systematic approach to gathering relevant data. Additionally, the chapter describes the analytical techniques employed to interpret the collected data, addressing the research questions and achieving the study's objectives.

3.1. Description of the study area.

The study area was located in Adama city, in the East Shewa zone of Oromia regional state. Adama is located in the central part of Ethiopia, 99km south-east of the capital, Addis Ababa. The absolute geographic location of Adama city is 8.5263° North latitude 39.2583° East longitudes with elevation of 1712 meter above sea level. The study was mainly conducted on the sidewalk along the arterial street of Adama.

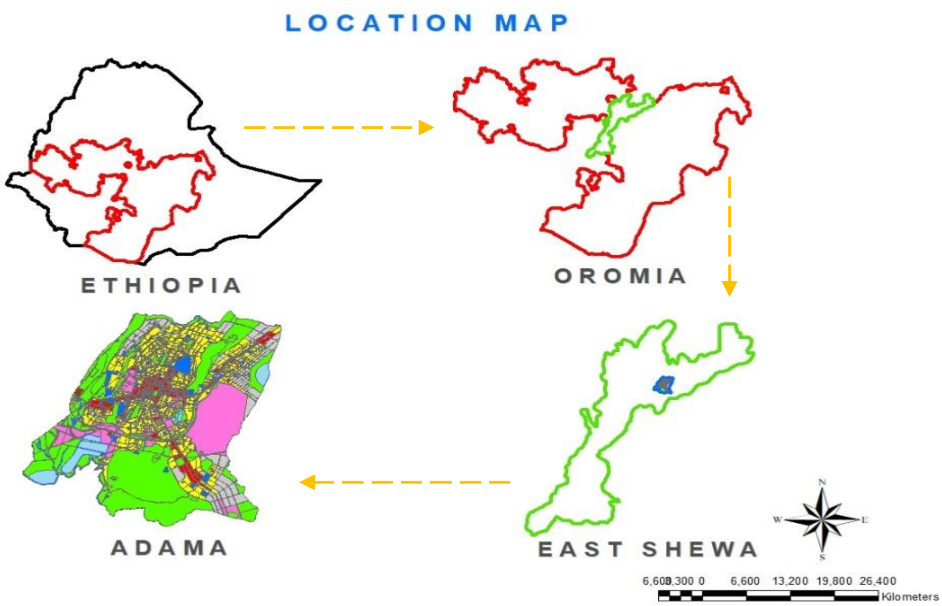


Figure 3-1: Location Map of Adama city (Source: Prepared by Author)

3.1.1. Site selection criteria

Various streets with different conditions were selected to test the developed method. This was crucial as it is important to select communities in a manner that properly represents different types of communities in the city. For this reason, the method was tested using data from different streets in Adama city.

The researcher divides the city into five zones based on the concentric zone model. However, based on his sample survey, sidewalk characteristics within zone 3, 4, and 5 were relatively close to one another. According to this, the pedestrian sidewalks were classified into three basic zones. The three zones were: commercial business district (CBD), transition zone, and residential zone (intermediate worker zone, better residence zone, and commuter zone), in which these three had different characteristics.

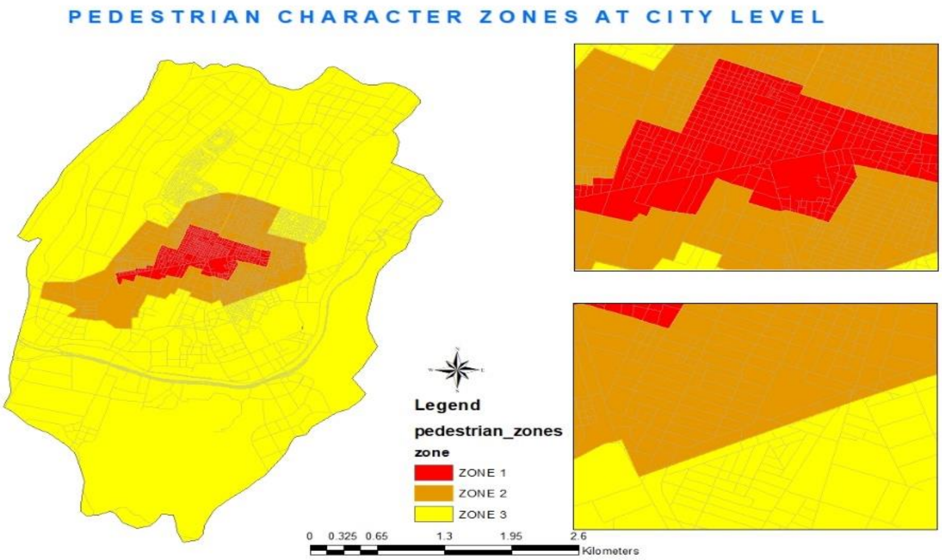


Figure 3-2: Adama city pedestrian character zones (source: Prepared by Author)

From the above three zones, four sidewalk segments were selected within the city in order to address all types of pedestrian sidewalk characteristics. The selection is done by setting site selection criteria.

Site selection criteria

The specific sidewalk segment on which the study conducted was selected based on the following criteria:

- Centrality of the street segment to the CBD
- Damaged Sidewalk physical condition that makes walking vulnerable.
- Centrality to active pedestrian movement
- Existence of basic social service nearly.
- Pedestrian density and flow rate
- Poor quality of sidewalk

Based on the above criteria, four pedestrian sidewalk segments were selected from the three zones. According to the sample survey taken, more than 50% of pedestrian flow density and poor quality of sidewalk were indicators for commercial business districts. So, two sidewalk segments from the CBD, one from the transit zone and one from the residential zone, were selected. The selected segments are shown on the Figure 3.1-3.

Figure 3-3: Location of Selected Street Segments (Source: Google Earth (edited by the author)

3.2. Background about the Study site

The four selected street segments, each recognized by their local names, are Franko, Postabet-Mebrat Hayil, 04 kebele – Mariam church, and Bole Street. Franko and Mebrat Hayil streets are known for their bustling commercial activities, attracting both pedestrians and vendors. Bole Street is characterized by its residential neighborhoods, offering a different pedestrian flow dynamic. Lastly, 04 kebele – Mariam church Street is a key arterial road, renowned for its mix of activity and social service accumulation such as Hospital, colleges and religious institutions contributing to high pedestrian traffic. These streets were chosen to provide a diverse representation of pedestrian experiences in different urban contexts.

The sidewalk paths constructed and renewed in this segments nowadays are not even sustainable and walkable. The sidewalks are exposed for a number of issues with poor sidewalk physical character. Some of those character are; Vendors occupied the path space, narrow width, improper placement of utility, uneven level change, stalls encroach walkways, construction material damped along walkway, maintenance of sidewalk, bad odour and germs from dusts on footpath, Discontinuation of the walkway creates problems to the disabled persons for walking conveniently, lack of street amenities and furniture, Illegal vehicle parking on footpath and Poor pavement design and construction materials.

3.3. Research Design

Research design is a comprehensive plan outlining how to conduct a research study, detailing the methods and procedures used to collect, analyze, and interpret data. It serves as a blueprint for the study, ensuring that the research is systematically and logically organized to answer the research questions effectively. In other words, the research design sets the procedure for the specified data, the methods to be applied to gather and analyze this data, and the way all of this is often visiting to answer the research question (Wilkerson, 2014). A descriptive research design was employed for the study to research the situations thoroughly.

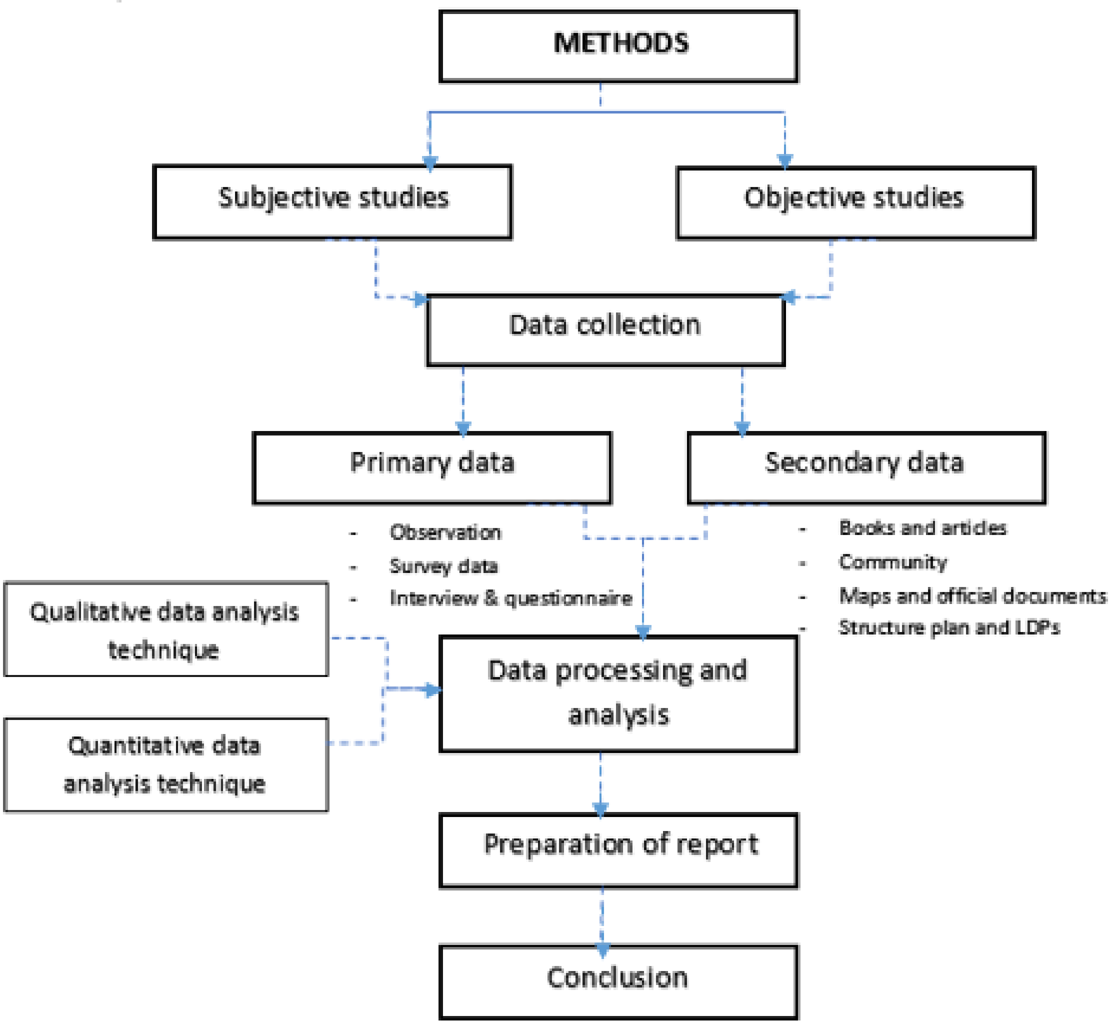


Figure 3-4: Research Design Diagram (source: Author, 2024)

3.4. Research Approach

The study applies a general deductive research approach to the study. During this approach, the study generates general information on specific information that enables them to gather both qualitative and quantitative data. A qualitative approach is vital for gathering respondents' attitudes and experiences regarding pedestrian facilities and related issues. Quantitative approaches, on the opposite hand, are important for obtaining numerical data through questionnaires, so the study can collect statistics in large-scale surveys. A mixed-methods is utilized, integrating quantitative data to capture measurable aspects of sidewalk conditions and pedestrian traffic, alongside qualitative data to understand the experiences and perceptions of pedestrians

3.5. Type and source of data

There are two main types of data sources will be involved in the process of study. Those data sources are namely primary data and secondary data. Primary data sources were questioners, visual survey and interview. While secondary data sources were mainly data from institutions and different studies, articles, LDPs and different books. The data's were collected through interview, observation and surveys.

3.6. Research methods

To achieve the objectives of this research, both quantitative and qualitative approaches were employed. The qualitative approach was used to explore the current quality and condition of available pedestrian facilities. This involved assessing the usability and effectiveness of these facilities through direct observation and field surveys. The quantitative approach was employed to measure the extent to which these existing facilities meet pedestrian demand.

Primary data sources were utilized for data collection in this study. The conditions of existing pedestrian facilities were observed and evaluated through field surveys, which involved measuring their extent of service and counting peak pedestrian volumes in the study area. This quantitative data provided insights into how well the facilities accommodated pedestrian traffic. The study focused on the selected Arterial street segment of Adama, selected due to its high concentration of business and service activities, which attract a significant flow of pedestrians. This area of interest was chosen to ensure that the findings would reflect the demands and challenges faced by pedestrians in a bustling urban environment. By integrating both qualitative and quantitative data, the research aimed to provide a comprehensive analysis of pedestrian facility conditions and their ability to meet the needs of users.

3.6.1. Method and Material used for first objective

3.6.1.1. Method used

A. Site survey and Observation

For the first objective, a comprehensive site survey and observation method was implemented. Primary data collection methods included site survey analysis, direct site observation, photography, and checklist observation. The initial data collection approach involved direct and controlled observation, taking site photos, and filling out prepared checklists to assess the physical qualities and characteristics of the sidewalks along selected street segments in Adama.

The checklists were precisely designed to cover a range of sidewalk elements, including sidewalk width, crossing facilities, pavement material quality, accessibility, obstructions, encroachments, sidewalk greenery, sitting areas, buffer zones, and all existing street amenities. These elements provided a detailed framework for documenting the current physical condition of the streets.

Table 3-1: List of sidewalk indicators.

Sidewalk Indicator	Description
Obstructions	Obstructions are defined as any permanent objects that obstruct the pedestrian path and reduce the width of the sidewalk below the allowed minimum. Sidewalk obstructions are usually caused by utility poles, tree trunks, signposts, fire hydrant, etc., which obstruct pedestrians on the sidewalk.
Continuity	The continuity of the sidewalk is important for pedestrians, especially disabled or elderly pedestrians. Continuous sidewalks are those sidewalks that do not have any up and downs. The continuous ups and downs make the sidewalk uncomfortable to use by pedestrians.
Physical Condition	The sidewalk physical condition affects the walking environment of pedestrians. This condition determines how difficult an area is to negotiate. A sidewalk surface should be firm, stable, slip-resistant, and free from cracks, bumps, and vertical faults for comfortable walking.
Encroachments	Encroachments are any temporary objects caused by commercial or any other activities that obstruct the sidewalk and reduce its width below the allowed minimum. Encroachments can be a garbage bin, plants, bushes, hoardings, cones, advertising signs, restaurant tables, vehicles parked on the street, etc.
Cleanliness	The walking environment should be a pleasant experience. The environment is governed by the surroundings of the facility. The sidewalk should be clean and free of litter, broken glass, etc.
Slope	A steep slope of a sidewalk can make pedestrians in wheelchairs or any other mobility devices uncomfortable.
Shade Trees	The presence of trees along the sidewalk increases the comfort level of pedestrians, especially during hot weather. Shade trees can keep pedestrians cool, protect them from the sun, and add a nice aesthetic element.
Buffer Zone	A buffer zone between the street and pedestrians greatly increases the comfort and safety of pedestrians and reduces the chance of a crash.

Source: Assessing Sidewalk and Corridor Walkability in Developing Countries (Shaaban k. , 2019)

By employing these methods, the research aimed to gain a thorough understanding of the existing physical conditions of pedestrian facilities. The use of photography and checklists allowed for accurate and detailed documentation of the sidewalks' features, facilitating a comprehensive analysis of their quality and functionality

Table 3-2: Levels of sidewalk indicator

Indicator *	Level			
Obstructions	(1) >5 obstructions	(2) 5–4 obstructions	(3) 3–2 obstructions	(4) 1–0 obstruction
Continuity	(1) No sidewalk along the segment	(2) Missing some sections	(3) Missing few sections	(4) Continuous
Physical Condition	(1) Many cracks/breaks	(2) Some cracks/breaks	(3) Few cracks/breaks	(4) No cracks/breaks
Encroachments	(1) Many encroachments	(2) Some encroachments	(3) No encroachments	
Cleanliness	(1) Large amount of litter	(2) Some litter	(3) Small amount of litter	(4) No litter
Width	(1) <5 ft	(2) 5–10 ft	(3) >10 ft	
Slope	(1) Cannot be used by a wheelchair	(2) Steep/ uncomfortable	(3) Few steep sections	(4) Comfortable
Shade Trees	(1) No trees	(2) Some trees	(3) Many trees	
Buffer Zone	(1) <3 ft	(2) 3–6 ft	(3) >6 ft	

Source: Assessing Sidewalk and Corridor Walkability in Developing Countries (Shaaban k., 2019)

B. Pedestrian level of service

For this research, the Highway Capacity Manual (HCM) was utilized to determine the level of service (LOS) for the sidewalks. The HCM method was chosen primarily for its efficiency and reliability in assessing the current status of sidewalk infrastructure. One of the key reasons for selecting this method is that it requires less time to collect and analyze data compared to other methods, making it highly practical for this study.

