

Assessing the Influence of Street Design on Pedestrian Walkability by using
Pedestrian Movement Modeling in Selected Areas of Downtown Adama City.



Behailu Abebe Dinku

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

June, 2024

Adama, Ethiopia

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DECLARATION

I hereby declare that this Research entitled “Assessing the Influence of Street Design on Pedestrian Walkability by Using Pedestrian Movement Modeling in Selected Areas of Downtown Adama City.” 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 Research have been duly acknowledged through citation.

Name of the student

Signature

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I, the advisor of this Research hereby certify that I have read the revised version of the thesis entitled " Assessing the Influence of Street Design on Pedestrian Walkability by Using Pedestrian Movement Modeling in Selected Areas of in Downtown Adama City” prepared under my guidance by Behailu Abebe Dinku 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 a revised version of the thesis to the department following the applicable procedures.

Major Advisor/Supervisor

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I, the advisor of the Research entitled " Assessing the Influence of Street Design on Pedestrian Walkability by Using Pedestrian Movement Modeling in Selected Areas of in Downtown Adama City" developed by Behailu Abebe Dinku, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the Research.

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LIST OF ACRONYMS AND ABBREVIATIONS

PVM	Pedestrian Movement Model
PLOS	Pedestrian Level of Service
PSV	Pedestrian Service Volume
PSR	Pedestrian Space Ratio
HCM	Highway Capacity Manual
CBD	Central Business District
ABM	Agent-Based Model
BRT	Bus Rapid Transit
TSP	Transit Signal Priority
GIS	Geographic Information System
SPN	Smart Pedestrian Network
LOS	Level of Service
PDA	Pedestrian Density Analysis
ADA	Americans Disabilities Act

ABSTRACT

Walkability is crucial for several reasons. It encourages physical exercise, enhances social interaction, lowers pollution and traffic, improves public health, and helps create thriving, livable communities. The main aim of this research is to investigate the influence of street design on pedestrian walkability, including different facilities on walkability, pedestrian density, pedestrian flow, and the condition of disability-friendly pedestrian amenities in downtown Adama City. The study used a mixed-methods approach, including a descriptive survey and manual field counts, to quantitatively and qualitatively assess pedestrian densities and identify the most congested pathways. It makes use of primary and secondary data sources, with surveys, interviews, and an investigation of accident data providing the necessary information. A sample of 386 was chosen, and the data was analyzed using descriptive statistical tools. The key findings show that the pedestrian route from National to Posta Bet was extremely congested, especially during peak hours, with a total peak hour volume of 825 walkers per 15-minute interval and a pedestrian level of service grade of F (constrained maneuverability). This route also experienced increased walking times, with an average of 750 seconds to cover the distance. The highest pedestrian flow was in Gurmmu Kebele's zone one, with 9,900 pedestrians on the Franco to Posta Bet route and around 8,460 on the Peacock to Posta Bet sidewalks daily. The research provides insights into the impact of pedestrian behavior on overall walkability. The primary gap identified is the lack of adequate pedestrian infrastructure, including small streets, few sidewalks, poor sidewalk conditions, poorly placed crossings, and non-functioning tactile pavement. The recommendations include providing necessary pedestrian amenities like seating and shade to enhance the walking experience and promote socialization, as well as developing design guidelines to educate stakeholders on appropriate sidewalk geometry standards.

Keywords: *Pedestrian, Walkability, pedestrian density, Hotspots, Street Design, Adama*

CHAPTER ONE

INTRODUCTION

According to the Culture and Tourism Office, the city has a broad and strategic ambition to overtake as Ethiopia's most important conference site (Adama City Municipality, 2012). Due to the effect of street design, Adama City, which is rapidly becoming more urbanized and has a growing population, confronts substantial obstacles in ensuring ideal pedestrian walkability. Because of the current roadway design's inadequate attention to pedestrian demands, there are safety, comfort, and disturbance issues. Achieving various socio-economic benefits in the absence of excellent street conditions is difficult. In Adama town, no research has been conducted to determine whether or not potential pedestrians are walkable. Thus, in this instance, roadway design may greatly affect pedestrian comfort and safety in any city, including Adama, Ethiopia. In addition to facilitating urban mobility, a well-planned pedestrian street may stimulate the city's social and commercial life.

In Adama, town pedestrian street design has been a topic of concern for many years. The city has been growing rapidly in recent years, with new residential and commercial developments popping up all over the city. Some of the factors that can impact pedestrians in Adama include the narrow streets, insufficient sidewalks, the condition of the sidewalks, the location of crossings, and the absence of traffic signals. Additionally, it does not work properly on tactile pavement for Blind walkways disabled walkways, and also a street pole light in the middle of the pedestrian street. There are numerous unsafe open spaces on the pedestrian path, these also create accidents.

1.1 Background of the study

The term "pedestrian walkability" describes how enjoyable and simple it is to walk in an area. It includes a range of elements, including accessibility, safety precautions, sidewalk availability, and quality, and the general layout of the built environment (Dörrzapf L, 2019). In addition to being a vital form of transportation, walking is also an integral part of a healthy and sustainable lifestyle. Urban areas need to be walkable to encourage healthy, active lives, decrease dependence on vehicles, and build growing, cohesive communities (Abdullah & Al-Qemaqchi, 2020). Urban areas may promote walking as a practical and enjoyable form of transportation by giving priority to pedestrian walkability. Furthermore, by encouraging individuals to spend more time in urban

areas, supporting small businesses, and promoting a feeling of community, walkability can benefit the local economy (Khabiri et al., 2020). Cities around the world are dealing with a variety of issues as a result of increasing urbanization, population expansion, and the increase in motorized traffic (United Nations, 2018). These problems, which are frequently linked together, lead to a worrisome reduction in the walkability of pedestrian areas, which brings about several negative outcomes such as sedentary lifestyles, increased air pollution, traffic jams, and social isolation. Because there is not enough pedestrians area. Even those who are they are not up to standard for cities hoping to effectively manage these problems, it becomes vital to acknowledge the critical role that street design plays in determining pedestrian walkability.

The relationship between street design and urban planning goes beyond practicality and aesthetics. As it turns out, it plays a crucial role in creating better environmental conditions that protect the health and safety of many user groups who utilize the streets. As a result of this mutually beneficial interaction, urban areas are created that not only effectively serve a variety of requirements but also align with environmental conservation principles, emulating an ethic of sustainability, efficiency, and justice (Svarre, 2013).

Because of the continent's fast urbanization, population growth, and increasing motorization, pedestrian walkability is a key issue in African towns. Unsafe road conditions, a lack of appropriate walkways, and poor pedestrian infrastructure are problems in many African towns. However, to meet pedestrian needs and encourage sustainable urban development, there is a rising recognition of the necessity of giving pedestrian-friendly street design priority. The impact of street design on pedestrian walkability has been the subject of recent research conducted in African cities, highlighting the significance of context-specific interventions. (Olaseni, 2020) Conducted research in Lagos, Nigeria, which emphasized the importance of pedestrian infrastructure, street connection, and safety measures in improving walkability and levels of pedestrian activity.

Even though walking accounts for a significant amount of urban travel in Sub-Saharan African cities, pedestrian infrastructure and other non-motorized transportation options have received little attention. City officials are particularly concerned with road-based transportation due to the high rates of motorization and the introduction of transportation technologies (Lukenangula, 2023).

Involves incorporating unofficial economic activity into the structure of cities. A large percentage of foot traffic in many African cities is related to street vendors and unofficial business. Africa

takes climate factors like severe temperatures and seasonal changes into account when determining pedestrian walkability. When creating walkable environments, shaded places, water accessibility, and other climate-responsive elements are all taken into account (Olaseni, 2020)

Ethiopia's fast urbanization has an impact on pedestrian walkability, which raises the need for effective and secure pedestrian transportation. To accommodate pedestrians, the nation's major centers require upgraded infrastructure (M. S. Tarekegn 2018). Ethiopia has problems with unplanned urban growth and informal settlements that make it difficult for people to walk there. Important factors to take into account are unofficial routes, inadequate infrastructure for pedestrians, and security issues (In 2019, Ayenew, T. & Bantider, A.).

Ethiopian walkability is a result of continuous government efforts to upgrade urban infrastructure. The goal of policies and initiatives is to improve pedestrian crossings, sidewalks, and generally walkable urban areas (Roads Authority of Addis Ababa Citym2016).

Ethiopian initiatives to make walking easier using public transportation systems are part of the country's pedestrian walkability. When creating public places and roadways, seamless transitions between walking and other forms of mobility are taken into account (Girma, A. (2014).

Adama is one of the biggest cities in Ethiopia. The urban area is growing and urbanizing at an alarming rate. The city of Adama has seen an incredible increase in both population and city size over the past several years. People prefer to utilize the sidewalks to get to work in the city center because of how quickly the city is expanding to its surroundings. However, there isn't a proper pedestrian street for this, therefore there is a greater need for cars, which raises the risk of air pollution and carbon emissions. This may worsen human health, impair air quality, and accelerate climate change. A city or neighborhood's general livability and attractiveness may suffer if there are no pedestrian streets.

Signalized intersections are of particular concern because there are so many of them on the road system in Adama City. While some of these crossroads are uncontrolled, many of them are under the authority of police officers or signage. Mobility is the primary purpose of many crossroads on large arterial or minor roads. At signalized intersections in the study area, potential safety issues include poor geometric design, high traffic conflict, poor visibility of traffic signs and pavement markings, improper pedestrian crosswalk placement and design, pavement distress, and inadequate

intersection channelization. Additionally, some of these intersections experience a sufficient number of specific crash types to suggest that safety needs to be improved (Tefera, 2018).