The HCM provides a systematic approach to evaluating the spatial characteristics of sidewalks, which includes measurements of sidewalk width, surface quality, and the presence of obstructions. By using the HCM, the study was able to assess the capacity and performance of sidewalks in accommodating pedestrian traffic. This method allowed for a detailed examination of how the physical attributes of sidewalks impact user experience, safety, and comfort.

Pedestrian Cordon Count

For this research, cordon counts, or manual field count techniques, were employed to obtain pedestrian numbers. This method involved observing pedestrian characteristics such as flow and speed at six selected survey sites. Pedestrian counts were conducted within these sites based on pedestrian activity along the streets, covering an area of 2 km within a 250-350-meter range.

The pedestrian counts were performed over a period of two consecutive weeks, from April 1, 2023, to April 14, 2023, encompassing both weekdays and weekends. This approach was chosen to capture variations in pedestrian volume and identify peak and low traffic days. Counts were conducted twice daily, from 7:30 am to 9:00 am in the morning and from 4:30 pm to 6:00 pm in the afternoon, ensuring comprehensive data collection during typical high-traffic periods. To avoid distortions caused by adverse weather conditions, the counts were made on "typical" days with favourable weather.

The data collection focused on six selected sites across four street segments: Mebrathayil, Franko, Hailemariam, and Bole. By conducting the counts over multiple days and time periods, the research aimed to provide a robust analysis of pedestrian flow, speed, and density in these areas. This detailed observation allowed for an in-depth understanding of pedestrian movement patterns and the capacity of sidewalks to handle varying levels of pedestrian traffic. The fundamental relationships between flow, speed, and density of pedestrians were investigated and analyzed, providing critical insights into the functionality and efficiency of the pedestrian infrastructure in the selected street segments.

Manual pedestrian walking speed calculation

Calculating manual pedestrian walking speed involves collecting data on how long it takes for pedestrians to travel a known distance. Here's the steps used to perform this calculation.

1. Select a Measurement Area: Choose a straight segment of the sidewalk with a known distance, ideally between 10 and 50 meters. Ensure the segment is free from significant obstacles and representative of typical pedestrian flow.
2. Prepare the Measurement Tools: Use a measuring tape to measure and mark the start and end points of the segment. Have a stopwatch ready for timing pedestrians as they walk through the segment.

3. Data Collection: Position yourself at the start point and, if possible, have a colleague stationed at the end point. As a pedestrian crosses the start point, start the stopwatch. Stop the stopwatch when the pedestrian crosses the end point. Record the time taken for each pedestrian to travel the distance.
4. Calculate Walking Speed: Use the formula Walking Speed = Distance/ Time and Convert the speed to the desired units, typically meters per second (m/s),.

The researcher used a minimum distance of 10 meters for measurements, as it was observed that several pedestrians were scattered and not following the same lane. This distance was marked using tape at the location. When a pedestrian crossed the starting point, the stopwatch was started, and the time was recorded when they reached the second point. The time required for the pedestrian to travel the 10-meter distance was noted in seconds. The pedestrian walking speed was then calculated by dividing the distance by the time taken.

In the study area, the walking speeds of over 20 pedestrians were measured to determine an average walking speed for all age groups. This manual measurement provided a reliable average walking speed. By knowing the pedestrian volume and calculating the walking speed, the Level of Service (LOS) for pedestrians was determined using the specifications provided in the Highway Capacity Manual (HCM).

Steps used to calculate Pedestrian level of service

The first step in calculating the Pedestrian Level of Service (PLOS) is measuring the width of the sidewalks in the selected survey areas. The total width of each sidewalk was recorded, and the effective width was determined by subtracting the space occupied by various obstacles, such as poles, benches, and signs. This process ensured that only the usable space available to pedestrians was considered.

Next, the pedestrian flow in the selected sites was observed and recorded using a digital hand tally counter. This step involved counting the number of pedestrians passing through a specific point over a set period. The maximum flow rate was then calculated based on these observations and the effective width of the sidewalk.

Finally, the PLOS was determined by analyzing the pedestrian flow rate relative to the effective sidewalk width. This analysis involved comparing the calculated flow rate with established criteria for pedestrian level of service, which categorizes the quality of pedestrian conditions from A (excellent) to F (failing). By following these steps, the study provided a clear assessment of the pedestrian infrastructure's capacity to accommodate current pedestrian volumes effectively.

Table 3-3: Pedestrian level of service Criteria

LOS	**Space (m2/ped)**	**Flow Rate (ped/min/m)**	**Average Speed (m/s)**	**v/c ratio (v/c)**
A	>5.6	<16	>1.3	0.21
B	3.7-5.6	16-23	1.27-1.30	0.21-0.3
C	2.2-3.7	23-33	1.22-1.27	0.31-0.44
D	1.4-2.2	33-49	1.14-1.22	0.44-0.65
E	0.75-1.4	49-75	0.75-1.14	0.65-1.0
F	<0.75	var.	<0.75	var.

Source: HCM, 2000

The followings are formulas used to calculate the pedestrian level of service (PLOS)

We = Wt - SAD (approximate obstructed width) ……………………… Equation 1

PF = No pedestrian/ min………………………………………………… Equation 2

PFR = Ped flow/We……………………………………………………… Equation 3

Where; -

We = Effective width of walkway PF = Pedestrian Flow (per/min)

Wt = total width of walkway PFR = Pedestrian Flow Rate (ped/m/min)

SAD = shy away from distance (approximate obstructed width)

3.6.1.2. Material Used

During the site observation period, the study used a Kodak PIXPRO digital camera to capture images of sidewalk segments, while a Field notebook was used for manual documentation of observed features. A checklist was prepared to facilitate controlled observation. For tasks such as assessing pedestrian level of services and measuring sidewalk width, a handheld portable swing measuring tape with a 30-meter length was employed. This combination of tools enabled the study to effectively capture and document pertinent information for analysis and evaluation of the study area's sidewalks. For pedestrian counts, Digital Standard hand tally recorders from the Google Play Store were used to accurately tally passing pedestrians, recording totals for 15-minute intervals. Custom counting books documented pedestrian numbers over three days.

Secondary data, including Adama city's structural map, provided insights into street activities. Arch GIS and AutoCAD delineated the study area, aiding spatial data analysis.

Additionally, Adobe Illustrator (AI) and Photoshop (PS) were used to create illustrative visuals, enhancing the presentation of site observations and improving data clarity. By integrating primary and secondary data sources with appropriate software tools, the study aimed to comprehensively understand pedestrian dynamics and urban characteristics within the research area.

3.6.2. Method and Material used for second and third objectives

3.6.2.1. Method Used

To achieve the study's second and third objectives, various data collection techniques were employed, including questionnaires and interviews. Data was collected from pedestrians using the selected streets through these methods. A total of 384 questionnaires were printed and distributed by data collectors to respondents. Pedestrians were chosen as respondents due to their direct, daily interaction with the sidewalks and their exposure to issues caused by the unconventional streets and sidewalks in the city. The questionnaires aimed to gain a better understanding of the current problems pedestrians face and their future desires for the selected street segments of Adama city.

Semi-structured interviews were employed in this study to facilitate direct interaction with professionals regarding the street conditions. Five professionals were interviewed to understand their perceptions of the existing sidewalks. The process of recording, transcribing, and analysing interview data, along with encoding questionnaire responses using SPSS V22, was carried out between February 3 and March 12, 2023. Responses were collected from various sidewalk users, vehicular drivers, and professionals. Additionally, data was gathered from published and conventional sources, including journals, articles, and reports, which helped contextualize and discuss the findings from the questionnaires and interviews.

3.6.2.2. Material Used

To achieve the second and third objectives of the study, printed questionnaires served as the primary data collection material. These questionnaires were comprehensive, consisting of five sections that included a mix of open-ended and close-ended questions. The questionnaire spanned two double-sided pages and was designed to be completed within 5 to 10 minutes. In addition to the printed questionnaires, several tools were utilized during the interviews. These included cell phones for immediate access to information, audio recorders for capturing detailed responses, and notebooks for jotting down observations and important points during the interviews. The collected audio recordings were later transcribed into text for detailed analysis.

After gathering the completed questionnaires, the valid responses were analyzed using SPSS software and Microsoft Excel. These tools facilitated thorough statistical analysis and data visualization, helping to interpret the responses accurately and draw meaningful conclusions.

3.6. Sampling

3.6.1. Sampling techniques

The main purpose of the research is addressing unseen obstacles and challenges facing pedestrians and (children, disabled and elders) in particular on the sidewalk and providing effective technical and design recommendation that ensure comfortable, convenient, inclusive and walkable pedestrian environment. To undertake this study appropriate sampling technique was used to improve accuracy of research findings. In order to do that probability and non-probability sampling of which systematic random sampling from probability and judgemental sampling from non-probability sampling could be used.

Mainly the study is highly linked to all pedestrians. For professional and experts sampling techniques used was judgemental sampling techniques deployed and systematic random sampling for data collected by questionnaires.

3.6.2. Sample size

Cochran's formula (1963) was utilized to determine the sample size for this study due to the unknown population size for pedestrian surveys. This statistical formula is particularly effective in cases where the population variance is high or the population size is not well-defined. It allows for the calculation of an appropriate sample size needed to achieve a desired level of precision and confidence in the results. By employing Cochran's formula, the study ensured that the sample size was sufficiently large to provide reliable and valid data. This approach takes into account the potential variability within the population and helps to minimize sampling errors, thereby enhancing the overall accuracy of the survey findings.

Necessary sample size $n = \frac{z^2pq}{e^2}$

Where;

n = sample size

Z = confidence level at 95% (standard value is 1.96)

P = the estimated proportion of an attribute that is presented in a population with 50%

q = 1-p

e = designed level of precision with + 5%

This study used a 95 % of confidence level, the value of standard deviation is p = 5 and margin of error is +/- 5 % and the z score for a 95 % confidence level is will be 1.96.

$$n= (1.96)^2 \times 0.5\ (1- 0.5) / (0.05)^2 = 9604/0.0025 = \underline{384.16}$$

For Random sampling technique 384 sample size determined depending on the above calculation. The sample from the four street segments were collected by cotta sampling techniques for the four street segments based sample pedestrian count for feefteen at the afternoon were pedestrian density on the sidewalk is high. Based on that pedestrian survey the cotta for each street segment is shown on table 3-4.

Table 3-4: selected number of respondent by cotta sampling from the four street segments

Segment name	**Average 3 day pedestrian count for 15 min.**			**Respondent cotta based on ped. Count result (number of respondent)**
	Time	**Number of ped.**	**Percentage %**	
Franko segment	Count on Monday, Tuesday and Wednesday At 11:00 -11:15	639	42.9%	164
Postabet – Mebrathayil segment		467	31.4%	120
04 – Mariam church segment		247	16.6%	64
Bole segment		136	9.1%	36
Total		**1489**	**100%**	**384**

Source: Author designed

3.7. Data analysis techniques

3.7.1. Quantitative data analysis

Before analysing collected questioner data, a reliability test is made to check the consistency of the data. The result showed 0.78 which placed good reliability result this shows the collected data were consistent. After checking the consistency questionnaires, the data were analysed by descriptive Data Analysis method to understand the perception of users on existing sidewalk and those analysed data have been evaluated and interpreted in numbers and percentages in tabular and graph forms. To analyse the sidewalk assessment data, descriptive statistics, such as means, medians, and standard deviations, were calculated to summarize key variables like sidewalk width and surface quality. Additionally, spatial analysis techniques, such as GIS mapping, were employed to visualize the distribution of physical challenges along arterial streets.

For the pedestrian survey data, frequency analysis was performed to summarize responses to closed-ended questions. Measures such as means, medians, and percentages were calculated to quantify pedestrian perceptions, satisfaction levels, and walking patterns. Statistical tests, like chi-square tests and correlation analysis, were used to explore relationships between variables, such as sidewalk conditions and pedestrian satisfaction. Furthermore, inferential statistical techniques, such as regression analysis, were applied to identify factors that significantly influence pedestrian perceptions or behaviours.

3.7.2. Qualitative data analysis

The processes of analysis are followed after site observation and interviews data were gathered carefully in forms of Audio, photography, observation notes and filled checklists. Transcribed and organized field observation notes and recordings were systematically analysed using thematic coding techniques to identify common themes or patterns related to pedestrian behaviours, adaptations, and interactions with sidewalk physical challenges. Similar codes were grouped into categories or themes to provide a structured analysis. Those data were analysed in Narrative analysis method by explaining the specific incidence of the street and sidewalk characters. The existing physical character and function of the streetscape narrated in this analysis and the result of the analysis was appraised by discussion and narration by images, tables, and maps.

Thematic coding was also applied to the open-ended survey responses to identify recurring themes, opinions, and experiences expressed by pedestrians. Content analysis techniques were used to gain deeper insights into pedestrian perspectives and experiences. Meaningful quotes or narratives were extracted to support the research findings and enhance the qualitative analysis.

Different data analysis tools will be used to analyse the data's collected in this study. The main tool that will used in the analysing process is were SPSS, Microsoft Excel, GIS, AutoCAD, and also many visual editing tools or software's will be used in the project so as to help us illustrate and interpreted as well as present the study in general.

3.8. Ethical consideration

Before starting data collection, a permission letter was presented to all participants. Informed consent was obtained by clearly explaining the research purpose and procedures, while respecting participants' right to withdraw at any time. Participant identities and confidential information were protected through anonymization and secure data storage. Participants were treated with respect, ensuring non-discrimination and maintaining their safety throughout the study. These ethical measures were implemented to safeguard participant rights and uphold the integrity of the research.

CHAPTER FOUR

4. RESULT AND DISCUSSION

This chapter involves descriptive and statistical analyses of data gathered from respondents, alongside discussions on the pedestrian level of service grading for each selected street segment. Collected data primarily address the physical challenges of pedestrian sidewalk and their impacts. The measurement of a safer pedestrian environment relies on sidewalk characteristics and the quality of pedestrian facilities, with methods aiming to measure pedestrian comfort levels when encountering these features. This chapter explores into the current state and conditions of sidewalks, addressing issues that impact walkability, and conducting a walkability analysis, focusing on selected sidewalk segments within Adama city.

4.1. Respondent pedestrian characteristics

4.1.1. Gender Distribution of the respondents

According to the surveyed data in the table, out of the total 371 respondents, approximately half were male, making up 50.7% of the respondents. The remaining 49.3% of the respondents were female. This gender distribution is almost even, with males having a slightly higher representation than females among the respondents.

Table 4-1: Gender distribution of respondents

Gender				
		Frequency	Percent	Valid Percent
Valid	Male	188	50.7	50.7
	Female	183	49.3	49.3
	Total	371	100.0	100.0

Source: survey result, 2024

4.1.2. Age Distribution

The study aimed to establish the age distribution of the respondents, recognizing that individuals from different age groups may have varying opinions on various issues. The results of this analysis are presented in Table 4.2.

The majority of the data were collected from respondents in the age groups 15-35 and 36-64, which comprised 38% and 30.5% of the total sample 371, respectively. Additionally, children aged 12-15 and elderly individuals over 65 years old were also represented in the study, accounting for 15.9% and 15.6% of the respondents, respectively.

These findings indicate that the sidewalks are used by a diverse range of age groups, including children, young adults, middle-aged adults, and seniors. This diversity underscores the importance of designing sidewalks that accommodate the varying needs of all age groups to ensure accessibility and usability for everyone.

Table 4-2: Age Distribution

Age				
		Frequency	Percent	Valid Percent
Valid	Less than 15	59	15.9	15.9
	15-35	141	38.0	38.0
	36-65	113	30.5	30.5
	Greater than 65	58	15.6	15.6
	Total	371	100.0	100.0

Source: survey result, 2024

4.1.3. Occupation Status of respondent

Among the total respondents, self-employed individuals made up approximately 28.6% of the sample, while students constituted about 27.8%. Civil servants accounted for around 17% of the respondents, and job seekers represented about 16.4%. The smallest occupational group was NGO workers, who comprised only 5.4% of the total respondents.

This demographic breakdown indicates that the respondents were predominantly members of the working class who are active and likely to have substantial experience with sidewalk conditions. Their diverse occupational backgrounds provide a comprehensive perspective on the usability and challenges of sidewalks, as they frequently navigate these spaces in their daily activities.

Table 4-3: Occupation Distribution of Respondent

Occupation				
		Frequency	Percent	Valid Percent
Valid	Student	103	27.8	27.8
	Self employed	106	28.6	28.6
	Civil servant	63	17.0	17.0
	NGO	18	4.9	4.9
	Job seeker	61	16.4	16.4
	Other	20	5.4	5.4
	Total	371	100.0	100.0

Source: survey result, 2024

4.1.4. Respondent Purpose on the trip

The survey data of pedestrians on the sidewalks on selected street segments of Adama City reveals that the primary purposes for trips are going to work (28.6%), going to school (25.3%), and shopping (23.2%). These three categories collectively represent over three-quarters (77.1%) of all pedestrian activity. Health-related trips make up 9.4%, social visits 5.1%, entertainment 4.6%, and other purposes 3.8%.

Table 4-4: Respondent Purpose of trip

Purpose of the trip				
		Frequency	Percent	Valid Percent
Valid	Going to work	106	28.6	28.6
	For shopping	86	23.2	23.2
	Going to school	94	25.3	25.3
	Health	35	9.4	9.4
	Visit	19	5.1	5.1
	Entertainment	17	4.6	4.6
	Other	14	3.8	3.8
	Total	371	100.0	100.0

Source: survey result, 2024

4.2. Current physical assessment of pedestrian sidewalk

The primary objective of the assessment was to evaluate the condition of sidewalks by assigning a score to each specific indicator and then calculating a cumulative score for overall walkability. This comprehensive assessment aims to provide valuable insights into the usability and accessibility of the sidewalks in the evaluated areas of selected street segments in Adama city and ultimately informing improvements.

4.2.1. Franko segment sidewalk assessment

According to the researcher site survey using sidewalk walkability indicator sidewalks along the Franko Street segment somewhat clean and in a good physical condition but it were in fair overall condition, with compromised structural integrity. The table 4-5 indicates walkability scores of sidewalk on the selected street segment. The survey was executed by dividing the segment in to eight section with 60 meter spacing to collect the reliable data. According the survey result few missing sections, numerous obstructions, some encroachments, and few cracks were among physical challenges facing pedestrian while walking on this sidewalk. These issues interrupted continuous pedestrian pathways, forcing individuals to walk on the road and posing safety risks. The sidewalk on this segment has no identified pedestrian zoning sections such as frontage zone, pedestrian zone and furnishing zones. The sidewalks were narrow and in close proximity to traffic, reducing pedestrian comfort and safety. They were also not accessible by wheelchair, highlighting a lack of inclusivity. Additionally, the area had few trees, providing Minimal shade and diminishing the street's aesthetic and environmental quality.

Table 4-5: Franko segment Scores of the sidewalk indicators

Indicator	Side of street	Width	Obstruction	Continuity	Physical condition	Encroachment	Cleanliness	Slope	Shade trees	Buffer zone	Average
Section 1	Side 1	2	2	4	4	2	4	4	1	1	2.67
	Side 2	1	1	3	2	1	3	4	1	1	1.89
	Aver.	1.5	1.5	3.5	3	1.5	3.5	4	1	1	2.28
Section 2	Side 1	1	2	1	2	2	4	4	1	1	2.00
	Side 2	1	1	3	3	1	4	4	1	1	2.11
	Aver.	1	1.5	2	2.5	1.5	4	4	1	1	2.06
Section 3	Side 1	2	1	3	3	2	3	4	1	1	2.22
	Side 2	1	2	4	4	2	4	4	1	1	2.56
	Aver.	1.5	1.5	3.5	3.5	2	3.5	4	1	1	2.39
Section 4	Side 1	2	1	4	3	1	2	4	1	1	2.11
	Side 2	2	1	3	4	2	3	4	1	1	2.33
	Aver.	2	1	3.5	3.5	1.5	2.5	4	1	1	2.22
Section 5	Side 1	1	1	4	3	1	3	4	2	1	2.22
	Side 2	1	2	4	4	2	3	4	3	1	2.67
	Aver.	1.5	1.5	4	3.5	1.5	3	4	2.5	1	2.50
Section 6	Side 1	1	1	4	2	1	3	4	2	1	2.11
	Side 2	1	1	4	3	1	2	4	1	1	2.00
	Aver.	1	1	4	2.5	1	2.5	4	1.5	1	2.06
Section 7	Side 1	1	1	2	4	2	2	4	1	1	2.00
	Side 2	2	2	4	4	1	3	4	1	1	2.44
	Aver.	1.5	1	3	4	1.5	2.5	4	1	1	2.17
Section 8	Side 1	1	1	3	3	1	3	4	1	1	2.00
	Side 2	1	1	4	3	1	3	4	1	1	2.11
	Aver.	1	1	3.5	3	1	3	4	1	1	2.06
Average	Side 1	1.5	1.25	3.12	3	1.38	2.75	4	1.25	1	2.14
	Side 2	1.25	1.37	3.62	3.38	1.38	3	4	1.25	1	2.25
	Aver.	1.37	1.31	3.37	3.19	1.38	2.87	4	1.25	1	2.19

Source: survey result, 2024

Entire the segment few sections of the sidewalk were absent, interrupting continuous pedestrian pathways and forcing individuals to walk on the road, posing safety risks. This analysis of the

Franko Street segment highlights critical issues that need to be addressed to improve pedestrian safety, accessibility, and the overall walkability of the area.

Figure 4-1: Franko segment sidewalk physical condition (source: Author site observation)

4.2.2. Postabet to Mebrathayil Segment Sidewalk Assessment

Based on the site survey results using the sidewalk walkability indicator along the Postabet to Mebrathayil Street segment, the sidewalks were found to be in poor physical condition and overall disrepair, with compromised structural continuity. Table 4-6 presents the walkability scores for the sidewalks on this street segment. According to the survey, the sidewalks faced numerous physical challenges, including many missing sections, numerous obstructions, frequent encroachments, and extensive pavement cracks. These issues interrupted continuous pedestrian pathways, often forcing individuals to walk on the road, thereby posing significant safety risks.

The sidewalk on this segment also lacked clearly defined pedestrian zoning sections, such as frontage zones, pedestrian zones, and furnishing zones. The sidewalks were narrow and situated very close to traffic, which reduced pedestrian comfort and safety. Accessibility for wheelchair users was severely limited, making navigation difficult for those with mobility challenges. Scattered trees provided some greenery but also contributed to the obstructions along the sidewalks.

Table 4-6: Postabet - Mebrathayil Segment Scores of the sidewalk indicators

Indicator	Side of street	Width	Obstruction	Continuity	Physical condition	Encroachment	Cleanliness	Slope	Shade trees	Buffer zone	Average
Section 1	Side 1	1	1	2	1	1	3	4	1	1	1.67
	Side 2	2	2	3	3	1	3	4	2	1	2.33
	Aver.	1.5	1.5	2.5	2	1	3	4	1.5	1	2.00
Section 2	Side 1	2	4	4	4	2	4	4	3	2	3.22
	Side 2	1	2	1	1	2	3	4	2	2	2.00
	Aver.	1.5	3	2.5	2.5	2	3.5	4	2.5	2	2.61
Section 3	Side 1	3	3	4	2	3	3	4	2	2	2.89
	Side 2	1	1	2	1	1	2	4	2	2	1.78
	Aver.	2	2	3	1.5	2	2.5	4	2	2	2.33
Section 4	Side 1	1	1	2	1	1	2	4	2	1	1.67
	Side 2	1	1	1	1	1	1	4	2	2	1.56
	Aver.	1	1	1.5	1	1	1.5	4	2	1.5	1.61
Section 5	Side 1	2	3	2	2	1	3	4	2	1	2.22
	Side 2	2	2	3	3	1	4	4	3	2	2.67
	Aver.	2	2.5	2.5	2.5	1	3.5	4	2.5	1.5	2.44
Section 6	Side 1	1	1	3	2	1	2	4	3	1	2.00
	Side 2	1	1	4	3	1	3	4	2	1	2.22
	Aver.	1	1	3.5	2.5	1	2.5	4	2.5	1	2.11
Section 7	Side 1	1	1	2	1	1	2	4	2	1	1.67
	Side 2	2	1	2	1	1	1	4	3	2	1.89
	Aver.	1.5	1	2	1	1	1.5	4	2.5	1.5	1.78
Section 8	Side 1	1	1	2	1	2	1	4	2	1	1.67
	Side 2	1	1	2	1	1	3	4	3	2	2.00
	Aver.	1	1	2	1	1.5	2	4	2.5	1.5	1.83
Average	Side 1	1.5	1.875	2.625	1.75	1.5	2.5	4	2.125	1.25	2.13
	Side 2	1.375	1.375	2.25	1.75	1.125	2.5	4	2.375	1.75	2.06
	Aver.	1.4375	1.625	2.4375	1.75	1.3125	2.5	4	2.25	1.5	2.09

Source: survey result, 2024

The width of the sidewalk along this segment varies significantly. Most sections of the sidewalk are narrow and insufficient to accommodate the high pedestrian volume, though a few locations are wide enough to handle the traffic. The quality and material of the pavement also differ across this segment. While some sections are paved with asphalt or cobblestones, a few areas remain unpaved. Most of the site is paved with terrazzo, including tactile surfaces designed to aid visually impaired pedestrians. However, the sidewalks are filled with obstructions, negating the benefits of the tactile paving. There are also uneven level changes at every curb cut. Additionally, the sidewalks are heavily encroached upon by street vendors, shoe shiners, retail activities, business displays, and other related activities, further complicating pedestrian movement.

Figure 4-2: Postabet - Mebrathayil segment sidewalk physical condition

4.2.3. 04 kebele to Mariam church Segment Sidewalk Assessment

This segment of the sidewalk was relatively clean and in fair condition, though it exhibited several issues. There were some obstructions and a number of cracks throughout, along with several missing sections that disrupted continuity. The sidewalks were quite narrow, making it difficult for pedestrians to navigate, especially during busy times. Accessibility for wheelchair users was severely limited due to the lack of proper ramps and the uneven surface.

Additionally, while there were some trees along the sidewalk, they did not provide adequate shelter from the sun or rain. The trees were sparsely planted and did not offer significant shade, diminishing their effectiveness in enhancing pedestrian comfort. The combination of these factors resulted in a challenging environment for all users, highlighting the need for significant improvements to ensure safety and accessibility

Figure 4-3: 04 - Mariam church segment sidewalk physical condition

Table 4-7: 04 - Mariam Church Segment Scores of the sidewalk indicators

Indicator	Side of street	Width	Obstruction	Continuity	Physical condition	Encroachment	Cleanliness	Slope	Shade trees	Buffer zone	Average
Section 1	Side 1	1	1	4	2	1	3	4	3	1	2.38
	Side 2	2	1	2	1	1	2	4	3	1	2.00
	Aver.	1.5	1	3	1.5	1	2.5	4	3	1	2.19
Section 2	Side 1	1	1	3	2	2	4	4	2	1	2.38
	Side 2	2	1	4	3	2	4	4	2	1	2.75
	Aver.	1.5	1	3.5	2.5	2	4	4	2	1	2.56
Section 3	Side 1	1	1	3	2	2	3	4	3	1	2.38
	Side 2	2	1	3	3	1	2	4	2	1	2.25
	Aver.	1.5	1	3	2.5	1.5	2.5	4	2.5	1	2.31
Section 4	Side 1	1	1	2	3	1	3	4	2	1	2.13
	Side 2	2	1	3	2	1	2	4	2	1	2.13
	Aver.	1.5	1	2.5	2.5	1	2.5	4	2	1	2.13
Section 5	Side 1	3	1	1	1	1	2	4	1	1	1.75
	Side 2	2	1	3	2	1	2	4	2	1	2.13
	Aver.	2.5	1	2	1.5	1	2	4	1.5	1	1.94
Section 6	Side 1	3	1	1	2	1	2	4	2	1	2.00
	Side 2	3	1	2	2	1	3	4	2	1	2.25
	Aver.	3	1	1.5	2	1	2.5	4	2	1	2.13
Section 7	Side 1	1	1	3	2	1	2	4	2	1	2.00
	Side 2	2	1	4	3	3	3	4	3	1	2.88
	Aver.	1.5	1	3.5	2.5	2	2.5	4	2.5	1	2.44
Section 8	Side 1	2	1	4	3	2	2	4	2	1	2.50
	Side 2	2	1	3	3	4	2	4	2	1	2.63
	Aver.	2	1	3.5	3	3	2	4	2	1	2.56
Average	Side 1	1.625	1	2.625	2.125	1.375	2.625	4	2.125	1	2.19
	Side 2	2.125	1	3	2.375	1.75	2.5	4	2.25	1	2.38
	Aver.	1.875	1	2.8125	2.25	1.5625	2.5625	4	2.1875	1	2.28

Source: site survey result, 2024

4.2.4. Bole Segment Sidewalk Assessment

The sidewalks were clean and generally in good condition, though they did have a few missing sections, occasional obstructions, miss curb ramp and some cracks. Despite these minor issues, the sidewalks maintained an acceptable width, allowing comfortable passage for pedestrians. They were also designed to be visual impaired accessible, with proper smooth surfaces facilitating easy navigation for individuals with mobility challenges.

Additionally, the sidewalks were lined with trees, which provided some degree of shade and aesthetic enhancement. The design of this segment effectively incorporated pedestrian zoning, including distinct areas such as the furnishing zone, frontage zone, and pedestrian zone. These designated zones helped organize space for various functions, such as street furniture, storefronts, and pedestrian movement, thereby improving the overall usability and experience of the sidewalk for all users

Table 4-8:Bole Segment Scores of the sidewalk indicators

Indicator	Side of street	Width	Obstruction	Continuity	Physical condition	Encroachment	Cleanliness	Slope	Shade trees	Buffer zone	Average
Section 1	Side 1	3	4	4	4	3	4	4	3	2	3.63
	Side 2	3	4	4	4	3	4	4	3	2	3.63
	Aver.	3	4	4	4	3	4	4	3	2	3.63
Section 2	Side 1	3	4	4	4	3	4	4	3	2	3.63
	Side 2	3	4	4	4	3	4	4	3	2	3.63
	Aver.	3	4	4	4	3	4	4	3	2	3.63
Section 3	Side 1	3	4	4	4	3	4	4	3	2	3.63
	Side 2	3	4	4	4	3	4	4	3	2	3.63
	Aver.	3	4	4	4	3	4	4	3	2	3.63
Section 4	Side 1	3	4	3	3	3	2	4	2	2	3.00
	Side 2	3	4	4	3	3	4	4	3	2	3.50
	Aver.	3	4	3.5	3	3	3	4	2.5	2	3.25
Section 5	Side 1	3	3	2	2	3	3	4	3	2	2.88
	Side 2	3	2	3	1	2	3	4	3	2	2.63
	Aver.	3	2.5	2.5	1.5	2.5	3	4	3	2	2.75
Section 6	Side 1	3	1	2	2	3	3	4	3	2	2.63
	Side 2	2	1	3	2	3	2	4	2	2	2.38
	Aver.	2.5	1	2.5	2	3	2.5	4	2.5	2	2.50
Average	Side 1	3.00	3.33	3.17	3.17	3.00	3.33	4.00	2.83	2	3.23
	Side 2	2.83	3.17	3.67	3.00	2.83	3.50	4.00	2.83	2	3.23
	Aver.	2.92	3.25	3.42	3.08	2.92	3.42	4.00	2.83	2	3.23

Source: site survey, 2024

Figure 4-4: Bole segment sidewalk condition

4.2.5. Discussion

According to the site survey using the sidewalk walkability indicator, the sidewalks along Franko Street were somewhat clean and in good physical condition. The survey identified key issues such as missing sections, numerous obstructions, encroachments, and cracks that disrupted continuous pedestrian pathways. These challenges often forced pedestrians to walk on the road, posing significant safety risks. Additionally, the segment lacked defined pedestrian zoning sections, such as frontage, pedestrian, and furnishing zones, resulting in narrow sidewalks close to traffic, which reduced pedestrian comfort and safety. Accessibility for wheelchair users was non-existent, highlighting a lack of inclusivity, and the minimal presence of trees offered little shade, diminishing the street's aesthetic and environmental quality.