1.2 Statement of the Problem

In Ethiopia, is known for having a high pedestrian density and busy streets. Increased pedestrian activity has been seen in several regions of as a result of the fast urbanization and population expansion the quantity of pedestrians in a certain region at a certain moment is referred to as pedestrian density. In Ethiopia, there is a lot of foot traffic, especially in the marketplaces, bustling business districts, and neighborhoods close to well-known attractions.

In Adama, Ethiopia, there has been an obvious rise in population densities and urban growth. Nonetheless, the city's pedestrian density is hindered by the lack of suitable pedestrian infrastructure. The provision of well-planned and easily accessible sidewalks is essential in promoting walking as a means of transportation in metropolitan environments. But in situations where there aren't enough accessible sidewalks, people pedestrians face challenges in safely navigating their routes.

When pedestrians are unable to find suitable sidewalks, they often resort to using narrow footpaths or walking along the edges of roads. This can lead to congestion and overcrowding, especially during peak hours when there is a higher volume of pedestrian traffic. The limited space on footpaths and the proximity to moving vehicles can create an unsafe and uncomfortable environment for pedestrians.

By developing pedestrian management measures, the researcher starts to address the extreme pedestrian density in downtown Adama. The study employs an innovative approach that includes a thorough examination of pedestrians and a walking analysis of their origin-destination.

Previous work on the effects of developing-nation cities, like those in Mozambique, on pedestrian behavior—particularly walking—was only done in link-based analyses; this study simply looks at pedestrian density and behavior (Mendiate, 2022). Here, the trip source area will be broken down for pedestrian density and pedestrian movement assessment, and the study will be conducted using an idealized model that employs pedestrian movement model analysis for pedestrian analysis in pedestrian analysis zone PAZ. By evaluating the amount of pedestrian density on the chosen route

and using pedestrian movement model analysis to look at pedestrian behavior and density, this study will try to identify pedestrian density hotspot areas in the city.

(Tufa, M.A. 2019) the abstract states that extremely low standards were discovered for pedestrian amenities, crossing locations, lights, and walkway surface quality. However, there remains a study vacuum concerning the infrastructure and amenity demands unique to pedestrians with disabilities. A possibility for research could be to identify the shortcomings of current pedestrian amenities and suggest enhancements that address the requirements of people with disabilities. However, there aren't enough pedestrian amenities that are accessible to those with disabilities.

(Lulseged, 2021) The history of pedestrian accidents is mentioned in the thesis, but neither the causes of pedestrian accidents nor viable solutions to increase pedestrian safety are thoroughly examined. A more thorough investigation of pedestrian density-related problems, encompassing the identification of pedestrian cognition areas, the investigation of accident causes, and the proposal of solutions aimed at reducing pedestrian injuries and fatalities, is lacking in the literature.

Numerous important features of pedestrian infrastructure and walkability in urban areas have not received enough attention in the amount of study that has already been done on the subject, especially when it comes to Adama. A significant lack of research studies that are primarily focused on Adama exists with the fact that studies have looked at elements like pedestrian density, pedestrian behavior, and the factors that determine walkability.

Of Adama, the research indicates notable gaps in understanding of the pedestrian infrastructure of the city and its influence on walkability. For example, previous research has not properly investigated the quality and number of pedestrian facilities that are accessible to people with disabilities, which is a crucial mistake considering the significance of inclusive design. Furthermore, a more thorough explanation of the primary variables affecting pedestrian walkability in Adama's urban core is required.

By undertaking a thorough examination of the impact of street design on pedestrian walkability in downtown Adama, this review seeks to fill these gaps. Through an emphasis on pedestrian density, behavior, and the accessibility of infrastructure, the study yielded important information that may guide the creation of livable, pedestrian-oriented urban settings inside the city. The results can also

advance our knowledge of how design decisions affect walkability in environments where pedestrian mobility is frequently forgotten.

1.3 Objectives

1.3.1 General Objective

The general objective of the research is to assess the Influence of Street Design on Pedestrian Walkability by using pedestrian movement modeling in selected areas in downtown Adama City.

1.3.2 Specific Objective

The specific objective of the study is to:

1. To investigate current pedestrian walkability in Adama City.
2. To analyze Adama's Pedestrian Street design from a design perspective.
3. To measure the influence of pedestrian behavior on walkability in downtown Adama city.
4. To identify pedestrian density hotspots along major selected Pedestrian Streets in Adama using a pedestrian movement model, and to measure their effect on walkability.

1.4 Research Question

1. What is the current pedestrian walkability in Adama City?
2. How is Adama City's pedestrian street design from a design perspective?
3. What is the influence of pedestrian behavior on walkability in downtown Adama City?
4. How pedestrian density hot spots area along the major can selected Pedestrian Streets in Adama, by using the pedestrian movement model, and how does pedestrian density affect walkability?

1.5 Significance of the Study

The research has made its own empirical and theoretical contributions, as well as filled a research gap on the subject.

To study pedestrian conditions that lessen the impact of street design on pedestrian walkability and to identify pedestrian density using this pedestrian movement model, this research has developed a thorough understanding of the theory and concept of street design on pedestrian walkability. This provides a strong theoretical foundation for the study. And it closes the gap left by prior, link-based research on pedestrian walkability by focusing on the broader street design

components that affect pedestrian movement, safety, and overall walking experience. By offering insights into the precise street design elements that affect pedestrian movement patterns, safety, and the overall walking experience, the study has helped to improve pedestrian walkability in downtown Adama. Urban planners, designers, legislators, and local governments can use this information to better prioritize the requirements of pedestrians and develop more pedestrian-friendly streetscapes.

Using pedestrian movement modeling (PVM), the project has evaluated the effects of various street design scenarios and offered evidence-based recommendations for design changes. This modeling and empirical analysis adds methodological rigor to the study. To improve pedestrian walkability, it can be used to identify design components that require improvement or alteration. This can help with informed decision-making during the urban planning and design processes.

Additionally, it makes urban areas more habitable and sustainable by enhancing pedestrian walkability. The study can support a more environmentally and socially inclusive urban fabric, encourage active lives, and lessen dependency on motorized transportation by giving priority to walkers.

In addition, this research finding contains scholarly contributions that help anyone start a pedestrian walkability examination and can be utilized as a reference for future research. It also acts as a guide for the demand assessment planning procedures of many road authority sectors

1.6 Scope of the Study

The study has been limited to Adama City's downtown, with a special focus on how walkable and pedestrian-friendly the area is. The analysis makes use of the city center's current pedestrian street, which offers every kind of access within the analysis area. The study has used a significant pedestrian street network that includes the following routes: the ones from Franco to Posta Bet; Mebrat hail to Posta Bet; Addis Ababa Meneharia to Posta Bet; National to Posta Bet; and Amede Gebeya to Posta Bet.

By offering evidence-based insights into how particular elements of street design affect pedestrian walkability—such as the street designs of particular urban routes in the city that are accessible to people with disabilities and how those designs affect pedestrians—this research aims to advance

the field of urban planning and design. The scope includes developing useful suggestions that designers and urban planners may apply to make urban landscapes more pedestrian-friendly.

1.7 Operational Definition

The degree to which an urban environment is purposefully planned and structured to promote and enable walking as a practical means of transportation is known as pedestrian walkability.

Pedestrian movement modeling is the process of evaluating and foreseeing pedestrian behavior and movement patterns in urban environments via the use of simulation models and computer techniques. To better understand and develop pedestrian-friendly urban settings, it helps researchers and planners to simulate and anticipate pedestrian movements (Zhang, J., & Duives, D. C., 2021).

1.8 Definition of Key Terms

Pedestrian Space Ratio (PSR) is a measure used in urban planning and design to assess the availability and adequacy of pedestrian spaces in the overall area. It is calculated by dividing the total pedestrian area (such as sidewalks, plazas, and walkways) by the total land area or street length.

AnyLogic is a simulation modeling software that can be used to model and simulate pedestrian density, pedestrian flow, pedestrian behavior, and movement within various environments. It provides a platform for creating agent-based models that represent individual pedestrians and their interactions with the surrounding environment.

The Highway Capacity Manual (HCM) is a widely used tool for analyzing and evaluating the capacity and performance of transportation systems, including pedestrian facilities. The model considers factors such as level of service, walking time, pedestrian volumes, and walking speeds.

Pedestrian Service Volume (PSV) is a measure used to evaluate the capacity and level of service of pedestrian facilities, such as sidewalks, crosswalks, or pedestrian corridors. It represents the number of pedestrians passing a specific point or using a facility within a given period. The PSV considers factors such as pedestrian volumes, walking speeds, and facility width to determine the level of service provided to pedestrians.

Pedestrian Density refers to the measurement of the concentration or number of pedestrians within a specific area or space. It is typically expressed as the number of pedestrians per unit area or length. Pedestrian density is used as a metric to assess the level of pedestrian activity in a given location or to evaluate the capacity and usage of pedestrian facilities.

1.9 Limitations of the Study

The study provides information on how pedestrian movement modeling in downtown Adama is used to evaluate the impact of street design on pedestrian walkability. The following are some of the difficulties encountered in these research techniques most frequently:

This researcher mostly uses manual field counting to assess pedestrian density, walking time, and speed. Since automatic recording equipment could not consistently collect these parameters in the research region, this approach was chosen. Consequently, these factors present significant challenges to the effective conduct of this study.

Data and information accessibility: Since certain information is available for security, privacy, or logistical reasons, it is difficult to get enough relevant data from primary or secondary sources. One of the main issues addressed during the information-gathering process is representative households' unwillingness to openly offer information. This hesitation stems from worries about the security implications of exchanging personal information. To overcome this challenge, a mediated technique must be used to establish trust and protect respondents' private information.

Because of the temporary security issue, the majority of them declined to respond when I asked those questions in every way.