In the segment from Postabet to Mebrathayil Street, the sidewalks were found to be in poor physical condition and overall disrepair. The survey revealed numerous physical challenges, including many missing sections, numerous obstructions, frequent encroachments, and extensive pavement cracks. Like Franko Street, this segment also lacked clearly defined pedestrian zones. The sidewalk width varied significantly, with many sections too narrow to accommodate the high pedestrian volume, and the pavement quality and material differed across the segment, with some areas paved with asphalt or cobblestones and others remaining unpaved.

The sidewalk segment from 04 Kebele to Mariam Church was relatively clean and in fair condition but exhibited several issues. Obstructions, cracks, and missing sections disrupted continuity, and the narrow sidewalks made navigation difficult, especially during busy times. The lack of proper ramps and an uneven surface severely limited accessibility for wheelchair users. Conversely, the Bole segment's sidewalks were generally in good condition, though they had a few missing sections, occasional obstructions, missing curb ramps, and some cracks. The sidewalks maintained an acceptable width, allowing comfortable passage for pedestrians, and were designed to be accessible for the visually impaired, with smooth surfaces facilitating easy navigation.

In summary, the common issues across all segments included interruptions in pedestrian pathways due to physical challenges, narrow sidewalks, lack of pedestrian zoning, and limited accessibility for wheelchair users. To address these issues, structural repairs are needed to fix missing sections, cracks, and obstructions. Implementing defined pedestrian zoning can organize space for various functions, enhancing safety and usability. Improving accessibility by adding proper ramps, smooth surfaces, and unobstructed tactile paving is crucial.

4.3. Pedestrian Perception on the Sidewalk Walkability

Understanding pedestrian perception is crucial for evaluating the overall walkability of sidewalks. This section delves into the subjective experiences and opinions of pedestrians regarding the sidewalks' usability, comfort, and safety. To gather data on pedestrian perception, a survey was conducted among regular sidewalk users. Participants were asked to rate various aspects of the sidewalks, including surface conditions, width, obstructions, lighting, and overall safety.

4.3.1. Pedestrian experience of existing sidewalk

The survey result provides insights into the preferences of respondents regarding walking as their primary mode of transportation. Out of a total of 371 respondents, 272 respondents answered "YES" to the question "Do you prefer walking as your primary transport?". The survey result indicates 75.2 percent of respondent had a strong preference for walking as the primary mode of transport among the respondents. This majority preference underscores the need for walkable sidewalk design efforts to focus on creating a pedestrian-friendly environment. Addressing the concerns of those who do not prefer walking, and enhancing the overall infrastructure, can lead to a more inclusive, healthy, and sustainable pedestrian community.

Table 4-9: walking preference of respondent

walking as a primary mode of transportation				
		Frequency	Percent	Valid Percent
Valid	Yes	279	75.2	75.2
	No	92	24.8	24.8
	Total	371	100.0	100.0

Source: survey result, 2024

According to survey on 271 pedestrian user 45.8% respondents indicate they use the sidewalk every day. This high daily usage suggests that the sidewalk is an essential part of daily routines for a significant portion of the population. It may serve as a critical route for commuting, accessing amenities, or engaging in daily activities.

The survey results demonstrate a significant reliance on sidewalks for daily activities, with a substantial number of respondents using them daily or even multiple times a day. This underscores the need for continuous investment in pedestrian infrastructure to ensure safety, comfort, and convenience. Addressing the needs of both frequent and infrequent users through targeted improvements can enhance overall sidewalk utility and promote a more walkable, healthy, and sustainable pedestrian environment.

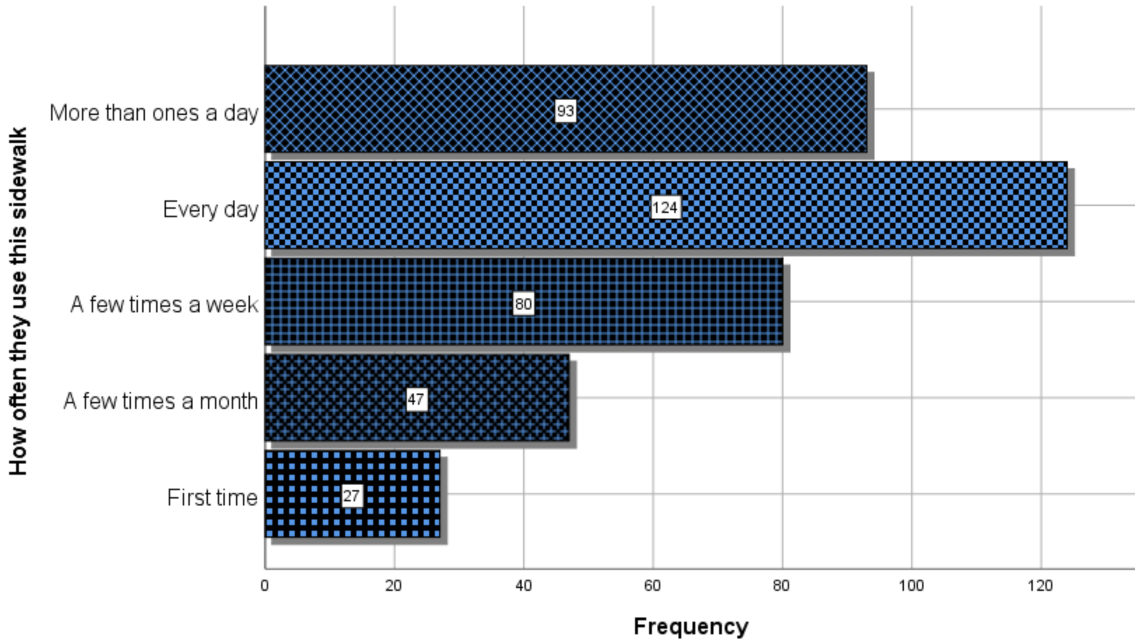


Figure 4-5: Frequency of Sidewalk Use

On the other hand survey on purpose of sidewalk user was conducted. The survey results reveal diverse purposes for which pedestrians use the sidewalk, highlighting the multifunctional nature of urban sidewalks. The most common reason, cited by 28.6% of the respondents, is travelling to work. This suggests a substantial reliance on pedestrian routes for daily work travels. Following closely, 25.3% of respondents use the sidewalks for school trips, emphasizing the importance of safe and accessible walkways for students. Shopping is another major purpose, accounting for 23.2% of the trips, indicating that many people prefer walking to shopping destinations.

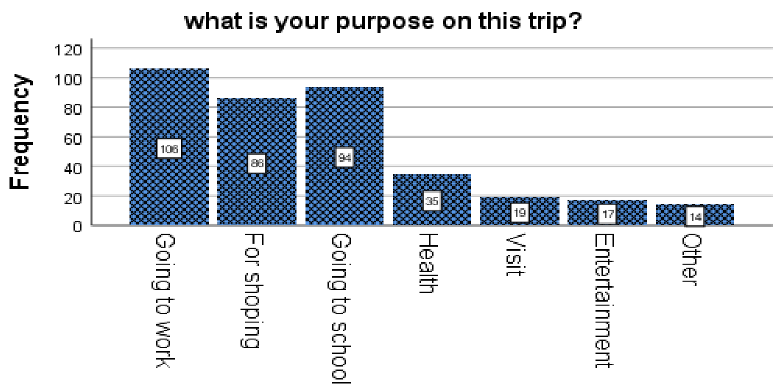


Figure 4-6: Purpose of the trip

Health-related trips, although less frequent, still represent a significant portion, with 9.4% of respondents walking for health reasons such as going to a clinic or engaging in exercise. Social visits and entertainment purposes, though less common, illustrate the sidewalks' role in facilitating social interactions and leisure activities, with 5.1% and 4.6% of trips respectively.

The survey results tells us various activities on the sidewalk that obstruct pedestrian movement, with significant implications for urban walkability and pedestrian comfort. Among the respondents, 30.7% identified street retailing as the most frequent obstruction, suggesting that the presence of vendors and stalls significantly impedes the flow of pedestrians. This is followed by begging, cited by 19.9% of respondents, indicating that pedestrians often encounter individuals soliciting alms, which can hinder their movement.

Table 4-10: Activities on the sidewalk most obstruct ability to walk

Activities on the sidewalk most obstruct ability to walk				
		Frequency	Percent	Valid Percent
Valid	Food selling on street	68	18.3	18.3
	Bicycling on the sidewalk	6	1.6	1.6
	street retailing	114	30.7	30.7
	Vehicle parking on the sidewalk	50	13.5	13.5
	Shoe shiner	59	15.9	15.9
	begging	74	19.9	19.9
	Total	371	100.0	100.0

Source: survey result, 2024

Overall, these findings underscore the need for comprehensive street design and management strategies to address the diverse obstructions impacting sidewalk walkability. Effective measures could include designated areas for street vending and shoe shining, strict enforcement against illegal parking, and dedicated spaces for non-pedestrian activities to ensure that sidewalks remain safe and accessible for all users.

4.3.2. Perceived indicator of existing sidewalk state

The survey results reveal a broad range of opinions regarding the adequacy of sidewalk width, reflecting varying levels of satisfaction and dissatisfaction among pedestrians. Table 4-11 shows a significant portion of respondents, 32.1%, rated the sidewalk width as poor, indicating widespread dissatisfaction with the current conditions. This suggests that many pedestrians find the sidewalks insufficiently wide to accommodate the volume of foot traffic comfortably.

Following this, 22.1% of respondents rated the sidewalk width as very poor, further underscoring the perceived inadequacy of the current infrastructure. The combined 54.2% of respondents rating the sidewalk width as poor or very poor signals a critical need for improvements to better meet pedestrian needs.

Table 4-11: Adequacy rate of sidewalk width

How do you rate adequacy of sidewalk total width?				
		Frequency	Percent	Valid Percent
Valid	Fair	55	14.8	14.8
	Very poor	82	22.1	22.1
	Poor	119	32.1	32.1
	Good	84	22.6	22.6
	Excellent	31	8.4	8.4
	Total	371	100.0	100.0

Source: survey result, 2024

Table 4-12 shows survey results highlight diverse perceptions of sidewalk surface quality among pedestrians. A notable 26.7% of respondents rated the surface quality as poor, and an additional 11.9% rated it as very poor. Together, these ratings signify that a significant portion of pedestrians (38.6%) are dissatisfied with the current state of the sidewalk surfaces, potentially facing issues such as cracks, uneven surfaces, or poor maintenance that affect their walking experience.

The largest group of respondents, 28.6%, rated the sidewalk surface quality as fair. This suggests that while the surfaces are adequate for basic use, there is considerable room for improvement to meet pedestrian expectations fully. These respondents likely encounter some issues but do not find them severe enough to rate the surface as poor or very poor.

Table 4-12: Rate of sidewalk surface quality

How do you rate sidewalk surface quality?				
		Frequency	Percent	Valid Percent
Valid	Very poor	44	11.9	11.9
	Poor	99	26.7	26.7
	Fair	106	28.6	28.6
	Good	89	24.0	24.0
	Excellent	33	8.9	8.9
	Total	371	100.0	100.0

Source: survey result, 2024

Table 4-13 shows respondent pedestrians perception on obstacles challenging them while walking on sidewalks. The survey results reveal that the presence of obstacles on sidewalks is a significant issue for pedestrians. A substantial 36.7% of respondents rated the presence of obstacles as poor, with an additional 24.5% rating it as very poor. Together, these figures indicate that over 60% of the respondents encounter frequent and disruptive obstacles, such as parked vehicles, street vendors, or construction materials, which severely impede their ability to walk comfortably and safely.

Conversely, 20.2% of respondents rated the presence of obstacles as fair, suggesting that while they do encounter obstacles, these are not as frequent or severe. A smaller segment of the population views the situation more positively, with 12.9% rating the presence of obstacles as good and 5.7% rating it as excellent. These respondents experience fewer or less impactful obstructions, allowing for a more pleasant and convenient walking experience.

Overall, the survey highlights a critical need for addressing the obstacles on sidewalks to improve pedestrian mobility. Removing or minimizing obstructions, such as unauthorized vehicle parking, street vendors encroaching on walking space, and other impediments, is essential. Ensuring clear and accessible sidewalks will significantly enhance pedestrian comfort and safety, promoting a more walkable and pedestrian-friendly urban environment.

Table 4-13: Presence of Obstacle on Sidewalk

Presence of obstacles on sidewalk

		Frequency	Percent	Valid Percent
Valid	Very poor	91	24.5	24.5
	Poor	136	36.7	36.7
	Fair	75	20.2	20.2
	Good	48	12.9	12.9
	Excellent	21	5.7	5.7
	Total	371	100.0	100.0

Source: survey result, 2024

The survey results indicate significant issues with the accessibility features on sidewalks as perceived by pedestrians. A considerable 38.8% of respondents rated the accessibility features as poor, and another 20.5% rated them as very poor. This combined total of 59.3% highlights that the majority of respondents find the current accessibility features seriously lacking. These respondents likely encounter difficulties such as insufficient curb ramps, uneven surfaces, and other barriers that impede access for people with disabilities, parents with strollers, and the elderly.

On the other hand, 21.3% of respondents rated the accessibility features as fair, suggesting that while some features are present, they are not entirely effective or consistently available. These pedestrians might find certain aspects of the sidewalks accessible but still face challenges in other areas. A smaller segment of the population views the accessibility features more positively, with 15.9% rating them as good and 3.5% rating them as excellent. These respondents likely benefit from more accessible infrastructure in certain areas, such as well-maintained clear pathways.

Table 4-14: Rate of accessibility feature on the sidewalk

How do you rate accessibility feature on the sidewalk?				
		Frequency	Percent	Valid Percent
Valid	Very poor	76	20.5	20.5
	Poor	144	38.8	38.8
	Fair	79	21.3	21.3
	Good	59	15.9	15.9
	Excellent	13	3.5	3.5
	Total	371	100.0	100.0

Source: survey result, 2024

Discussion

Overall, the survey results underscore a pressing need to improve sidewalk accessibility. Enhancements such as adding more curb ramps, ensuring even surfaces, and removing obstructions are crucial for creating a more inclusive and navigable pedestrian environment. By addressing these deficiencies, urban planners and policymakers can significantly enhance the mobility and safety of all sidewalk users, particularly those with accessibility needs.

4.3.3. Correlation analysis

Table 4-15 shows the correlation analysis between three variables. This data presents the Pearson correlation coefficients between three variables: "sidewalk effective width," "number of obstructions," and "speed." Pearson correlation measures the strength and direction of the linear relationship between two variables. The correlation coefficient of -0.768 indicates a strong negative correlation between sidewalk effective width and the number of obstructions. This means that as the effective width of the sidewalk increases, the number of obstructions tends to decrease, and vice versa.

The correlation coefficient of 0.994 indicates an extremely strong positive correlation between sidewalk effective width and speed. This suggests that as the effective width of the sidewalk increases, speed also tends to increase.

The significant correlations suggest robust relationships between these variables. Wider sidewalks not only tend to have fewer obstructions but also facilitate higher speeds, while more obstructions are associated with reduced speeds. These insights could be valuable for urban planning and the design of pedestrian-friendly environments.

Table 4-15: Correlation analysis

Correlations

		sidewalk effective width	number of obstruction	speed
sidewalk effective width	Pearson Correlation	1	-.768*	.994**
	Sig. (2-tailed)		.026	.000
	N	8	8	8
number of obstruction	Pearson Correlation	-.768*	1	-.744*
	Sig. (2-tailed)	.026		.034
	N	8	8	8
speed	Pearson Correlation	.994**	-.744*	1
	Sig. (2-tailed)	.000	.034	
	N	8	8	8

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Source: survey result, 2024

4.4. Evaluation of Existing Sidewalk Pedestrian Level of Service

4.4.1. HCM Method PLOS Evaluation Result

For evaluating walkability and Pedestrian Level of Service (PLOS), the study recognized the presence of various perspectives, as detailed in Chapters 2 and 3. Each perspective demands different types of data, complicating the data collection process. In this part of the study, the methods for collecting the necessary data for PLOS evaluations are explained under pedestrian counts, infrastructure data, and pedestrian speed. Pedestrian level of service at the four selected street segment was evaluated by conducting data's from two data collection points in each segments and take the average for the segment. Based on this eight points were selected from all street segments.

Figure 4-7: Selected pedestrian count points

Table 4-16: HCM PLOS Criteria

LOS	Space (m2/ped)	Flow Rate (ped/min/m)	Average Speed (m/s)	v/c ratio (v/c)
A	>5.6	<16	>1.3	0.21
B	3.7-5.6	16-23	1.27-1.30	0.21-0.3
C	2.2-3.7	23-33	1.22-1.27	0.31-0.44
D	1.4-2.2	33-49	1.14-1.22	0.44-0.65
E	0.75-1.4	49-75	0.75-1.14	0.65-1.0
F	<0.75	var.	<0.75	var.

Source: HCM, 2000

I. HCM PLOS Result of Franko street segment

Pedestrian level of service at this segment is evaluated by selecting two data collection points from both sides of sidewalk at different sections. Based on this point A segment and point B were selected.

Pedestrian count result

Table 4-17 presents the results of a 15-minute pedestrian count at point A and B of the Franko segment, conducted on different days during the morning and night. This was to determine which day of the week experiences the highest pedestrian volume, the average pedestrian count from Monday to Sunday was calculated. The analysis revealed that Saturday had the highest average pedestrian movement, with approximately 602 pedestrians, while Sunday had the lowest pedestrian count.

The total width of the sidewalk at the selected site is 2 meters. However, to determine the effective width available for pedestrians, shy distances from obstacles such as curbs, trash bins, and poles in the middle of the sidewalk were subtracted, resulting in an effective width of only 1 meter. This indicates that the sidewalk is significantly obstructed, reducing the usable space for pedestrians

Table 4-17: Franko segment pedestrian count result

Day’s	Average of Point A and B pedestrian Random count in 15 min			Sidewalk effective width(m)
	Morning	Night	Average	1 m
Monday	491	652	571	
Tuesday	421	578	499	
Wednesday	508	639	573	
Thursday	487	613	550	
Friday	398	538	468	
Saturday	493	712	602	
Sunday	352	493	422	

Source: site survey, 2024

Pedestrian flow result

Table 4-18 below illustrates the pedestrian flow results by dividing the average number of pedestrians by the time elapsed to pass the sidewalks over seven different days. This approach provides insights into the pedestrian flow rate, a critical metric for understanding pedestrian movement patterns. The highest pedestrian flow was observed on Saturday, with a rate of 40 pedestrians per 15 minutes. These findings indicate a peak in pedestrian activity during the weekend, particularly on Saturday, which is essential for determining the pedestrian flow rate and identifying the busiest times.

Table 4-18: Franko segment pedestrian Flow Result

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
PF = No ped/ min 571 ped /15 min 38.06 ped/min	PF = No ped/ min 499 ped /15 min 33.26 ped/min	PF = No ped/ min 573 ped /15 min 38.2 ped/min	PF = No ped/ min 550 ped /15 min 36.66 ped/min	PF = No ped/ min 468 ped /15 min 31.2 ped/min	PF = No ped/ min 602 ped /15 min 40 ped/min	PF = No ped/ min 422 ped /15 min 28.13 ped/min

Source: site survey, 2024

Pedestrian flow rate result of Franko segment

Table 4-19 below illustrates the pedestrian flow rate (PFR) by dividing the average number of pedestrians by the effective width (WE) of the sidewalk over seven different days. The PFR is expressed as the number of pedestrians per minute per meter of effective width. The results indicate that the pedestrian flow rate varies throughout the week, with the highest flow rate observed on Saturday at 40 pedestrians per minute per meter. This suggests that Saturday experiences the highest pedestrian activity, requiring more infrastructure support to manage the flow. Conversely, Sunday has the lowest flow rate at 28.13 pedestrians per minute per meter.

Table 4-19: Franko segment pedestrian Flow rate Result

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
PFR = Ped flow/ WE 38.06 ped/min/m	PFR = **Ped flow/ WE** 33.26 ped/min/m	PFR = Ped flow/ WE 38.2 ped/min/m	PFR = Ped flow/ WE 36.66 ped/min/m	PFR = Ped flow/ WE 31.2 ped/min/m	PFR = Ped flow/ WE 40 ped/min/m	PFR = Ped flow/ WE 28.13 ped/min/m

Source: site survey result, 2024

According to the Level of Service (LOS) criteria table, the average pedestrian traffic rate is 35.07 pedestrians per meter per minute, resulting in a pedestrian Level of Service (LOS) D. This classification, based on the Highway Capacity Manual (HCM) criteria, indicates that the sidewalks are not convenient or comfortable for walking. The current conditions restrict individual walking speed and make it difficult to bypass other pedestrians. Consequently, these sidewalks require upgrades to improve their LOS and enhance the overall pedestrian experience.

II. HCM PLOS Result of Postabet to Mebrathayil street segment

Pedestrian level of service at this segment was also evaluated by selecting two data collection points from both sides of sidewalk at different sections. Based on this point C and point D are selected.

Pedestrian count result

Table 4-20 presents the results of a 15-minute pedestrian count at point C and D of the Postabet to Mebrathayil segment, conducted on different days during the morning and night. This was to determine which day of the week experiences the highest pedestrian volume, the average pedestrian count from Monday to Sunday was calculated. The analysis revealed that Saturday had the highest average pedestrian movement, with average 473 pedestrians, while Sunday had the lowest pedestrian count 263. The total width of the sidewalk at the selected site is 1.6 meters. However, to determine the effective width available for pedestrians, shy distances from obstacles such as curbs, trash bins, and poles in the middle of the sidewalk were subtracted, resulting in an effective width of only 0.85 meter. This indicates that the sidewalk is significantly obstructed, reducing the usable space for pedestrians

Table 4-20: Mebrathayil segment pedestrian count result

Day's	Average of Point C and D pedestrian Random count in 15 min			Sidewalk effective width(m)
	Morning	Night	Average	0.7 m
Monday	343	463	403	
Tuesday	359	413	386	
Wednesday	243	467	355	
Thursday	316	481	398	
Friday	228	359	293	
Saturday	420	527	473	
Sunday	228	299	263	

Source: site survey, 2024

Pedestrian flow result

Table 4-21 below illustrates the pedestrian flow results by dividing the average number of pedestrians by the time elapsed to pass the sidewalks over seven different days. This method provides insights into the pedestrian flow rate, a critical metric for understanding movement patterns. The highest pedestrian flow was observed on Saturday, with a rate of 31.5 pedestrians per 15 minutes. These findings indicate a peak in pedestrian activity during the weekend, particularly on Saturday, which is crucial for determining pedestrian flow rates and identifying the busiest times..

Table 4-21: Mebrathayil segment pedestrian Flow Result

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
PF = No ped/ min 403 ped /15 min 26.8 ped/min	PF = No ped/ min 386 ped /15 min 25.7 ped/min	PF = No ped/ min 355 ped /15 min 23.67 ped/min	PF = No ped/ min 398 ped /15 min 26.53 ped/min	PF = No ped/ min 293 ped /15 min 19.53 ped/min	PF = No ped/ min 473 ped /15 min 31.5 ped/min	PF = No ped/ min 263 ped /15 min 17.53 ped/min

Source: site survey, 2024

Pedestrian flow rate result

Table 4-22 below illustrates the pedestrian flow rate (PFR) by dividing the average number of pedestrians by the effective width (WE) of the sidewalk across seven different days. The PFR is expressed as the number of pedestrians per minute per meter of effective width.

The results show significant variation in the pedestrian flow rate throughout the week. The highest flow rate is observed on Saturday, with 45 pedestrians per minute per meter, indicating the peak in pedestrian activity. This high volume suggests a need for enhanced infrastructure support on Saturdays to manage the increased flow and ensure pedestrian safety and comfort. Measures such as widening the sidewalks, improving signage, and increasing the number of pedestrian amenities could be considered to better accommodate the high pedestrian volume

Conversely, Sunday has the lowest pedestrian flow rate at 25.04 pedestrians per minute per meter. This lower volume indicates reduced demand on the sidewalks, allowing for less intensive infrastructure requirements. However, consistent maintenance and addressing any obstructions are still necessary to ensure a safe and pleasant walking environment.

Table 4-22: Mebrathayil segment pedestrian Flow rate Result

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
PFR = Ped flow/ WE 37.85 ped/min/m	PFR = **Ped flow/ WE** 36.7 ped/min/m	PFR = Ped flow/ WE 33.8 ped/min/1	PFR = Ped flow/ WE 37.9 ped/min/1	PFR = Ped flow/ WE 27.57 ped/min/1	PFR = Ped flow/ WE 45 ped/min/1	PFR = Ped flow/ WE 25.04 ped/min/1

Source: site survey result, 2024

Based on the Level of Service (LOS) criteria table, the average pedestrian traffic rate is 34.84 pedestrians per meter per minute, which corresponds to a pedestrian Level of Service (LOS) D. This rating, derived from the Highway Capacity Manual (HCM) standards, signifies that the sidewalks are neither convenient nor comfortable for walking. Under these conditions, individual walking speeds are restricted, and it becomes challenging for pedestrians to bypass one another. As a result, the current sidewalk infrastructure fails to adequately meet the needs of pedestrians.

To address these issues, significant upgrades are necessary to enhance the LOS. Improvements could include widening the sidewalks to accommodate higher pedestrian volumes, removing obstacles that impede movement, and enhancing overall sidewalk maintenance. Additionally, implementing better signage and pedestrian signals could help manage pedestrian flow and improve safety. These upgrades would not only improve walking conditions but also encourage more people to walk, thereby promoting a healthier and more sustainable urban environment.

III. HCM PLOS Result of 04 kebele to Mariam church street segment

Pedestrian count result

Table 4-23 presents the results of a 15-minute pedestrian count at points E and F of the 04 Kebele to Mariam Church segment, conducted on different days during the morning and evening. The analysis revealed that Monday had the highest average pedestrian movement, with 293 pedestrians, while Sunday had the lowest, with 161 pedestrians.

The total width of the sidewalk at the selected site is 1.4 meters. However, after accounting for shy distances caused by obstacles such as curbs, trash bins, and poles, the effective width available for pedestrians is reduced to only 0.62 meters. This significant obstruction greatly diminishes the usable space for pedestrians, impacting their ability to move comfortably and safely.

Table 4-23:04 kebele to Maroam church segment pedestrian count result

Day’s	Average of Point E and F pedestrian Random count in 15 min			Sidewalk effective width(m)
	Morning	Night	Average	0.62 m
Monday	274	312	293	
Tuesday	234	226	230	
Wednesday	191	247	219	
Thursday	228	281	254	
Friday	241	254	247	
Saturday	167	223	195	
Sunday	132	189	161	

Source: site survey, 2024

Pedestrian flow result

Table 4-24 below illustrates the pedestrian flow results. The highest pedestrian flow was observed on Monday, with a rate of 19.53 pedestrians per 15 minutes. These findings indicate a peak in pedestrian activity during the working days, particularly on Monday, which is crucial for determining pedestrian flow rates and identifying the busiest times.

Table 4-24: 04 kebele to Maroam church segment pedestrian flow result

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
PF = No ped/ min 293 ped /15 min 19.53 ped/min	PF = No ped/ min 230 ped /15 min 15.3 ped/min	PF = No ped/ min 219 ped /15 min 14.6 ped/min	PF = No ped/ min 254 ped /15 min 16.93 ped/min	PF = No ped/ min 247 ped /15 min 16.47 ped/min	PF = No ped/ min 195 ped /15 min 13 ped/min	PF = No ped/ min 191 ped /15 min 12.73 ped/min

Source: site survey, 2024

Pedestrian flow rate result

Table 4-25 below illustrates the pedestrian flow rate (PFR) of the sidewalk across seven different days. The PFR is expressed as the number of pedestrians per minute per meter of effective width.

The results show significant variation in the pedestrian flow rate throughout the week. The highest flow rate is observed on Monday, with 31.5 pedestrians per minute per meter, indicating the peak in pedestrian activity. Measures such as widening the sidewalks, improving signage, and increasing the number of pedestrian amenities could be considered to better accommodate the high pedestrian volume

Conversely, Sunday and Saturday has the lowest pedestrian flow rate at 21 pedestrians per minute per meter. This intermediate volume indicates reduced demand on the sidewalks, allowing for average intensive infrastructure requirements. However, consistent maintenance and addressing any obstructions are still necessary to ensure a safe and pleasant walking environment.

Table 4-25: 04 kebele to Mariam church segment pedestrian Flow rate Result

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
PFR = Ped flow/ W_E 31.5 ped/min/m	PFR **= Ped flow/ W_E** 25.5 ped/min/m	PFR = Ped flow/ W_E 24.33 ped/min/m	PFR = Ped flow/ W_E 28.21 ped/min/m	PFR = Ped flow/ W_E 27.45 ped/min/m	PFR = Ped flow/ W_E 21.67 ped/min/m	PFR = Ped flow/ W_E 21.22 ped/min/m

Source: site survey result, 2024

Based on the Level of Service (LOS) criteria table, the average pedestrian traffic rate is 25.7 pedestrians per meter per minute, which corresponds to a pedestrian Level of Service (LOS) C. According to the Highway Capacity Manual (HCM) Pedestrian Level of Service (PLOS) criteria, a grade C indicates a pedestrian environment that is somewhat acceptable but has noticeable issues affecting comfort and convenience. Specific characteristics of PLOS grade C includes, sidewalks are moderately crowded, occasional interruptions in walking speed and movement, some obstructions or uneven surfaces, pedestrians feel less secure due to poor lighting, limited visibility, or minor conflicts with vehicles and not fully accommodate all users, including those with mobility impairments.

To address these issues, significant upgrades are necessary to enhance the LOS. Improvements could include widening the sidewalks to accommodate higher pedestrian volumes, removing obstacles that impede movement, and enhancing overall sidewalk maintenance. Additionally, implementing better signage and pedestrian signals could help manage pedestrian flow and improve safety. These upgrades would not only improve walking conditions but also encourage more people to walk, thereby promoting a healthier and more sustainable urban environment.

Overall, a PLOS of this segment which graded C signifies a pedestrian environment that functions adequately but requires improvements to enhance safety, comfort, and convenience. Pedestrians can navigate these sidewalks, but their experience may be marred by occasional discomfort or inconvenience.

IV. HCM PLOS Result of Bole street segment

Pedestrian count result

Table 4-26 presents the results of a 15-minute pedestrian count at points G and H of the Bole segment, conducted on different days during the morning and evening. The analysis revealed that Wednesday had the highest average pedestrian movement, with 197 pedestrians, while Sunday had the lowest, with 73 pedestrians. The total width of the sidewalk at the selected site is 3.5 meters. However, after accounting for the effective width available for pedestrians is 2 meters.