1.10 Structure of the Research

Five chapters comprise the organization of the research. With an emphasis on the purpose of the article, Chapter One examines the background of the study and offers a general introduction to the topic. It demonstrates the goal of the study. The literature review, which includes a theoretical and empirical analysis of the topic, is covered in the second chapter. The research method, or the study's plan, is covered in the third chapter. This chapter contains parts of the study population, sample technique, data type and source, research design, study approach, and study area description. The methods for data processing, data analysis, and data gathering are the main topics of this chapter. This is the overall structure of this paper.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Introduction

This chapter covers the literature review that is pertinent to the research problem. It provides more in-depth reports on how street design in the study region affects pedestrian walkability, including walkways, pedestrian density, street illumination, safety issues, and the disabled. It also explores previous studies on the topic conducted by various academics and talks about the theories that inform designs for pedestrian walkability. Walking allows one to engage in experiences and interactions with the surrounding community and larger society that are not feasible while utilizing other modes of transportation, especially motor vehicles Gemzoe and Gehl (2003). This will provide information on the differences between the theories and rules that guide the requirements of the researcher. An investigation of the link between the independent and dependent variables for the research completes the chapter.

2.2 Theoretical Review

The literature related to the study's main terms is presented in this section of the research. I'll talk about their definition, the qualities of the concept of pedestrian walkability, Pedestrian Movement Modeling, and their utilization, which includes sidewalk width, pedestrian density, and crosswalks (Global Street Design Guide 2023). To properly use urban transportation, including street design and walkability according to (Urban Street Design Guidelines 2016). Which improves society's quality of life, the research attempted to review the literature on the subject.

2.2.1 The Importance of Street Design

According to Gehl and Svarre (2013), street design has a crucial role in determining the overall quality of life in urban areas, beyond simple utility. As public areas, streets have an impact on neighborhood unity, social interactions, and ultimately, pedestrian experiences. Street design influences not only land use but also the environmental sustainability, public health, economic activity, and cultural significance of urban areas (Global Street Design Guide 2023). Theoretical theories underscore the complex interplay between safety, aesthetics, and accessibility in street design. The functionality, safety, and general quality of urban areas are greatly influenced by street

design. Influencing many facets of a city or neighborhood, it is a crucial component of transportation engineering and urban planning.

Sidewalk: the lateral separation between a sidewalk's outer border and a nearby road or property line. A crucial aspect of design that affects pedestrian comfort and movement capacity is sidewalk width. Sidewalks need to be unrestricted with surfaces that are level, constant, and non-marking; they shouldn't have any decrease projections or sudden level changes. It ought to be given senses of touch and visual indications as route finders, as well as guiding bricks for those who are blind or visually impaired. It should employ various colors and textures to create clearly defined roads and routes (Urban Street Design Guidelines 2016).

Sidewalk corridor zones

Sidewalk areas refer to the different functional spaces of a street that are only dedicated to pedestrians. These zones include frontage and marketing zones Areas of sidewalk that are located at the frontage of buildings along the streets. These spaces include building entrances and front yards, outdoor café seating spaces, vending areas, window shopping, and building-related utility areas. The second zone is the pedestrian clearway zone: it is the most important area of sidewalks which is provided for the clear, continuous, and safe movement of pedestrians. The provision of its clearway width depends on the amount of pedestrian activity along the street. The third zone is the Furnishing and planting zone: the area of offside walk on which pedestrian amenities like dust bins, bicycle racks, sitting benches, lighting poles, and plantations are provided. The last zone is the edge/buffer zone: the area of the sidewalk which is behind the street curb stone, which serves as a buffer between the adjacent street and sidewalk (Officials), 2022)This zone may have signposts, curb extensions, decorative pavers, and garbage set outs, the parklets, stormwater management features, parking, cycle racks, cycle share stations, and curbside cycle tracks. (Linda Bailey, Matthew Roe, 2016)

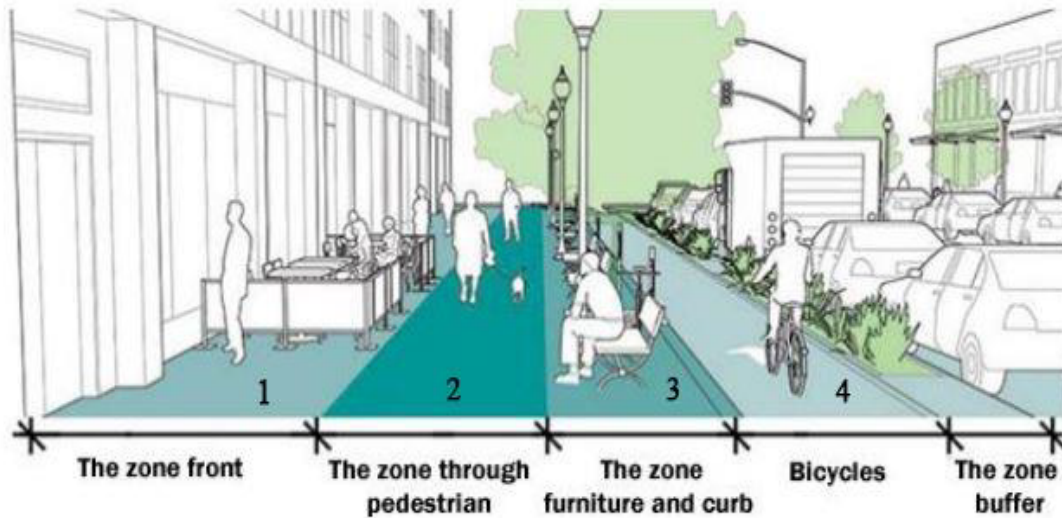


Figure 2.1 Global Street Design Guide sidewalk zone (Officials), 2022)

Clearway zone width provision varies depending on the place where they are provided and for whom they are provided. (Toronto complete street guideline, 2016)



Figure 2.2 Standard size of walkways (Toronto complete street guideline, 2016)

Street Lighting: the installation of artificial lighting alongside roadways to improve evening visibility, safety, and appearance. To make a pedestrian environment safe and welcoming, street illumination is essential Klein, Steemers (2003). The illumination of sidewalks and roadways to improve visibility at night or in low light is referred to as street lighting. Because it increases perceptions of safety, lowers the chance of accidents, and improves visibility for both automobiles and walkers, proper street lighting is crucial for pedestrian safety. To provide sufficient illumination, street lighting may consist of lampposts, overhead lights, or other carefully positioned lighting equipment.

2.2.2 Universal accessibility

Pedestrian ramps

Refers to inclined plans which are provided for disabilities with wheelchairs and other pedestrians with strollers, carts, or heavy luggage to easily access the pedestrian sidewalks. These ramps should be constructed from non-slippery materials having a maximum slope of 8 to 10 %. The ramp should be as wide as the pedestrian clearway zone which is a minimum of 1.8 meters wide, 2.4 meters is recommended. These ramps should be provided at every pedestrian crossing (Steinfeld, 2021)

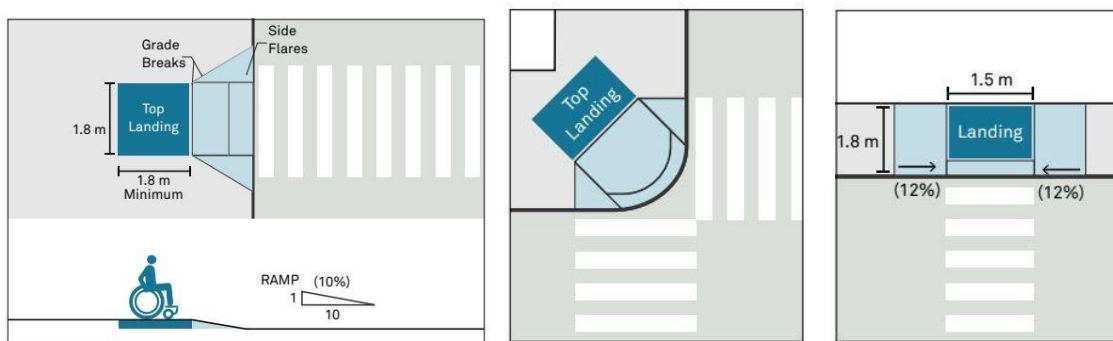


Figure 2.3 Ramp standard (Officials), 2022)

Detectable surfaces

Refers to surfaces that have distinctive textures providing certain information for pedestrians with disabilities. These surfaces can be tactile pavers.