Table 4-26: Bole segment pedestrian count result

Day’s	Average of Point G and H pedestrian Random count in 15 min			Sidewalk effective width(m)
	Morning	Night	Average	2 m
Monday	163	145	154	
Tuesday	124	145	134	
Wednesday	191	203	197	
Thursday	98	121	109	
Friday	107	89	98	
Saturday	113	97	105	
Sunday	79	67	73	

Pedestrian flow result of Bole street segment

Table 4-27 below illustrates the pedestrian flow results. The highest pedestrian flow was observed on Wednesday, with a rate of 13.13 pedestrians per 15 minutes. These findings indicate a peak in pedestrian activity during the working days, particularly on Wednesday, which is crucial for determining pedestrian flow rates and identifying the busiest times.

Table 4-27: Bole segment pedestrian flow result

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
PF = No ped/ min 154 ped /15 min 10.26 ped/min	PF = No ped/ min 134 ped /15 min 8.93 ped/min	PF = No ped/ min 197 ped /15 min 13.13 ped/min	PF = No ped/ min 109 ped /15 min 7.26 ped/min	PF = No ped/ min 98 ped /15 min 6.53 ped/min	PF = No ped/ min 105 ped /15 min 7 ped/min	PF = No ped/ min 73 ped /15 min 4.87 ped/min

Source: site survey, 2024

Pedestrian flow rate result of Bole segment

Table 4-28 below illustrates the pedestrian flow rate (PFR) of the sidewalk across seven different days. The PFR is expressed as the number of pedestrians per minute per meter of effective width.

The results show significant variation in the pedestrian flow rate throughout the week. The highest flow rate is observed on Wednesday, with 6.56 pedestrians per minute per meter, indicating the peak volume in pedestrian activity of the segment. Conversely, Sunday has the lowest pedestrian flow rate at 2.43 pedestrians per minute per meter.

Table 4-28: Bole segment pedestrian Flow rate Result

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
PFR = Ped flow/ WE 5.13 ped/min/m	PFR = **Ped flow/ WE** 4.46 ped/min/m	PFR = Ped flow/ WE 6.56 ped/min/m	PFR = Ped flow/ WE 3.63 ped/min/m	PFR = Ped flow/ WE 3.26 ped/min/m	PFR = Ped flow/ WE 3.5 ped/min/m	PFR = Ped flow/ WE 2.43 ped/min/m

Source: site survey result, 2024

Based on the Level of Service (LOS) criteria table, the average pedestrian speed rate is 4.13 pedestrians per meter per minute, which corresponds to a pedestrian Level of Service (LOS) A. According to the Highway Capacity Manual (HCM) Pedestrian Level of Service (PLOS) criteria, a grade A represents the highest level of service for pedestrian environments, indicating a superior walking experience

Based on our survey result Specific characteristics of PLOS grade A of Bole street segment includes, are uncrowded, allowing pedestrians to walk at their desired speed without needing to adjust their pace or direction, widen enough, free of obstructions, and minimal conflicts with vehicles. Some challenges on this sidewalk in adequate pedestrian facility, uneven level changes for unpaved sections and lack of curb ramp at curb cuts.

Overall, a PLOS result of this segment signifies a pedestrian environment that provides an optimal walking experience. The sidewalks were designed to the highest standards, ensuring comfort, convenience, and safety for users. Pedestrians in a grade A environment can expect a seamless, pleasant, and enjoyable experience.

4.4.2. Discussion

The Pedestrian Level of Service (PLOS) results for various street segments offer crucial insights into the quality and usability of the pedestrian environment. By analysing pedestrian counts, flow rates, and the effective width of sidewalks, the study provides a thorough understanding of pedestrian traffic patterns and the adequacy of the existing infrastructure.

The Franko Street segment's pedestrian level of service (PLOS) analysis highlights critical issues in its current state. Despite a total sidewalk width of 2 meters, various obstructions reduce the effective width to just 1 meter, significantly impacting pedestrian comfort and flow. The highest pedestrian flow rate recorded was 40 pedestrians per 15 minutes on Saturday, emphasizing the need for better management during peak periods. The segment receives a grade of LOS D, with an average pedestrian traffic rate of 35.07 pedestrians per meter per minute, indicating overcrowded sidewalks that make walking uncomfortable and restrict speeds. This level of service reveals that the current infrastructure is inadequate to handle pedestrian volumes effectively, leading to congestion and reduced walking efficiency

The analysis of the Postabet to Mebrathayil Street segment reveals key issues in pedestrian movement and infrastructure. The sidewalk's total width of 1.6 meters is reduced to an effective width of 0.85 meters due to various obstacles, mirroring issues seen on Franko Street. The highest flow rate of 45 pedestrians per minute per meter on Saturday underscores the need for better infrastructure management during peak times. Rated as LOS D, with an average pedestrian traffic rate of 34.84 pedestrians per meter per minute, this segment's sidewalks are overcrowded, making walking inconvenient and uncomfortable. These conditions restrict walking speeds and make it difficult for pedestrians to bypass each other, highlighting significant inadequacies in the existing infrastructure.

The examination of the 04 Kebele to Mariam Church Street segment reveals that Monday has the highest pedestrian count at 293, while Sunday has the lowest at 161, indicating higher pedestrian traffic at the start of the week. Rated as LOS C, with an average pedestrian traffic rate of 25.7 pedestrians per meter per minute, this segment's pedestrian environment is somewhat acceptable but has noticeable issues. To improve comfort and safety, widening sidewalks, regular maintenance, and enhancing lighting and visibility are crucial.

The Bole Street segment shows the lowest average pedestrian movement compared to other segments. The sidewalk's total width of 3.5 meters, with an effective width of 2 meters, indicates fewer obstructions. Rated as LOS A, with an average pedestrian speed rate of 4.13 pedestrians per meter per minute, this segment provides a superior pedestrian environment. It offers wide sidewalks and minimal obstructions, ensuring high comfort and convenience. However, improvements such as addressing uneven surfaces and adding pedestrian facilities like curb ramps could further enhance the walking experience, making it even safer and more pleasant for all users.

The analysis of pedestrian flow and level of service (LOS) across various street segments reveals several critical insights. A major issue identified is the significant reduction in effective sidewalk width due to obstructions such as curbs, trash bins, and poles. This reduction greatly impacts pedestrian comfort and safety, making it difficult for individuals to navigate the sidewalks efficiently. The data also highlights that pedestrian activity peaks on Saturdays and certain weekdays, depending on the segment. This peak in activity underscores the need for better infrastructure support during these times to manage the increased pedestrian volumes effectively.

Segments like Franko and Postabet to Mebrathayil, which have received LOS D ratings, clearly require substantial upgrades to handle pedestrian traffic more effectively. The LOS D rating indicates overcrowded sidewalks that are uncomfortable for walking and restrict pedestrian movement. Addressing these issues involves widening the sidewalks to provide more space for pedestrians, removing obstacles that currently impede pedestrian flow, and enhancing overall sidewalk maintenance to ensure they remain in good condition.

Additionally, improving pedestrian signage and signals can help manage pedestrian flow and enhance safety. Clear signage and well-timed signals can guide pedestrians more effectively and reduce conflicts at intersections. Regular maintenance of sidewalks is also crucial to ensure they remain safe and comfortable for all users. This includes fixing any uneven surfaces and ensuring that the sidewalks are clean and free of debris.

4.4.3. Australian Method PLOS Evaluation Result

The Australian method for evaluating Pedestrian Level of Service (PLOS) is an approach designed to assess and improve the quality and safety of pedestrian environments. This method involves multiple criteria and metrics to evaluate the comfort, convenience, and safety of pedestrians. Those criteria's were seen in three categories such as design factor, location factor and user factors. The evaluation involves data collected from the four selected street segments.

Table 4-29: Australian PLOS grade scale

No	PLOS Grading	Score value
1	A	132 or higher
2	B	101 to 131
3	C	69 to 130
4	D	37 to 68
5	E	36 or Lower

Source: Gallin, 2001

I. Franko and Mebrathayil Segment PLOS Result

The findings, which provide a detailed assessment of the pedestrian level of service (PLOS) for each segment, are systematically presented in Table 4-30. This table summarizes the PLOS results, illustrating how each sidewalk segment performs according to the specified evaluation criteria.

Table 4-30: Franko and Mebrathayil Segment PLOS Result

Category	Factor	FRANKO Segment				Postabet to Mebrathayil Segment			
		Measurement value	Number of point	Weight	Weight score	measurement value	Number of point	Weight	Weight score
Design factor	Path width	1.8m	3	4	12	1.2m	2	4	8
	Surface quality	Moderate quality	2	5	10	Poor quality	1	5	5
	Obstruction	73 obtruction	0	3	0	91 obtruction	0	3	0
	Crossing opportunities	some provided but poorly located	1	4	4	some provided but poorly located	1	4	4
	Support facilities	Few provided but poorly located	1	2	2	Few provided but poorly located	1	2	2
Location factor	Connectivity	Reasonable	2	4	8	Poor	1	4	4
	Path Environment	unpleasant environment close to vehicilar traffic	0	2	0	Unpleasant environment close to vehicilar traffic	0	2	0
	Potential for vehicle conflict	10 to 15 potential vehicle conflict point per KM	2	3	6	Poor situation	1	3	3
User Factor	Pedestrian volume	More than 350 per day	0	3	0	More than 350 per day	0	3	0
	Mix of path user	Less than 20% non pedestrian	3	4	12	Approx. 51% - 70% of path users are non pedestrian	1	4	4
	Personal Security	Good	3	4	12	Poor	1	4	4
LOS VALUE		Average Score			66	Average Score			34
		LOS Grade			LOS D	LOS Grade			LOS E

Source: Author survey result, 2024

According to Table 4-30, the Franko segment sidewalk is graded D, indicating poor and suboptimal pedestrian conditions. This rating reflects several issues that significantly impact safety and comfort. The sidewalk has poor surface conditions with cracks, uneven surfaces, and obstacles, and is too narrow, causing overcrowding. Lack of maintenance leads to debris, litter, and overgrown vegetation. Safety is compromised due to high-speed traffic nearby without adequate barriers, poorly marked crosswalks, and insufficient lighting, especially at night. Accessibility is limited by the absence of ramps, curb cuts, and tactile paving, as well as interruptions in the pedestrian network.

The Pedestrian Level of Service (PLOS) assessment for the segment from Postabet to Mebrathayil was assigned a grade of E, signifying an extremely poor and unsuitable walking environment. This grade reflects a critical evaluation where all contributing factors design, location, and user characteristics fall below acceptable standards. Consequently, the overall pedestrian experience on this segment is significantly compromised. The grade E indicates severe deficiencies in the sidewalk's infrastructure, safety, and usability, making it a suboptimal and potentially hazardous route for pedestrians. This result underscores the urgent need for improvements to elevate the service level to meet at least the minimum acceptable standards for pedestrian safety and comfort

II. 04 Kebele to Mariam church and Bole Segment PLOS Result

Table 4-31 summarizes the PLOS results, of these two segment by illustrating how each sidewalk segment performs according to the specified evaluation criteria.

Table 4-31: 04 Kebele to Mariam church and Bole Segment PLOS Result

Category	Factor	04 kebele to Mariam church				BOLE Segment			
		Measurement value	Number of point	Weight	Weight score	Measurement value	Number of point	Weight	Weight score
Design factor	Path width	1.7m	3	4	12	2m	3	4	12
	Surface quality	Moderate quality	2	5	10	Reasonable quality	3	5	15
	Obstruction	59 obtruction	0	3	0	7 obtructions	2	3	6
	Crossing opportunities	some are reasonably provided and located but more are required	2	4	8	some provided but poorly located	1	4	4
	Support facilities	Few provided and reasonably well located	2	2	4	Several provided & well located	3	2	6
Location factor	Connectivity	Good	3	4	12	Good	3	4	12
	Path Environment	Unpleasant environment close to vehicilar traffic	0	2	0	Acceptable environment between 1 & 2m of curb	2	2	4
	Potential for vehicle conflict	1 to 10 or less conflict point per KM reasonable	3	3	9	Pleasant environment	4	3	12
User Factor	Pedestrian volume	More than 350 per day	0	3	0	More than 350 per day	0	3	0
	Mix of path user	Pedestrian only	4	4	16	Pedestrian only	4	4	16
	Personal Security	Poor	1	4	4	Excellent	4	4	16
LOS VALUE		Average Score			75	Average Score			103
		LOS Grade			LOS C	LOS Grade			LOS B

The survey result on Table 4-31 reveals notable differences between the sidewalk conditions of the 04 Kebele and Bole segments. In the 04 Kebele segment, the sidewalk was graded as a basic level which was Grade C, indicating a pedestrian environment with significant shortages impacting safety and comfort. Factors such as uneven surfaces, inadequate lighting, proximity to traffic, and narrow width contribute to an environment that may discourage pedestrian activity and pose safety risks. Conversely, the Bole segment is graded higher as Grade B, signifying a standard level of pedestrian infrastructure. Here, conditions are generally favourable, with smoother surfaces, sufficient lighting, adequate width and better separation from vehicular traffic, fostering a more comfortable and safe walking experience.

The contrast between the two segments underscores the importance of investing in pedestrian infrastructure to enhance urban liveability and promote community well-being. Improvements in the 04 Kebele segment could mitigate safety concerns and encourage pedestrian activity, while continued maintenance and enhancements in the Bole segment ensure its ongoing suitability for pedestrian use. Overall, these assessments provide valuable insights for urban planners to prioritize targeted interventions and allocate resources effectively to create pedestrian-friendly environments that benefit local communities.

Cross Sectional Analysis

The provided data table presents a cross tabulation of Pedestrian Level of Service (PLOS) results according to the Highway Capacity Manual (HCM) and the Australian PLOS Method across different sidewalk segments.

Table 4-32: PLOS Cross tabulation result

PLOS of Selected Segment Cross tabulation

			Australian PLOS Method				
Segment Name			LOS B	LOS C	LOS D	LOS E	Total
FRANKO SEGMENT	HCM Result	LOS D			1		1
	Total				1		1
MEBRATHAYIL SEGMENT	HCM Result	LOS D				1	1
	Total					1	1
04 KEBELE - MARIAM CHURCH SEGMENT	HCM Result	LOS C		1			1
	Total			1			1
BOLE SEGMENT	HCM Result	LOS A	1				1
	Total		1				1

Source: survey result, 2024

This table helps to compare the sidewalk conditions of various segments using two different evaluation methods. FRANKO segment is rated as LOS D by the HCM method and LOS E by the Australian PLOS Method, indicating that this segment has poor pedestrian conditions according to both methods, with the Australian method rating it even lower. Mebrathayil segment receives a consistent rating of LOS D by both methods, indicating poor pedestrian conditions. 04 kebele - Mariam church segment is rated as LOS C by both methods, showing a moderate level of pedestrian service. Bole segment is rated the highest with LOS A by the HCM method and LOS B by the Australian method, suggesting good to very good pedestrian conditions. The cross tabulation highlights inconsistencies and consistencies between the HCM and Australian PLOS methods in assessing sidewalk conditions. The Bole Segment stands out with the best ratings, while Franko and Mebrathayil Segments indicate areas needing significant improvement.

4.4.4. Discussion

The pedestrian level of service (PLOS) results for the Franko and Postabet to Mebrathayil segments highlight critical issues in pedestrian infrastructure and safety. According to PLOS result on Table 4-30, the Franko segment sidewalk received a grade of D, indicating poor pedestrian conditions. Several factors contribute to this rating, including uneven surfaces, cracks, and obstacles that create trip hazards, poor lighting that compromises visibility, and inadequate maintenance that results in deteriorated infrastructure. These conditions severely affect pedestrian safety and comfort, with hazards like obstructions, insufficient crosswalks, and inadequate pedestrian signals increasing the risk of accidents. Narrow sidewalks, lack of shade, and high encroachment levels further reduce the pedestrian experience. Accessibility is also compromised by physical barriers such as steps, high curbs, and obstructions, which hinder movement, especially for those with disabilities.

The Postabet to Mebrathayil segment received a grade of E, indicating an unsuitable and among the worst-rated walking environments. The sidewalks in this area were severely damaged with large cracks, holes, and other impediments making walking nearly impossible in some areas. There is likely a near-total absence of crosswalks, pedestrian signals, and protective barriers between pedestrians and traffic. Insufficient sidewalk width can lead to overcrowding, forcing pedestrians to walk on the road. All critical service factors, including surface quality, width, safety features, and amenities, are well below acceptable standards. Harsh environmental conditions without adequate shelter or greenery further degrade the pedestrian experience.