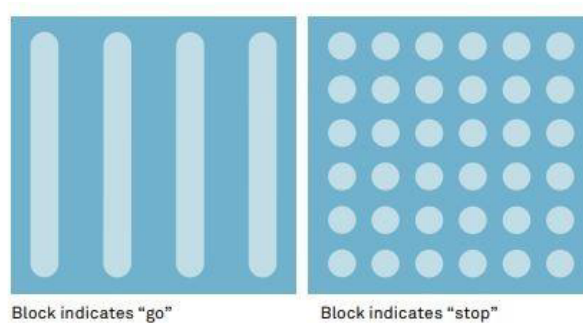


Figure 2.4 Tactile surfaces (Officials), 2022)

Pedestrian crossings

Since pedestrians' mobility is highly sensitive to a change in grade, geometry, and surface materials quality while using sidewalks, high attention shall be given while designing them. This includes the provision of crosswalks shall be provided every 80 -100 meters, in which distances more than 200m shall be avoided. It should also be as wide as the sidewalk it connects to and not be less than 3 meters wide. In addition to this, if pedestrians take more than three minutes to walk without pedestrian crossing, they may choose to take a more direct path to cross streets which is mostly unsafe. (Jure Kostanjsek and Lipar, (2007)

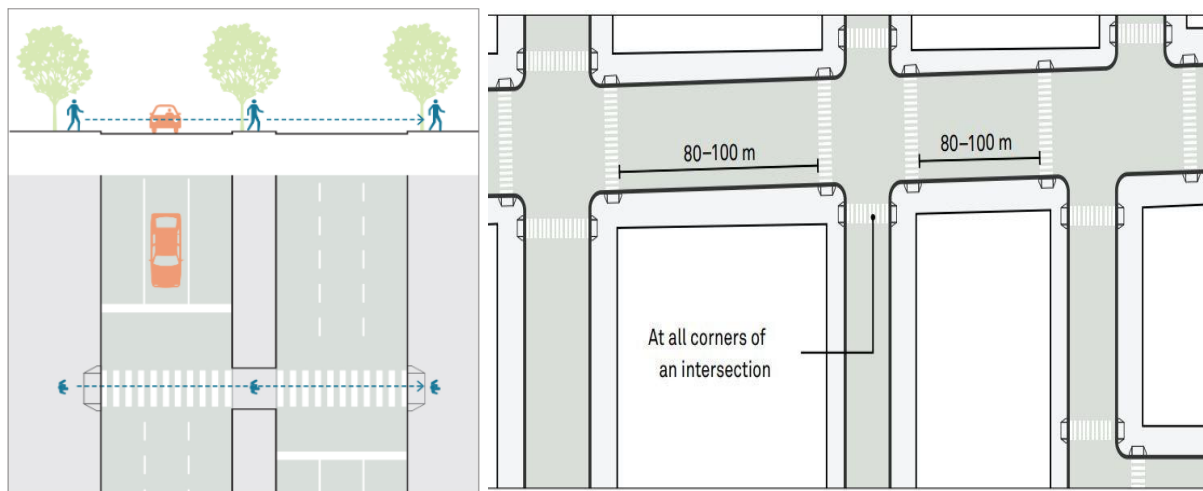


Figure 2.5 Pedestrian crossing distance

2.2.3 The Concept Pedestrian Walkability

The concept of "pedestrian walkability" describes how well an area or urban environment is planned and organized to facilitate comfortable, convenient, and safe walking. A pedestrian-friendly environment must take into account elements like illumination, roadway plants, sidewalk width, and general safety. The physical layout of a city, especially the establishment of welcoming and safe pedestrian zones, is a crucial factor in pedestrian walkability (Carlson and others, 2018). It consists of several components that support and improve accessibility and pedestrian flow in a certain area. The idea behind pedestrian walkability is the knowledge that walking is a vital form of transportation and a key element of a sustainable, livable city. Since walking and cycling are seen as "green" forms of transportation, they are good substitutes for putting sustainable urban mobility concepts into practice (Rafiemanzelat, 2017).

Improving pedestrian walkability is becoming increasingly important in urban planning and architecture (Sun et al., 2019). To do this, attention must be directed toward enhancing several crucial elements, including street connectivity, pedestrian safety, and sidewalk quality (Asriana, 2021).

2.2.4 Pedestrian Density Analysis

The goal of pedestrian density analysis, or PDA, is to evaluate and understand information on the number of pedestrians in a given area. Urban planners may use this study to better understand and anticipate pedestrian behavior as well as assess the performance of the current infrastructure. (2018), Lai and Kontokosta Pedestrian density analysis involves the assessment and quantification of the number of pedestrians within a specific area or zone. (In 2007 Clifton et al) the movement and concentration of people within a certain region may be measured and analyzed using a technique called pedestrian density analysis. (Wey and Chiu, 2013) Researchers and planners can enhance the overall safety and effectiveness of pedestrian flow, make educated judgments regarding urban design and infrastructure, and provide important insights into how people use public areas by having a thorough grasp of pedestrian density. It provides insights into the level of pedestrian activity and concentration in different parts of a city, urban space, or specific pedestrian infrastructure. Pedestrian density analysis is valuable for urban planners, transportation engineers, and researchers to understand pedestrian behavior, assess the performance of pedestrian facilities, and inform design and planning decisions. Here are some key aspects of pedestrian density analysis:

Data Collection: Pedestrian density analysis typically involves collecting data on pedestrian movements within the target area. Data can be collected through various methods, including manual counts, video recordings, automated sensors (such as infrared sensors or camera-based systems), or mobile tracking apps. The collection methods may vary depending on the scale of analysis, available resources, and desired level of detail (Cheng Zhang, 2023)

Spatial Analysis: Once pedestrian data is collected, it can be analyzed spatially to determine pedestrian density. Spatial analysis involves dividing the study area into smaller zones, such as grid cells or polygons, and calculating the number of pedestrians within each zone. This analysis helps identify areas with high pedestrian concentrations and areas with lower pedestrian activity (Liu, 2022).

Density Metrics: Various density metrics can be used to quantify pedestrian density. Common metrics include the number of pedestrians per unit area (e.g., pedestrians per square meter or square kilometer), pedestrians per unit length of a street segment, or pedestrians per unit time (e.g., pedestrians per hour). These metrics provide a quantitative measure of pedestrian activity and concentration within specific zones or along specific routes (Zhang, 2021).

Visualization Techniques: Visualization techniques, such as heat maps or contour maps, can be used to visually represent pedestrian density. Heat maps use color gradients to indicate areas of high and low pedestrian density, providing a clear visual representation of pedestrian activity patterns. Contour maps display lines of equal pedestrian density, allowing for a better understanding of spatial variations in pedestrian activity (Wang et al., 2020).

Temporal Analysis: Pedestrian density analysis can also incorporate temporal aspects by examining variations in pedestrian activity over different periods. This analysis can reveal peak pedestrian hours, daily patterns, or seasonal fluctuations in pedestrian density. Temporal analysis helps identify when and where pedestrian congestion may occur and informs the design of appropriate interventions (Weihua Zhang a b, 2021).

Benchmarking and Comparison: Pedestrian density analysis often involves benchmarking and comparison with established standards, guidelines, or similar urban contexts. Comparing pedestrian density in different areas or at different times can highlight areas of concern, identify areas with insufficient pedestrian infrastructure, or assess the impact of interventions or changes in land use (Donghwan Ki, 2022).

Planning and Design Implications: The findings from pedestrian density analysis can inform urban planning and design decisions. It can guide the allocation of resources, such as the provision of adequate pedestrian infrastructure, the location of crosswalks, the design of public spaces, or the implementation of traffic calming measures. The analysis can also help identify areas where pedestrian-oriented interventions are needed to improve safety, comfort, and overall pedestrian experience (Xiaolin Yang, 2023)

2.2.5 Pedestrian Density Measure

Pedestrian Level of Service (PLOS)

It is a measure used to assess the Pedestrians density and comfort of walking conditions and facilities for Pedestrians It provides an evaluation of the level of service experienced by pedestrians in a specific area, similar to how Level of Service (PLOS) is used for assessing the quality of Pedestrians flow (Manual, 2016). The measure categorizes the performance of a transportation facility into six letter grades (A to F), considering factors such as speed, density, and delay. PLOS is a widely accepted measure among transportation planners and researchers in assessing roadway congestion (Chester, 2013). However, the limitation of PLOS is that it does not take road users' perceptions into account.

Walking Time

As a Density measure, walking time is a direct indicator of mobility, reflecting the time required by sidewalk users to traverse a specific distance (D. Erath, 2018). Using walking time data can provide insights into density patterns and help prioritize transportation improvements (Jin, 2018). While walking time is an essential measure, it is dependent on various data sources like GPS data and manual field surveys, affecting its accuracy and reliability (Zheng, 2016).

Pedestrians Flow

Pedestrian flow refers to the movement of pedestrians through a given area or along a specific route. It is a measure of the number of pedestrians passing through a particular point or segment within a given period.

2.2.6 Pedestrian Movement Modeling

Pedestrian movement modeling is a crucial aspect of urban planning, safety analysis, transportation design, and other related fields. Most pedestrian movement volume models were constructed for urban areas that developed based on pre-modern planning (Itzhak Omer 2015). This modeling involves the study and prediction of how pedestrians move within urban areas, considering various factors such as speed, behavior at crossings, and interactions with infrastructure and other pedestrians. To understand pedestrian dynamics, researchers have developed different models such as cellular automata, the social force model, and agent-based models (Erkan, 2017).

Urban planners and designers can evaluate the effects of many elements on walkability and pedestrian behavior, including land use patterns, street designs, and infrastructural configurations, by using pedestrian movement modeling. These models may represent the intricacy of pedestrian motions and offer insights into how various design scenarios affect pedestrian flow, pedestrian density, and overall pedestrian experience by simulating individual individuals as autonomous agents.

2.2.7 Pedestrian Simulation in AnyLogic Analysis

Pedestrian simulation in AnyLogic provides a robust framework for analyzing pedestrian density and flow dynamics within urban environments. By leveraging agent-based modeling, AnyLogic allows for the creation of sophisticated simulations that capture the intricate interactions between pedestrians and their surrounding environment. These simulations enable researchers and urban planners to explore various scenarios and design interventions to optimize pedestrian flow and enhance walkability Smith, J. (2023).

In pedestrian simulation studies, pedestrian density serves as a crucial metric for understanding the level of crowding and congestion within different areas of the urban landscape (Manera, 2018). By simulating pedestrian movement under different scenarios, researchers can observe how changes in infrastructure, such as sidewalk width or crosswalk placement, impact pedestrian density. Through the analysis of pedestrian density patterns, planners can identify areas of high congestion and develop targeted interventions to alleviate bottlenecks and improve overall pedestrian mobility (Meng, 2017).

Pedestrian flow analysis in AnyLogic allows researchers to assess the efficiency of pedestrian movement within a given space. By quantifying pedestrian flow rates and observing movement patterns, planners can identify areas of smooth circulation as well as potential chokepoints where pedestrian movement may be impeded. This information is instrumental in optimizing urban design to facilitate efficient pedestrian flow and enhance the overall walkability of the environment (Rajabi, 2020).

AnyLogic

A multi-method simulation modeling tool. It gained its name called AnyLogic because it supported all three well-known modeling approaches; System dynamics, Discrete-event simulation, and Agent-based simulation. Hence this software is used for modeling of discrete event modeling approach for this study (Gebeyehu, 2019). AnyLogic is a simulation software that can be used to model and analyze pedestrian walkability, pedestrian density, and pedestrian flow in various environments. Pedestrian simulation models are valuable tools for analyzing and understanding pedestrian movement in urban areas (Papadimitriou 2014). It provides a comprehensive platform for creating detailed pedestrian models and conducting simulations to understand and evaluate the behavior and interactions of pedestrians. AnyLogic is a simulation software that allows users to create and analyze various types of models, including agent-based, system dynamics, and discrete-event models (AnyLogic, 2008). It provides users with a user-friendly graphical interface and a wide range of modeling components and tools to build complex simulation models. AnyLogic is known for its versatility and flexibility (Popov 2016). AnyLogic is a simulation software that can be used to model and analyze pedestrian walkability, pedestrian density, and pedestrian flow in various environments.

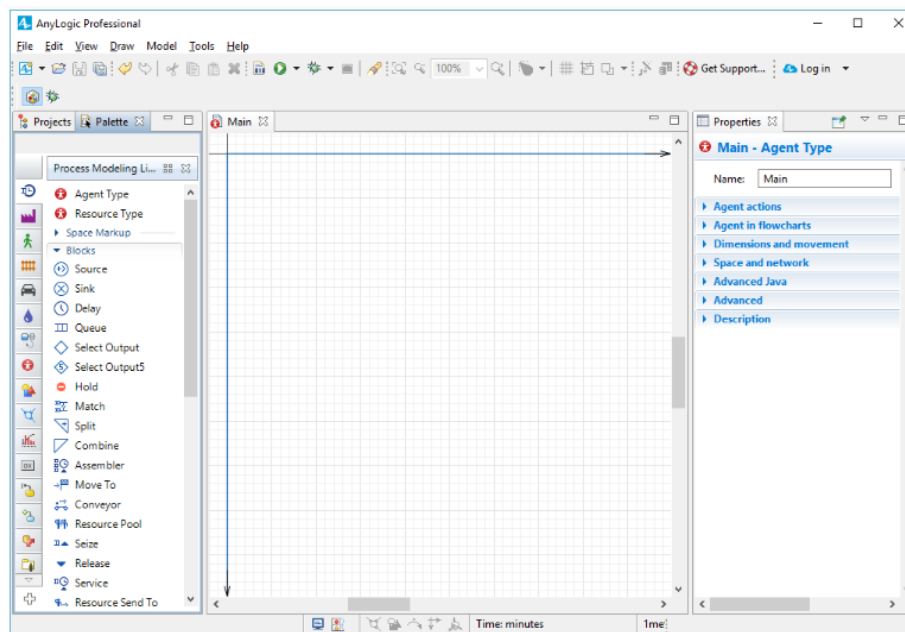


Figure 2. 6) New model is created. It already has one agent type called Main and an experiment called Simulation experiment.

To use AnyLogic for analyzing pedestrian walkability, density, and flow, you would typically follow these steps:

Model Creation: Design the layout of the environment, such as streets, sidewalks, buildings, or public spaces, using AnyLogic's graphical interface. Define the pedestrian-specific elements like crossings, intersections, or other relevant infrastructure.

Pedestrian Attributes: Specify the attributes of pedestrians, such as walking speeds, destinations, and decision-making rules. AnyLogic allows you to define different types of pedestrians with varying characteristics to represent the diversity of real-world populations.

Walkability Analysis: Conduct simulations to analyze pedestrian walkability. You can measure metrics like average walking distance, time taken to reach destinations, or ease of navigation within the environment. By observing pedestrian behavior in the simulation, you can identify potential issues and areas for improvement in terms of walkability.

Density and Flow Analysis: Use AnyLogic to simulate pedestrian density and flow. By specifying the number of pedestrians and their movement patterns, you can observe the distribution of pedestrians in different areas and measure pedestrian flow rates. This analysis helps in understanding how pedestrian density affects movement efficiency and potential congestion points.

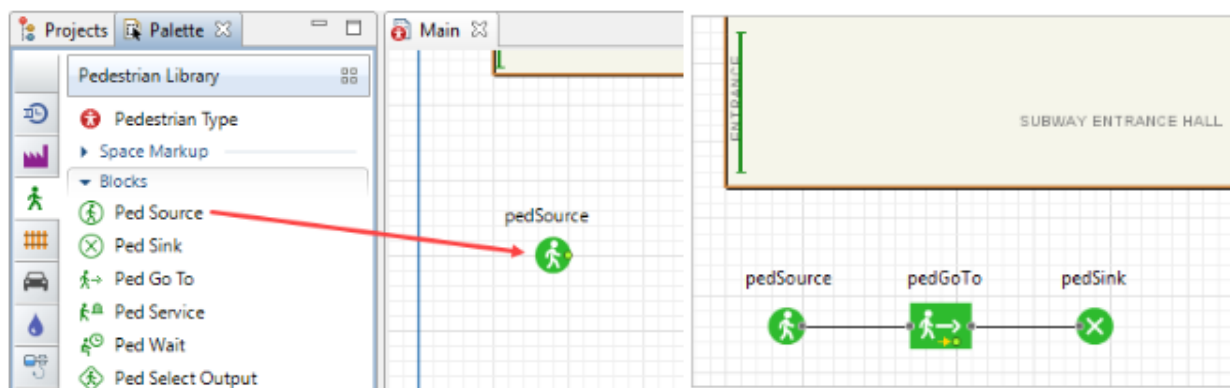


Figure 2.7) Creating a flowchart defining the pedestrian flow

Visualization and Analysis: AnyLogic provides visualization tools to create 2D or 3D animations that represent pedestrian movement in real time. You can observe the behavior of individual pedestrians and analyze the overall flow and interactions. Additionally, you can generate

performance metrics such as pedestrian density distribution, wait times, queue lengths, or throughput to evaluate the efficiency and safety of pedestrian systems.

By using AnyLogic for pedestrian walkability, density, and flow analysis, you can gain insights into the behavior of pedestrians in different environments. This information can be valuable for urban planning, designing pedestrian-friendly spaces, optimizing traffic flow, improving crowd management, or evaluating the impact of infrastructure changes on pedestrian movement.

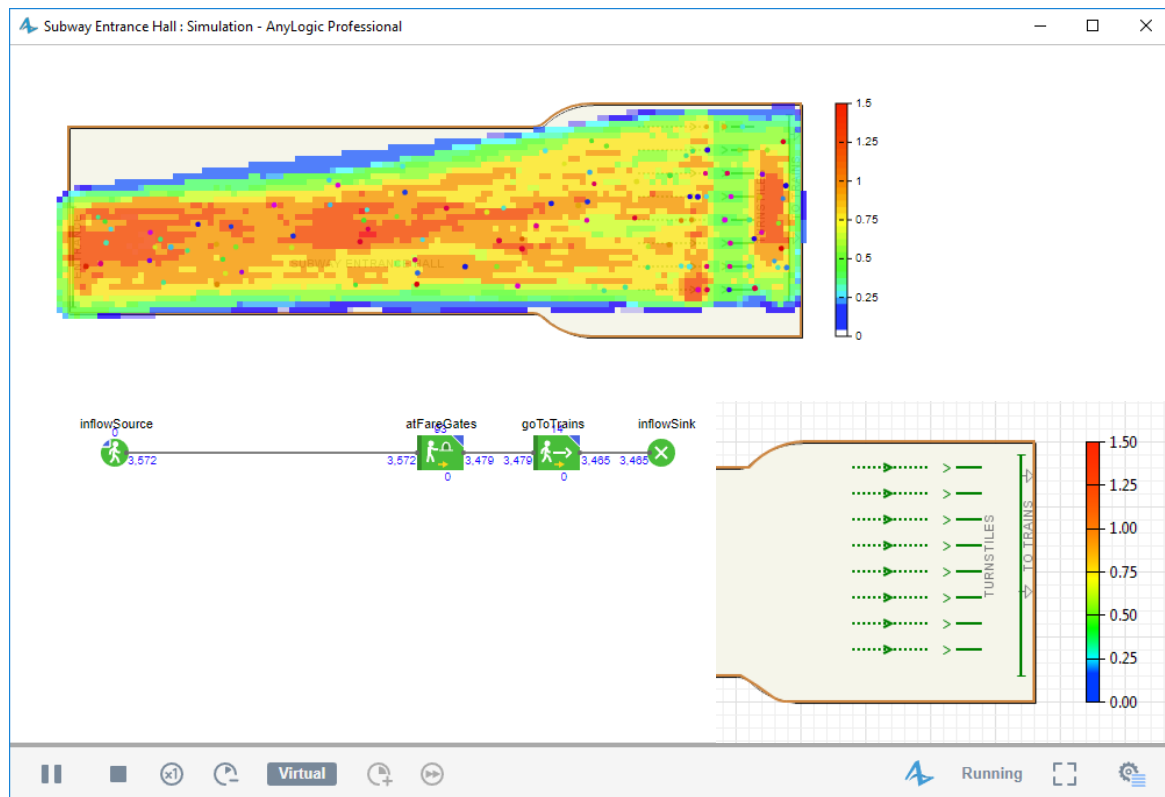


Figure 2.8 Display the pedestrian density map

2.2.8 Pedestrian simulation in AnyLogic measure

AnyLogic's pedestrian simulation offers several metrics for evaluating how well people perform and behave in a certain setting. Among the crucial actions are:

Pedestrian flow is the quantity of humans walking through a specific location in a given amount of time; it is typically expressed in terms of people per minute or hour. This may be seen in AnyLogic as the number of pedestrians passing via a certain location during the simulation.