These conditions have significant implications for public health and safety. Poorly maintained sidewalks and inadequate safety features heighten the risk of pedestrian accidents and injuries, while lack of accessibility and comfort can discourage walking, contributing to associated health problems. These conditions disproportionately affect vulnerable groups such as the elderly, children, and individuals with disabilities, limiting their mobility and access to essential services.

The Pedestrian Level of Service (PLOS) results for the 04 Kebele and Bole segments offer key insights into the quality of pedestrian infrastructure in these areas. The 04 Kebele segment received a grade of C, indicating a basic but suboptimal sidewalk environment. While generally walkable, these sidewalks likely have minor cracks, unevenness, occasional obstructions, and basic but incomplete safety features. Issues such as narrow sidewalks, lack of amenities, insufficient shade, occasional obstacles, and poorly connected sections compromise accessibility and pedestrian safety. In contrast, the Bole segment received a grade of B, reflecting a standard sidewalk environment that meets pedestrian needs. The Bole sidewalks are mostly smooth, adequately wide, and free of major defects, providing a comfortable walking experience. Future improvements in the Bole segment aim to enhance pedestrian comfort by adding amenities such as benches, trash bins, greenery, and shade.

The implications of these PLOS results are significant. In 04 Kebele segment, the basic conditions mean that pedestrians might still face risks due to uneven surfaces, insufficient safety features, and occasional obstructions, leading to a poor pedestrian walkability environment. Vulnerable groups, such as the elderly, children, and individuals with disabilities, are disproportionately affected, limiting their mobility and access. In contrast, the standard conditions in Bole promote safer and more comfortable walking, reducing the risk of pedestrian accidents and encouraging more people to walk. These conditions provide a more equitable environment, supporting the mobility.

The findings highlight a critical need for investment in pedestrian infrastructure to improve safety, accessibility, and comfort. Policymakers must prioritize pedestrian-friendly urban design, incorporating features like wider sidewalks, better lighting, regular maintenance, and traffic calming measures. Poor sidewalk conditions can decrease the overall liveability of a neighborhood, making it less attractive for residents and businesses. Efforts to improve pedestrian infrastructure can foster greater community engagement and a sense of ownership among residents. Addressing these issues is crucial for enhancing safety, accessibility, and overall quality of life for pedestrians, thereby promoting a more inclusive and liveable urban environment.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

This chapter provides a comprehensive conclusion of the study and presents recommendations based on the research findings. The primary objective was to evaluate the impact of sidewalk physical challenges on pedestrian walkability in Adama City. The conclusions drawn from the data analysis offer critical insights into the relationship between sidewalk characteristics and pedestrian behavior, while the recommendations aim to inform policy and urban planning to enhance pedestrian infrastructure.

5.4. Conclusion

This research aimed to evaluate the impact of sidewalk physical challenges on pedestrian walkability in Adama City, specifically focusing on selected arterial streets. Examining the existing condition of the sidewalk helps the study to see what the current issues are related to the pedestrian walkability as well the users' preferences and expectations of what elements contribute to increased levels of enhancing pedestrian comfort of Adama city pedestrian sidewalk. The outputs of the observed analysis are very clear that the current sidewalk is not convenient for its users because it's exposed to challenges such as narrow width, poor surface quality, presence of obstruction, lack of accessibility feature and street amenity.

Based on the study the sidewalk are exposed to numerous physical challenges, including many missing sections, numerous obstructions, frequent encroachments, and extensive pavement cracks. The sidewalk segment also lacked clearly defined pedestrian zones. The sidewalk width varied significantly, with many sections too narrow to accommodate the high pedestrian volume at peak hour, and the pavement quality and material differed across the segment, with some areas paved with asphalt or cobblestones and others remaining unpaved.

The Pedestrian Level of Service (PLOS) results for various street segments offer crucial insights into the quality and usability of the pedestrian environment. The Franko and postabet to mebrathayil Street segment's pedestrian level of service (PLOS) analysis highlights critical issues in its current state. The segments receives a grade of LOS D, indicating overcrowded sidewalks that make walking uncomfortable and restrict speeds. 04 kebele segment Rated as LOS C, with an average pedestrian traffic rate of 25.7 pedestrians per meter per minute which is somewhat acceptable but has noticeable issues. The Bole Street segment shows the lowest average pedestrian movement with LOS A It offers wide sidewalks and minimal obstructions, ensuring high comfort and convenience.

Generally, the common issues across all segments included interruptions in pedestrian pathways due to physical challenges, narrow sidewalks, lack of pedestrian zoning, and limited accessibility for wheelchair users. To address these issues, structural repairs are needed to fix missing sections, cracks, and obstructions. Implementing defined pedestrian zoning can organize space for various functions, enhancing safety and usability. Improving accessibility by adding proper ramps, smooth surfaces, and unobstructed tactile paving is crucial.

5.5. Recommendation

Based on the research findings, it is evident that the current street faces several detrimental issues. A thoughtfully designed and fully developed street serves as a crucial component of urban development, not only ensuring accessibility and safety but also fostering vibrant and attractive urban spaces with economic vitality. The governing executive body has consistently demonstrated a forward-thinking approach to street corridor development that incorporate pedestrian friendly sidewalks and street furniture's. Therefore, the subsequent recommendations have been formulated based on these research insights.

5.5.1. Policy recommendation

- **Sidewalk Width Standards:** Establish clear and enforceable standards for sidewalk width throughout. These standards should ensure that sidewalks are wide enough to accommodate pedestrians comfortably, including individuals with disabilities, strollers, and groups walking together.
- **Sidewalk Maintenance Mandates:** Implement policies that mandate regular maintenance of sidewalks by property owners or relevant municipal departments. This includes repairing cracks, addressing uneven surfaces, removing debris, and ensuring that sidewalks are free from obstructions.
- **Obstruction Management Regulations:** Enact regulations to manage and minimize obstructions on sidewalks. This could include restrictions on street vending in certain areas, designated zones for temporary structures like food carts, and enforcement mechanisms to prevent illegal parking or encroachments onto sidewalks.
- **Accessible Infrastructure Requirements:** Introduce policies requiring all new infrastructure projects, including road construction and redevelopment initiatives, to prioritize the creation of accessible sidewalks that adhere to universal design principles. This ensures that pedestrian infrastructure is inclusive and accessible to all members of the community.

- **Public-Private Partnerships:** Foster partnerships between municipal authorities and private stakeholders, such as businesses and property owners, to jointly fund and implement sidewalk improvement projects. This collaborative approach can leverage resources and expertise from both sectors to enhance pedestrian walkability across the city.
- **Enforcement Mechanisms:** Strengthen enforcement mechanisms to ensure compliance with sidewalk-related regulations. This may involve increasing the number of enforcement officers dedicated to monitoring sidewalk conditions, issuing citations for violations, and implementing penalties for non-compliance

5.5.2. Recommendation for Governmental Organization

- Concerning the street environment, on the other hand, arrangements such as curb ramps to help wheel chair users to use the foot way should be made, illegal street vending must be controlled, blocking streets for private construction works should be punished, finishing road construction according to the plan must be observed, controlling vehicle parking on foot paths and other barriers should also be considered; and paths for animals, people and cars should be differentiated. Concerning zebra crossing, the steep slope should be avoided, bridges should bear escalators, and speed limit of zebra crossings should be observed.
- Facilitating Regular Sidewalk Maintenance. Establish a systematic schedule for regular sidewalk maintenance, including tasks such as repairing cracks, smoothing uneven surfaces, and clearing debris. Assign responsibility for sidewalk upkeep to relevant municipal departments and ensure adequate funding for maintenance activities.
- Launch periodic campaigns to remove obstructions from sidewalks, such as illegally parked vehicles, street vendors, and overgrown vegetation. Collaborate with law enforcement agencies, local businesses, and community organizations to coordinate clean-up efforts and raise awareness about the importance of clear sidewalks for pedestrian safety.
- Prioritize sidewalk expansion projects in areas with high pedestrian traffic or where sidewalks are narrow or obstructed. Allocate resources for the widening of sidewalks and the creation of pedestrian-friendly zones, especially in commercial districts, transit hubs, and residential neighborhoods.
- Improve pedestrian crosswalks by installing tactile paving, audible signals, and visual markings to enhance accessibility and safety for pedestrians, especially those with

visual or mobility impairments. Ensure that crosswalks are well-lit and clearly marked to improve visibility for both pedestrians and motorists.

- Implement a sidewalk monitoring and reporting system that allows residents to report sidewalk issues, such as obstructions, damage, or maintenance needs, to the relevant authorities. Establish a centralized database to track reported issues, prioritize maintenance requests, and monitor progress on sidewalk improvement projects.
- Collaborate with local businesses to address sidewalk challenges in commercial areas. Encourage business owners to maintain clear sidewalks in front of their establishments and provide incentives for compliance, such as tax breaks or marketing opportunities. Work with business associations and chambers of commerce to promote a culture of sidewalk stewardship among local businesses.

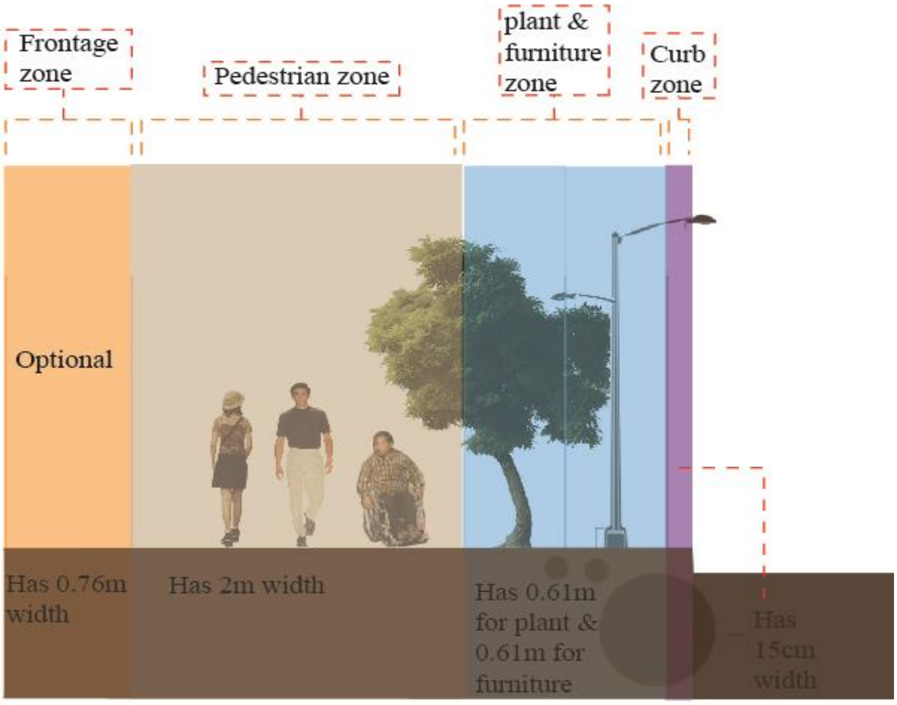
5.5.3. Design solution for the street segments

On the analysis part sidewalk condition have been identified among the main reasons made difficulty to pedestrian by hindering access across the network. Therefore, it is important that sidewalks are constructed and maintained correctly. This bring design solution to create accessible and comfortable sidewalk environment that enhance and improve disabled walking desire. In new developed construction, the commitment to create sidewalk corridor that meets the needs of all pedestrians that involve disabilities should be made during the planning stage. Generally, different design intervention are involved based local and international standards and guidelines.

The zone system should be used to determine the width of sidewalk corridor and to ensure that obstacles such as trash cans or utility poles, are not limit pedestrian access. The four zones within sidewalk corridor:

1. Curb zone
2. Planter/ furniture zone
3. Pedestrian zone
4. Frontage zone

The width of sidewalk corridor determined by the width of planter/ furniture, pedestrian and frontage zones. The size of curb zone is generally constant through all international and local standards. So that, based on the above zoning system recommended width of sidewalk for the study area regarding its pedestrian density flow and disability consideration about 4.1m which exceeds the minimum recommended effective width by 1.7m.



Zones	Recommended width
Curb zone	15cm
Planter and street furniture zone	1.22m
Pedestrian zone	2m
Frontage zone	76cm
Total sidewalk corridor	4.13m

Figure 5-1: pedestrian zone design of sidewalk

Curb zone

The curb zone is first 15cm of the sidewalk corridor immediately adjacent to the drive way. It is an integral part with drainage system and prevent excess water from collecting in the sidewalk corridor. The curb zone also discourages motor from driving into sidewalk corridor and used by people with vision impairment to identify the border between sidewalk corridor and the roadway.

Pedestrian zone: The pedestrian zone an area of sidewalk corridor that is specifically reserved for pedestrian travel. It ought to be free of obstacle, overhanging objects and vertical barriers because they can be hazardous to pedestrians, particularly for individuals with visual impairments. The following design components of sidewalks are considered in pedestrian zone design. It’s minimum of 2m in order to hold two wheelchair users comfortably at a time.

Planter or furniture zone

The planter/ furniture zone lies between the curb and pedestrian zone and intended to housing utility, such as traffic poles and fire hydrant and pedestrian amenity such as benches and bus shelter. The purpose of this zone is to ensure that the pedestrian zone will be free of obstacles. It has minimam width of 1.5m

Figure 5-2: pedestrian and planting zone (Author design)

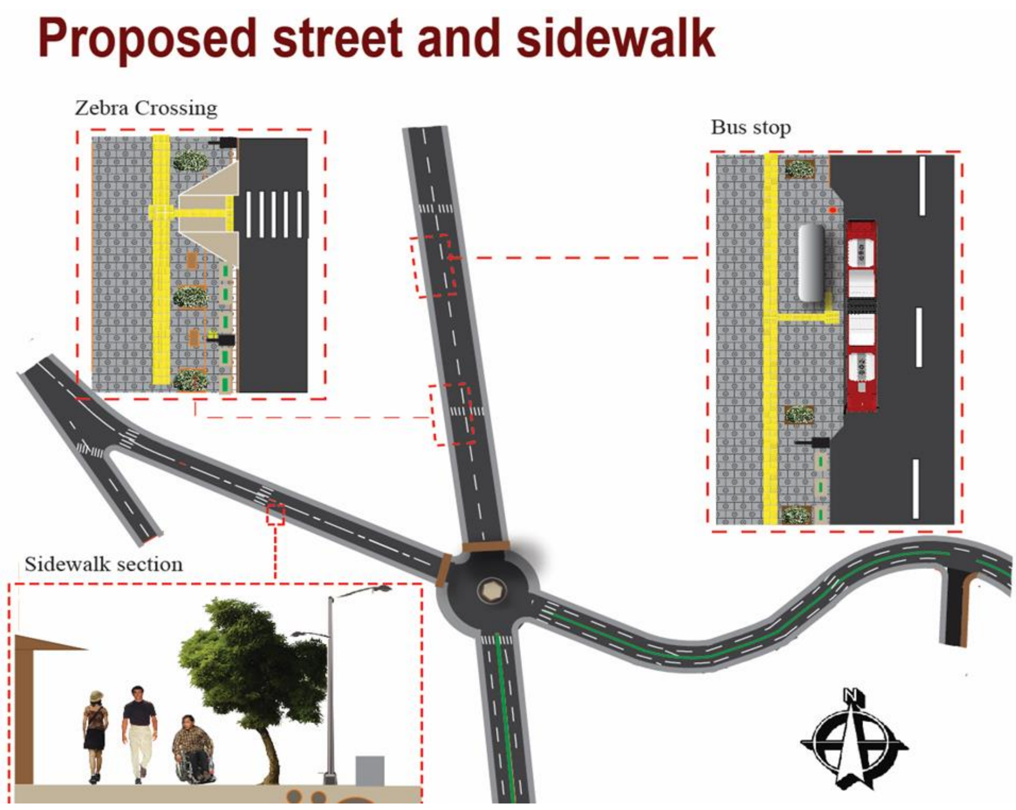


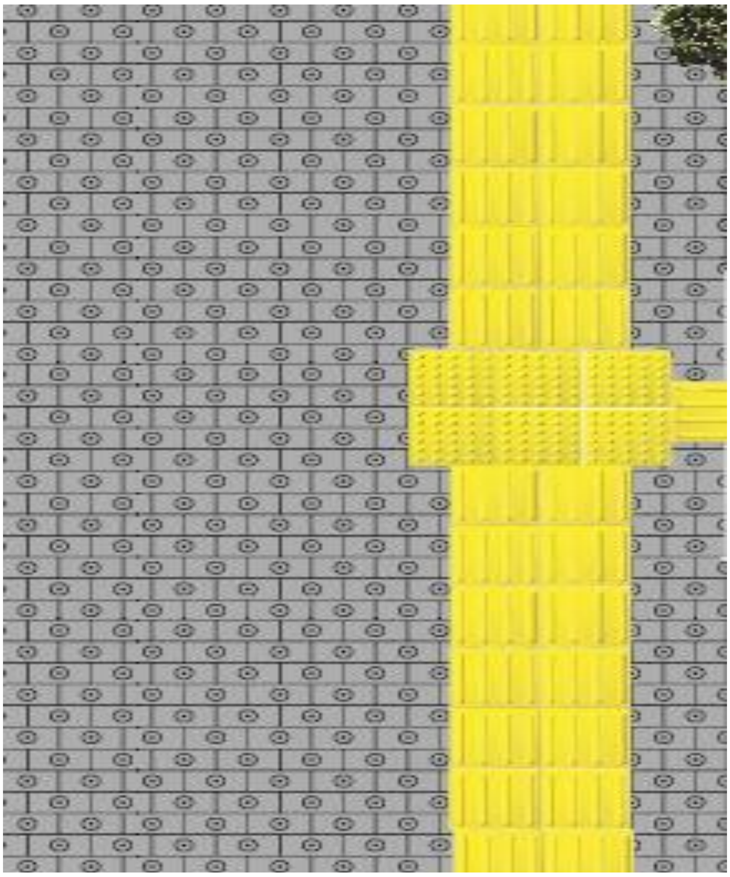
Figure 5-3: proposed sidewalk and street design (source: Author)

Proposed pavement

Surfaces should be firm, slip-resistant in wet and dry conditions and should not be made of reflective material. Dished channels (for drainage) should not be incorporated within pedestrian routes. Surfaces should be pedestrian friendly, providing a layout that complements the surrounding environment which does not disadvantage any user groups. Any unevenness of pavement can cause problems for some wheelchair users and some visually impaired cane users. The Joints between flags and pavers should not be less than 2mm and not more than 5mm.

Tactile paving: - Tactile paving should be used on access routes to provide warning and guidance to blind and partially sighted people. Layouts of all pedestrian areas should be simple, logical and consistent. This enabled disabled to memorize the environments that they used frequently and forecast and understand environments that they are meeting for the first time.

Blister surfaces: - Blister paving slabs are used to indicate a pedestrian crossing facility. This type of surface consists of parallel rows of flat-topped blisters 5mm (±0.5mm) high, 25mm in diameter.



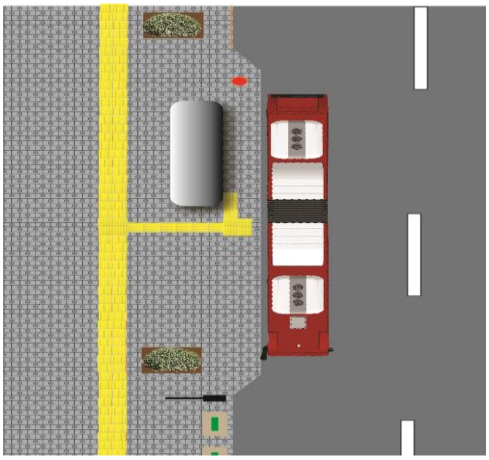


Figure 5-4: pavement design

Curb ramp: The curb ramps are used at every curb cuts and crossing wheelchair users comfortable and accessible to the sidewalk. The sidewalk cross slope is about 2% and curb ramp has maximum 8.3% gradient down walking area with tactile pavement to visually impaired.

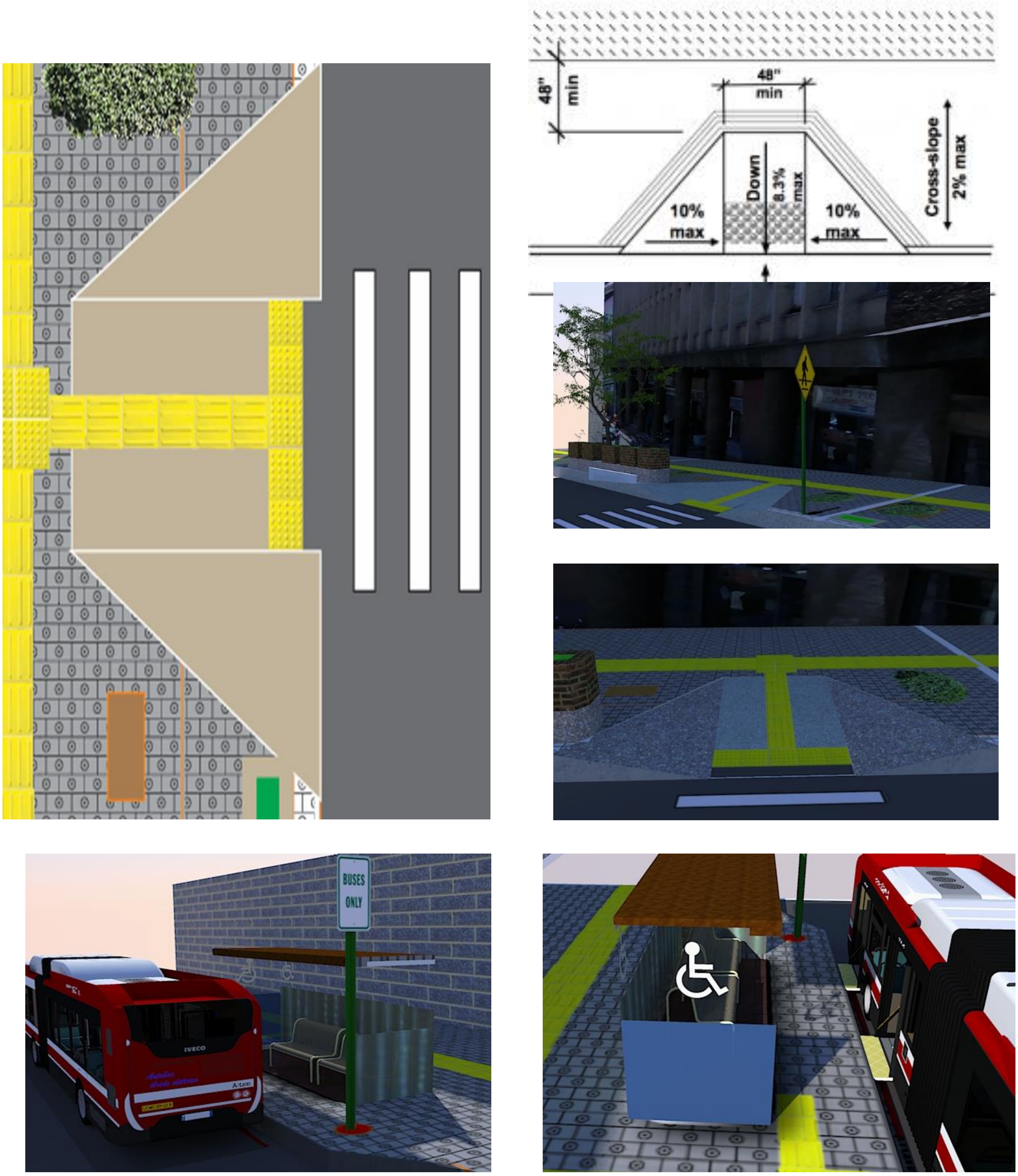


Figure 5-5: Curb ramp design

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Appendex A: Questionnaire for pedestrian

Research title: Evaluating the Impact of Sidewalk Physical Challenges on Pedestrian Walkability in adama city: The case of selected arterial Streets

Dear respondent,

I am inviting you to participate in this research by completing the following survey. The aim of this research is to investigate the physical challenges of urban pedestrian sidewalk in Adama city. The following questionnaire will require approximately 5-8 minutes to complete. The collected data will remain confidential and used solely for academic purposes. Thank you very much for taking your time and complete the survey!

Sincerely,

Tesfaye Regasa, final year postgraduate student of urban planning and design program.

Email: tesfayeregasa@gmail.com

Pedestrian perception survey questionnaire the case of Adama city

Direction: Thick one among the choice provided for choose questions, mark in the box, and elaborate your feelings for open-ended questions.

<u>Part I: Respondent personal information</u>

1. Gender: ☐ Male ☐ Female
2. Age: ☐ Less than 15 ☐ 15 - 35 ☐ 36 - 65 ☐ Over 65
3. Do you struggle to walk because of a physical disability? ☐ Yes ☐ No
4. If yes what your disability status? ☐ Visually impaired ☐ Hearing impaired ☐ wheelchair/crunch user ☐ Chronic health problem
5. Occupation: ☐ Student ☐ Self- employed ☐ Civil servant ☐ NGO s ☐ob seeker ☐ Other________
6. Monthly income: ☐ < 500br ☐500 -2000br ☐2000 -5000br ☐000 - 10000br ☐10000br
7. Residence location:___________________________________

<u>PART 2: Pedestrian Behavior and Patterns</u>

1. Do you prefer walking as a primary mode of transportation? ☐ Yes ☐ No
2. What is your purpose on this trip?

☐ Going to Work ☐ For Shopping ☐ Going to School ☐ Health ☐ visit ☐ For Entertainment Others

3. How often do you use this sidewalk?

☐. First time ☐ A few time a month ☐ A few times a week ☐ Every day ☐ More than once a day

4. Where did you start your walking trip? ___________________________________
5. How long did it take walking from there to here? ___________min
6. Where will you complete your trip? _____________________________________
7. How long will it take from here to there? _____________min
8. Are you feeling happy with the time you take to complete your trip? ☐ Yes ☐ No
9. What time of a day do you take long time to reach your destination? (Local time)

☐ 2:00 - 5:00 am ☐ 5:00 - 700 am ☐ 7:00 - 11:00 am ☐ 11:00am - 1:00pm ☐ ☐

10. What activities on the sidewalk most obstruct your ability to walk?

☐ Food selling on the street ☐ Bicycling on the sidewalk ☐ Street retailing
☐ Vehicles parking on the sidewalk ☐ shoe shiner ☐ wood work on the sidewalk

11. How much do you feel comfortable walking down this sidewalk with street vendors around?

☐ Uncomfortable ☐ slightly uncomfortable ☐ comfortable ☐ very comfortable

12. What time of a day do you feel unsafe and in secured to reach your destination?

Why? ____

☐ Morning ☐ Mid-day ☐ Night

PART 3: Assessment of Sidewalk Physical Conditions.

Please rate the following aspects of the sidewalks along arterial streets in Adama city on a scale of 1 to 5, where 1 represents "Very Poor", 2 represent “poor”, 3 represent “Fair”, 4 represent “Good” and 5 represents "Excellent."

R.No	Sidewalk aspects (adequacy of Pedestrian space and amenities and the quality condition)	Pedestrian perception on the aspects				
		1	2	3	4	5
1	Sidewalk Width					
2	Surface Quality					
3	Presence of Obstacles					
4	Accessibility Features					
5	Street amenities and furniture's					
6	Disabled pedestrian infrastructure					

Part 4: Investigation of Specific Challenges Faced by Pedestrians

Please indicate your level of agreement or disagreement with the following statements on a scale of 1 to 5, where 1 represents "Strongly Disagree", 2 represents “Disagree", 3 represents "Neutral", 4 represents "Agree" and 5 represents "Strongly Agree."

R.No	Specific Challenges Faced by Pedestrians	Pedestrian perception				
		1	2	3	4	5
1	I often face conflicts with vehicular traffic while walking on arterial streets.					
2	The space for walking on sidewalks is insufficient.					
3	The infrastructure for pedestrians is inadequate					

Part 5: Analysis of Effects on Pedestrian Behavior

Please answer the following questions based on your experiences while walking on arterial streets in Adama city.

13. How would you describe your typical walking patterns and comfort along the sidewalk?

-

____

___

14. Do you feel safe while walking on sidewalks? Please explain.

____

____

_____

15. Overall, how satisfied are you with the walking experience along the sidewalk?

____

____

______

Part 6: Recommendations for Improving Sidewalk Design, Maintenance, and Accessibility

1. Please provide your suggestions for enhancing the walkability of arterial streets in Adama city, considering factors such as pedestrian safety, comfort, and the promotion of sustainable transportation options.

Thanks for your advanced support!!!

Appendex B: Questionnaire for Municipality and Experts

Questionnaire for municipality

1. How many pedestrian sidewalks are provided on the arterial streets of Adama city?

   ____

2. Does pedestrian safety and accessibility considered in our development? Especially in constructing street infrastructure?

   ____
   ____
   ___

3. How does your institution consider Pedestrian Level of Service in designing and constructing urban pedestrian sidewalk?

   ____
   ____
   ___

4. How does disabled considered in road and sidewalk design?

   ____
   ____
   ___

5. What factor and mechanism determine pedestrian travel?

   ____
   ____
   ___

6. What integral policy program need to be recommended?

   ____
   ____
   ___

Appendex C: Site observation checklist

Name of data collector: ______________	**T**ime of survey: ______________
Name of street segment/junction: ______________	**S**urvey direction: ______________
1. Number of legs ______________ 2. Type street linked to the segment/ junction______________ 3. size of splitter Iceland______________ 4. Width and Height of sidewalk______________ 5. Length of the sidewalk______________ 6. Pavement material ______________ 7. Texture of pavement material______________ 8. Location of ramp and detectable texture for disabled on the sidewalk______________ 9. Location of damaged pavement ______________ 10. Number of obstacles on sidewalk ______________ 11. Location and type of obstacle ______________ 12. Pedestrian count at pick hour (ped/m/min) ______________ 13. Sight distance ○ Roundabout sight distance______________ ○ Crossing sight distance______________ 14. Setback distance and use ______________ 15. Number of mid-block crossing______________ 16. Location and size of crossing______________ 17. Crossing distance______________ 18. Crossing time______________ 19. Waiting time at crossing______________ 20. Type, size and location of pedestrian crossing bridge______________	21. Number of curb cut ______________ 22. Location of curb cut/ramp______________ 23. Location of Change in level on sidewalk (stair, ramp and steps) ______________ 24. Access to building from sidewalk (level entry, ramp or steps) ______________ 25. Number and type of signal equipment ______________ 26. Location, height, orientation and symbol of sign______________ 27. Type, location, height, distance and color of lighting______________ 28. Number, type and distance of trees and length of its canopy at different time of a day______________ 29. Location and type street furniture______________ 30. Location and type of street furniture for disabled______________ 31. Alignment of utility lines on Sidewalk ______________ 32. Cleanness of walking path(sanitation) ______________ 33. Average temperature ______________ 34. Average traffic volume at the area ______________ 35. Average traffic speed at the area______________ 36. Land use beside the street______________

Appendex D: pedestrian count table

Day’s	pedestrian Random count in 15 min			Sidewalk effective width(m)
	Morning	Night	Average	
Monday				
Tuesday				
Wednesday				
Thursday				
Friday				
Saturday				
Sunday				

Appendex E: Checklist of sidewalk indicator collected at every 60m distance section

Name of segment:		
Specific location of the 60m section:		
Indicator	**Measurements**	**Values**
Width	Width in Meter	
Obstructions	Number of obstruction	
Continuity	• No sidewalk along the segment • Missing some sections • Missing few sections	
Physical Condition	• Many cracks/break • Some cracks/break • Few cracks/break • No cracks/break	
Encroachments	Number of encroachment	
Cleanliness	• Large amount of litter • Some litter • Small amount of litter • No litter	
Slope	• Cannot be used by a wheelchair • Steep/ uncomfortable • Few steep section • Comfortable	
Shade Trees	Number of trees	
Buffer Zone	Width in meter	