Density: The quantity of pedestrians per unit area is known as pedestrian density. It aids in determining how congested a given place is. AnyLogic makes it possible to see pedestrian density by using color gradients to represent it in the simulation environment.

Speed: The pace at which pedestrians travel through the environment that has been represented is referred to as pedestrian speed. The ability to gauge and display pedestrian speed in various environmental contexts is offered by AnyLogic.

The length of time a pedestrian waits in a line or queue is known as queuing time. Queuing time may be tracked and analyzed in AnyLogic to pinpoint areas of congestion and enhance pedestrian movement.

2.2.9 Validation of the model

To make sure that the pedestrian simulation model in AnyLogic appropriately reflects what happens in real life, validation of the model is necessary. It involves comparing the model's prediction with actual or past data. When it comes to pedestrian simulation, the model needs to faithfully capture the movement of pedestrians, how they communicate with the surroundings, and the amount of time it takes them to travel different paths. A comparison of the observed and simulated data is done to validate the AnyLogic model. It is possible to examine the correlation between the two sets of data using statistical methods. (Rossetti, 2021)

2.2.10 Pedestrian Level of Service (PLOS)

The pedestrian level of service (PLOS) is a crucial performance indicator for evaluating the current conditions of pedestrian crossing facilities. Assessing the quality of roads and other traffic infrastructures is essential for improving the service of existing facilities and developing new ones. (Mac Karlo E. Alfonso, 2023)

PLOS is a metric for evaluating the standard of care given to pedestrians. It is frequently established by taking into account several variables, including speed and pedestrian density. The performance of pedestrian facilities is assessed by LOS categories, which range from a (good) to F (poor), which assist in informing design choices (Devica, 2015).

When designing pedestrian zones that are practical, safe, and beneficial in compliance with a design standard, Level of Service standards provide a very near approximation. Designing pedestrian environments is another application for the concept of Level of Service (Banerjee et al.,

2018). The freedom to walk at any speed and the ability to select a regular tempo of movement should be the foundation of pedestrian service standards. When setting pedestrian service requirements, it is important to take into account factors including the ability to maintain a regular speed of travel, the ability to avoid slow-moving pedestrians, and the relative ease of cross- and reverse-flow movements in busy areas (Devica, 2015). The relationship between (Permana, 2014).

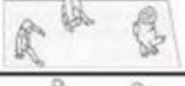
Level of Service		Flow Rate (pedestrian/hour)
A		0 -120
B		120-240
C		240-480
D		480-800
E		800-1200
F		>1200

Table 2.1 Pedestrians' level of service. (Source: Van Nes & Yamu, 2021; Devica (2015).

2.2.11 Pedestrian Movement Influence

Understanding and analyzing pedestrian movement is essential for effective urban planning and ensuring the safety and efficiency of urban areas (Permana, 2014) By studying pedestrian behavior and patterns, urban planners can identify areas of high foot traffic, determine optimal locations for crosswalks and sidewalks, and implement measures such as traffic calming measures or signal timings that can enhance pedestrian safety and comfort (Angelalia Roza, 2021) Additionally, pedestrian movement studies can help identify areas with insufficient pedestrian infrastructure and inform the design and placement of public amenities such as benches, lighting, and signage to further facilitate pedestrian movement and improve the overall urban experience (Permana, 2014).

Pedestrian movement influence refers to the factors and elements that shape, guide, and impact the behavior of individuals on foot within urban environments. Understanding these influences is

crucial for urban planners, designers, and researchers seeking to create safe, efficient, and pedestrian-friendly spaces. Several key factors contribute to the movement influence of pedestrians: Street Design, Infrastructure and Amenities, Land Use and Destination Accessibility

2.3 Empirical Literature Review

The influence of street design on pedestrian walkability has been the focus of previous studies. In addition, (Ewing, 2009) conducted a significant study that examined the effects of several physical design elements on the perceived walkability of city streets. The researchers discovered that pedestrians' assessments of a street's walkability were significantly influenced by several criteria, including street enclosure, image ability, human size, transparency, and complexity. Study participants consistently assessed streets as more walkable when they had a better feeling of spatial enclosure, higher levels of visual attraction and engagement, and a more human-scaled design. In a similar vein (Alfonzo, 2018) investigated how street design can promote walking as a means of transportation. According to their findings, there was a significant correlation between increased walking activity and the existence of sidewalks, street lights, street (Ewing, 2009) trees, and traffic calming measures. On the other hand, it was discovered that greater traffic volumes, the absence of pedestrian infrastructure, and on-street parking discouraged walking.

Building on these results, (Saelens, 2008) carried out a thorough examination of the research on the correlations between walking and the built environment. Street connection, residential density, land use mix, and the presence of pedestrian-oriented design features (such as sidewalks, crosswalks, and street furniture) were all shown to be positively correlated with greater levels of walking for both leisure and transit. The researchers stressed how crucial it is to use careful roadway design and urban planning to create a constructed environment that encourages pedestrian movement.

The pedestrian movement model has also been used to forecast pedestrian movement based on the configuration of the street network and spatial variables using Pedestrian simulation AnyLogic Analysis. Analysis has been done on the relationship between the density and variety of amenities and the intensity of pedestrian movement.

The use of this paper is to identify theoretical gaps and limitations in past studies related to this assignment and assessment. Based on these findings, an effective model for the study area's

pedestrian density, pedestrian behavior, and pedestrian infrastructure. Using Pedestrian Simulation in AnyLogic has been developed.

2.3.1 Best practices Pedestrian simulation in AnyLogic

Traffic control strategies at intersections have evolved through applying advanced control technologies during recent decades, especially for signalized intersections around urban areas. Now, with emerging connected vehicle technology there is a renewed potential to improve the overall efficiency and safety conditions at intersections.

A group from the Department of Civil and Environmental Engineering at The University of Tennessee, Knoxville conducted a study of the relationship between average system delay and average queue length for traffic approaching signalized intersections. The team utilized data from the City of Detroit collected in a field test during the 2014 Intelligent Transportation Systems World Congress. The study presented an in-depth analysis of how to use the information from the connected vehicles to simulate real-world situations so that an optimal traffic signal control solution can be achieved at intersections.

Results from the AnyLogic agent-based simulation model showed a decrease in average system delay, reduced traffic queue for different traffic lanes, and a positive relationship between the average system delay and the average traffic queue length.



Figure 2.9 Improving Intersection Efficiency with Connected Vehicle Technology (Xiaobing Li 2014)

2.3.2 Pedestrian Simulation in Ethiopia

Most city planners in developing nations, such as Ethiopia, do not have the resources to keep up with new planning theories, analysis methods, or planning strategies like AnyLogic Model (Berhanu, 1994). Although space syntactic analysis is not widely employed in Ethiopia's planning process, they have been used by a few scholars. For example, Melkamu Ambelu Biazen and Sisay Geremew Gebeyehu have used (2019) utilize AnyLogic 7.2.0 model simulation.

In this work, we have used AnyLogic 7.2.0 Personal Learning Edition to simulate the case company's existing working operational conditions. It consists of two basic building blocks called elements and agents. The elements define the process to be simulated with its properties. The agent typically represents one of the model's logical sections. This allows decomposing a model into many levels of detail. The elements are grouped under different pallets and these elements describe the dynamic processes in the model. They are considered as the nodes or places through which agents flow or where from agent source or sink is. Agents are a model's building blocks, and it is possible to use them to model all kinds of real-world objects, including organizations, companies, trucks, processing stations, resources, cities, retailers, physical objects, controllers, and so on. The characteristics of each element and agent are explicitly described in the properties view. The production line of the case company is a purely assembly line. Different components or accessories are assembled to produce the end product. However, due to the complexities of the components, considering all components as agents is difficult since analyzing all of the components is bulky and well is not that necessary for this paperwork. Due to the mentioned reasons, mobile phone is taken as agents in the flow diagrams of the discrete event modeling of the case company. In the development of this discrete-event simulation modeling of the case company TC, Process Modeling Library elements such as source, sink, Delay, Queue, Select Output, Conveyor, resource Pool, Seize, Release, Services, Time Measure Start, Time Measure End ETC are as shown in Fig.

2.4 Summary of literature review

Table 2.2: Literature Review International

Title of the paper	Description
(W S N Wan Mohammad, 2021)The implication of street network design for walkability	This study examines how roadway network designs impact walkability from the viewpoint of the urban neighborhood. Using the keywords "street network design" and "walkable city," a systematic literature review technique was used to find and analyze the papers published in the Sciencedirect.com database between 2004 and 2020. The primary conclusion implied that appropriate street designs were linked to street networks. Consequently, the development of a walkable city from a vibrant street network design enhanced neighborhood physical activity levels and well-being.
(Zeyad Ali Ismael, 2021)The Impact of Pedestrian Streets Design on the Urban Scene of the Iraqi City Center.	the focus of the research is concerned with the study of pedestrian streets and their impact on the urban scene, so the research problem was (Neglecting the design of pedestrian streets in the Iraqi city) and the research determined the hypothesis (the design of pedestrian streets positively affects the urban scene of the Iraqi city)
(Fernando Fonseca, 2019)Smart Pedestrian Network: An Integrated Conceptual Model for Improving Walkability	The goal of the Smart Pedestrian Network (SPN) research project, which is to promote walkability as one of the essential components of intelligent and sustainable urban mobility, is presented in this article. The study examines the several SPN-connected elements that can enable a pedestrian network to become "smart," making it a competitive option for motorized transportation.

(Ayse Ozbil, 2015) The Effects of Street Design, street-network Configuration, and land-use on the Pedestrian Movement Model	By adjusting for land use, this research helps to clarify the relationship between pedestrian mobility and objectively observed street network structure and methodically measured street-level urban design characteristics.
(Hajrasouliha, The impact of street network connectivity on pedestrian volume, 2014)	The effect of street network connections on pedestrian volume is examined in this article. The majority of recent studies measuring street network connectedness solely account for the physical or metric properties of the streets.

Table 1.3 Literature Review Local

(Desta, 2022) competence of bus rapid transit systems coupled with transit signal priority at signalized junctions	This study aims to characterize the relationship and influence of the operation at a particular intersection (the Mexico Square signalized intersection), which is under consideration for a TSP study, on traffic performance.
(Lulseged, 2021) The Influence of Street Design on Pedestrians in Selected Areas of Addis Ababa, Ethiopia	In a few districts of Addis Ababa, Ethiopia, this study evaluates the impact of street design on pedestrians, taking into account various amenities on roadways, walkways, safety, and public transportation accessibility. The researcher can analyze data both quantitatively and qualitatively using the descriptive survey approach.
(Getachew, 2020) Pedestrian Safety, Comfort and Convenience: The Case of Addis Ababa's Sidewalks	This study examined how to evaluate the degree of service provided to pedestrians by examining both the objective and subjective measures of service quality. The Australian technique and the Highway Capacity Manual, which include both objective measurement and subjective judgment, are the two PLOS methodologies employed in this study. Sidewalks featuring street vendor activity are also used in the research. Street sellers are neutrally seen as neither significant nor inconsequential when they are present along the sidewalk. The fact that they might negatively affect the amount of space available for walking makes their existence noteworthy.

(Kibret Gebremedhin Hagos, 2020) Effect of sidewalk vendors on pedestrian movement characteristics: A microscopic simulation study of Addis Ababa, Ethiopia.	This study assessed how the average pedestrian density was affected by three different integration strategies for sidewalk vendors. A macroscopic method was used to calibrate a pedestrian microsimulation model (PTV-Viswalk-11) that is based on social forces. The impact of a kiosk, a sidewalk vendor in frontage, and a sidewalk vendor in furniture zones on pedestrian flow was then assessed using a calibrated model in various situations.
(TUFA, 2019) Impact of Roadside Vendors and Inadequate Walkability Infrastructures on Pedestrian Safety in Addis Ababa: A Case Study of Gulele Sub-city.	With an emphasis on the Gulele Sub-city, this research sought to evaluate the level of pedestrian mobility in Addis Ababa, investigate the negative effects of roadside sellers and poor walkability infrastructures on pedestrian safety, and offer reasonable alternatives. The last 25 years have seen a notable increase in the population of Addis Ababa (Finfinnee), as young people from rural regions have moved in large numbers in pursuit of various employment opportunities, including street hawking.

Source: Own computation 2016, E.C.

Table 2.4: Summary of Related Work and Their International Research Gap

Author	Title	Types of Research Gap	Research Gap
(Julia Sievert André Landwehr Philipp Preuner Katharina Borgmann, 2021)	Modeling Pedestrian Flows: Agent-Based Simulations of Pedestrian Activity for Land Use Distributions in Urban Developments	Methodological Gap	While the paper discusses the use of agent-based modeling (ABM) and analyzes the correlation between pedestrian flow intensity and the density and diversity of amenities, it does not extensively explore other factors that may influence pedestrian activity. For example, the paper mentions the importance of urban morphology and land use distribution, but it does not provide a detailed analysis of how these

			factors specifically impact pedestrian flows.
(Mohammad, 2021)W S N Wan Mohammad (2021)	The implication of street network design for walkability		The research highlights that street designs for pedestrian walkways are commonly ignored, with more emphasis on vehicular access. however, there is a gap Lack of Focus on Street Network Design Walkability
(Ayse Ozbil, 2015)	Modeling Walkability: The Effects of street design, street-network Configuration and land-use on Pedestrian Movement	Methodological Gap	Limited Quantitative Analysis: The paper mentions the effects of street design, street network configuration, and land use on pedestrian movement, but it does not provide a detailed quantitative analysis of these effects. Further research could focus on conducting rigorous quantitative studies to measure and quantify the specific impacts of street design elements.
Amir Hajrasouliha (2014)	The impact of street network connectivity on pedestrian volume	Contextual research gap	In this research, one research gap that can be identified is the lack of attention given to visual connectivity in studies analyzing the impact of street network connectivity on pedestrian volume.
(Yoav Lerman, 2014)	Using Space Syntax to Model Pedestrian Movement in Urban Transportation Planning	Empirical gap	The research emphasizes the use of space syntax analysis to predict pedestrian movement based on spatial variables and street network configuration, it does not delve into the influence of pedestrian density and pedestrian infrastructure factors on pedestrian behavior.

Source: Own computation 2016, E.C.

Table 2.5: Summary of Related Work and their Local research gap

Author	Title	Types of Research Gap	Research Gap
Desta R. (2022)	Competence Of Bus Rapid Transit Systems Coupled With Transit Signal Priority At Signalized Junctions	Contextual research gap	This study examines the effectiveness of Bus Rapid Transit (BRT) systems in conjunction with Transit Signal Priority (TSP) at signalized intersections, with a particular focus on Ethiopia's Addis Ababa BRT-B2 line. It looks at how TSP affects trip duration, speed, length of line, and passenger delay. The study utilizes microscopic models and simulation tools like PTV VISSIM to analyze different scenarios. However the need for further investigation and analysis of the broader impacts and effectiveness of BRT systems coupled with TSP in different contexts, beyond the specific case of the Addis Ababa BRT-B2 line.
(Lulseged, 2021)	The Influence of Street Design on Pedestrians in Selected Areas of Addis Ababa, Ethiopia	Methodological Gap gathered through surveys and interviews of passengers in the selected Area	There is a problem with the variable. Dependent variables such as pedestrian density, comfort, and pedestrian satisfaction have not been taken.

Nardos A. G. (2020)	An Investigation On Safety, Comfort And Convenience Of Pedestrians in Addis Ababa: A Case Of Arterial Street's Sidewalks	Knowledge Gap	The research gap identified in these studies is the dearth of data and studies on the evaluation of pedestrian comfort, safety, and convenience on the sidewalks in Addis Ababa, particularly the degree of service provided to pedestrians and user perceptions.
(Gebru, 2015)	CREATING WALKABLE ENVIRONMENT FOR AXUM CITY TO ENCOURAGE TOURIST MOBILITY /The case of Axum Old Settlement/	Contextual research gap	Lack of a comprehensive analysis of the current walkability conditions in the Axum Old Settlement The study refers to a walkability analysis that used serial vision and data from pedestrian excursions. It's impossible to assess how comprehensive this analysis was and if it covered all relevant aspects of the walkability of the neighborhood in the absence of other information.
Tufa, M.A. (2019)	"Impact of Roadside Vendors and Inadequate Walkability Infrastructures on Pedestrian Safety in Addis Ababa, A Case Study of Gulele Sub-city	Contextual research gap	Inadequate attention to accessibility and pedestrian needs: The study emphasizes how critical it is to attend to pedestrian needs, particularly those of people with disabilities. There is, therefore, a study vacuum about the particular difficulties faced by Addis Ababa pedestrians and the practical ways to enhance their safety and accessibility.

Source: Own computation 2016, E.C

This review takes a comprehensive approach to analyzing pedestrian density and infrastructure, filling a critical gap in existing research. While previous studies have often overlooked the unique demands and specifications of pedestrians, this review employs a novel methodology to gain deeper insights.

The researchers utilized a multifaceted data collection and analysis approach, incorporating detailed pedestrian flow studies, walking time analyses, and advanced pedestrian simulation modeling using tools like AnyLogic. This allowed for a nuanced examination of how pedestrian behaviors and movement patterns influence the overall walkability and functionality of urban environments. Unlike past efforts, this review places a strong emphasis on understanding the perspectives and needs of pedestrians themselves, including factors like comfort, safety, and accessibility. By focusing on the pedestrian experience, the findings provide invaluable guidance for urban planners seeking to develop more inclusive and effective infrastructure. Through the application of cutting-edge pedestrian movement modeling techniques, this review contributes to a transformative understanding of pedestrian density dynamics. The insights gleaned can empower planners to design urban spaces that truly prioritize and accommodate the requirements of those traveling on foot, fostering walkable, livable communities.

2.5 Conceptual Framework for Pedestrian Movement Modeling

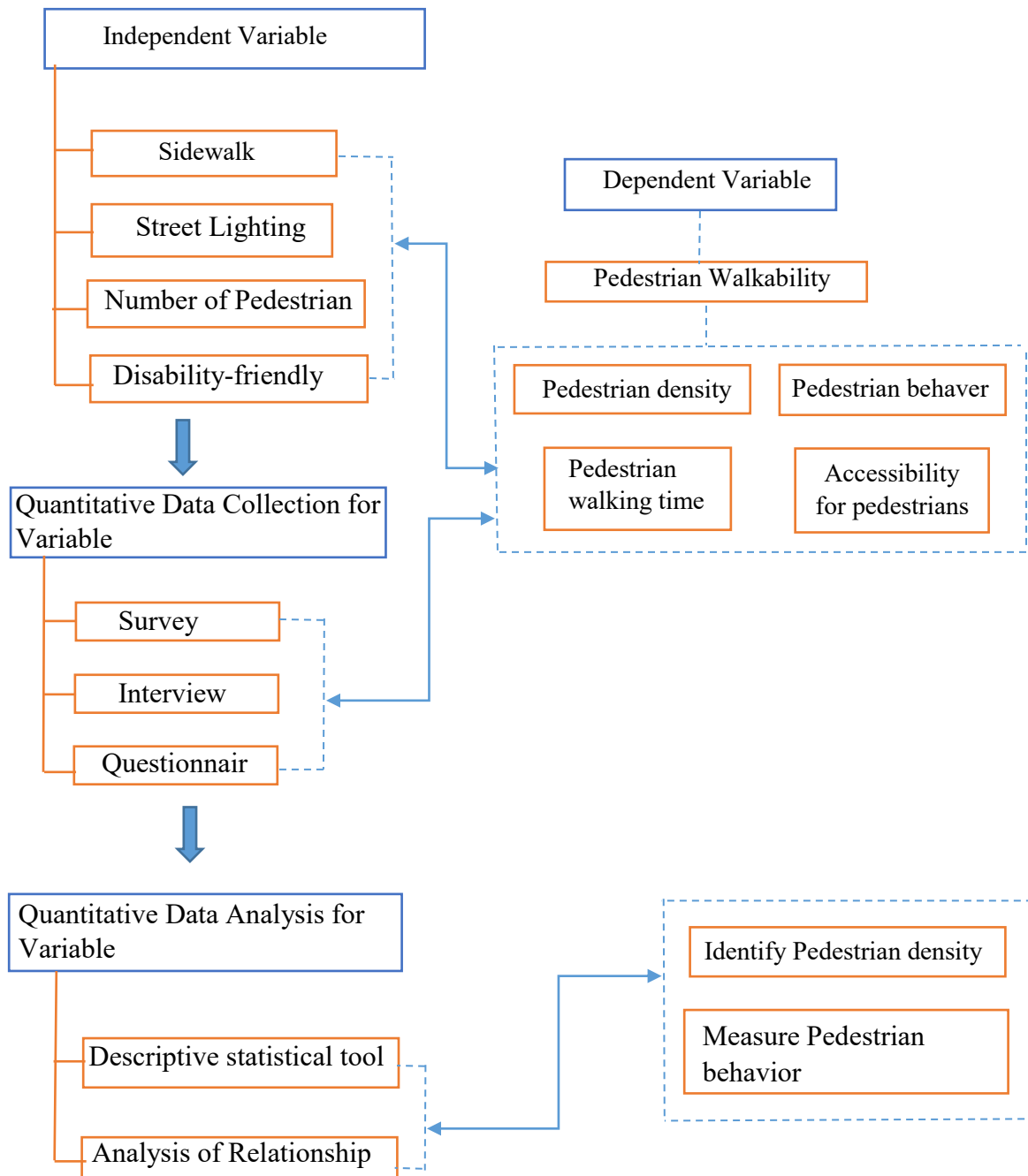


Figure 2.10 Conceptual Framework for Pedestrian Movement Modeling Analysis

CHAPTER THREE

RESEARCH METHODS

3.1 Description of the Study Area

3.1.1 Location of the study area

Adama is a city in central Ethiopia, sometimes referred to as Nazret or Nazareth. Situated around 100 kilometers southeast of Addis Ababa, the capital, it is situated in the Oromia region. Adama serves as the East Shewa Zone's administrative base and is an important point for regional trade and transportation. At an approximate elevation of 1,713 meters (5,620 feet) above sea level, Adama has an elevation.

Adama City has economic connections to several areas and municipalities. It was formally founded as a transportation center along the Addis Ababa-Djibouti railway. The port of Djibouti is a destination for commercial goods, manufacturing, and agricultural supplies.

The city receives its grain and animals from Arsi, Bale, and Borana, but its primary natural resource suppliers are Kereyu and Afar (fuel wood, charcoal). The estimated total population, as of the 2015 Census, is 324,000. The Eth-Djibouti port transport system and hospitality were the cornerstones of Adama's economy.

The economy of Adama is increasingly reliant on tourism and Ethiopian-Djiboutian transit. The town hosts multiple congresses from Addis Ababa and other regions of the nation. Even with its recent explosive growth, Adama is becoming more and more of a rural city, and compared to other cities, it has a lot more industrial zones.

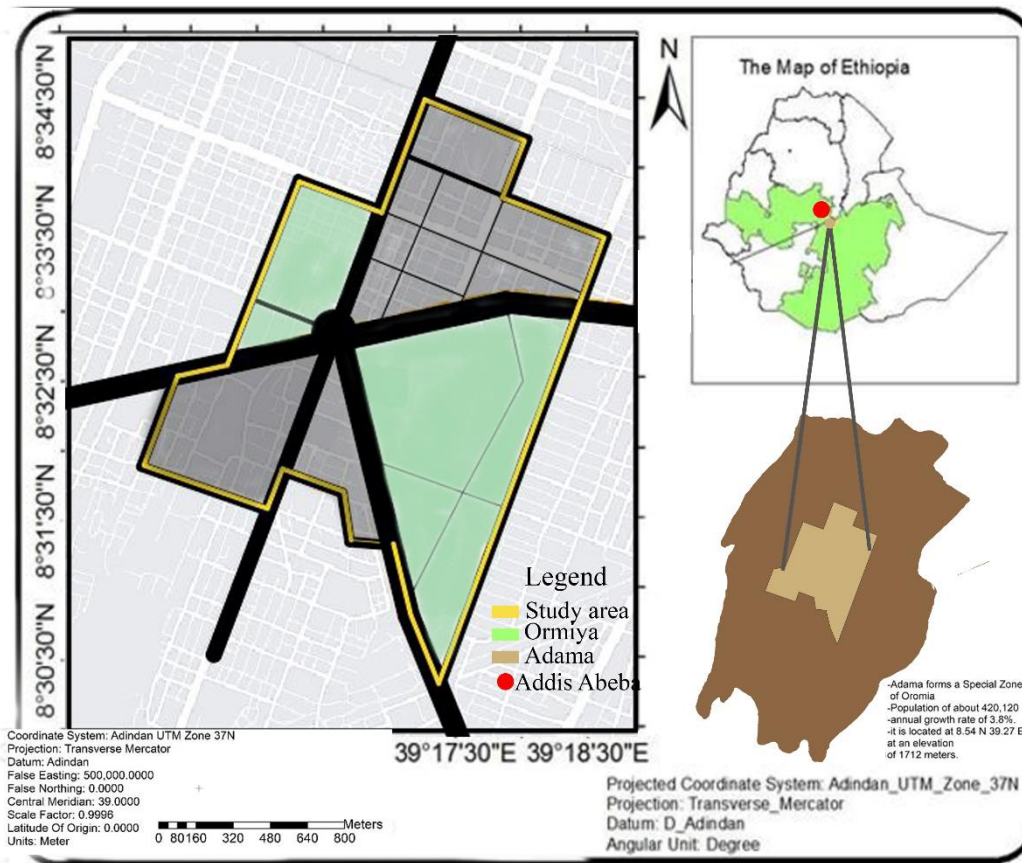


Figure 3.1 Location Map of Study Area

3.1.2 Physical environment

Climate

Adama features a distinct wet and dry season due to its tropical savanna climate. June to September is the hot and rainy season; October to May is the drier season. Adama's average yearly temperature is approximately 18.5°C (65.3°F), with typical monthly highs and lows of 25–27°C (77–80°F) and 11–15°C (52–60°F), respectively. Acacia trees scattered here and there and mixed savanna grasslands make up the majority of Adama's natural vegetation.

Topography

Adama's topography is largely level with some minor slopes. Plains make up the majority of the environment, with occasional hills and mountains in the surrounding areas. The Ethiopian Highlands, which are a component of the Great Rift Valley system, climb up in the west. The vast area of Adama is around 29.86 square kilometers or 11.53 square miles. Around 1,712

meters (5,617 feet) are Adama's elevation above sea level. Adama is located next to the Awash River, which supplies vital water resources for both human consumption and agriculture.

3.1.3 Socioeconomic conditions

Administrative condition

Adama is an important administrative hub and the capital of the East Shewa Zone. It contains six administrative centers for sub-cities, each with a sub-kebele or woreda. The administration of Adama includes managing issues about infrastructure development, public utility management, public service delivery, and urban planning. The Adama City Administration, which is in charge of the general management and policy direction of the city, has jurisdiction over it.

Economic activity

Adama's economy is mostly centered on trade and industry, and it is a significant hub for transportation and trade. Recent years have seen a large investment in infrastructure, notably the construction of the Eth-Djibouti Railway, which runs through the city and increases its economic significance and connectivity within Ethiopia.

Agriculture, manufacturing, trade and commerce, and the service (hospitality) sector are the main drivers of Adama's economic activity. Its advantageous position and proximity to Addis Ababa bolster its possibilities for economic growth and development.

Population

As per the 2015 census, Adama has a population of between 300,000 to 400,000, making it one of the most populated cities in the nation. The city is a significant hub for industry, transportation, and trade.

Adama, Ethiopia has a population density of about 220,000 persons per square mile, according to the 2007 census. Adama occupies an area of approximately 29.86 square kilometers. The population density would be roughly 7,366 persons per square kilometer based on these facts.

3.2 Research Methods

3.2.1 Approach and Research Design

Both quantitative and qualitative research methods have been used in this investigation. An empirical, methodical study that uses numerical data to evaluate phenomena, test theories, and identify patterns or relationships is known as quantitative research. To measure connections, quantify variables, and extend results to a broader population. It uses organized tools including experiments, surveys, and statistical analysis. Exploratory in nature, qualitative research makes use of words, narratives, and meanings in addition to non-numerical data collection and analysis to attempt to understand and interpret social phenomena. Within a single study, mixed methods research includes components of both quantitative and qualitative research. By combining information from several sources, it aims to offer improved comprehension. The research has been focused on a mixed research approach both the quantitative and qualitative data collection have been conducted. The researcher has been using an objective data-gathering approach and strategy to get pertinent data for the study.

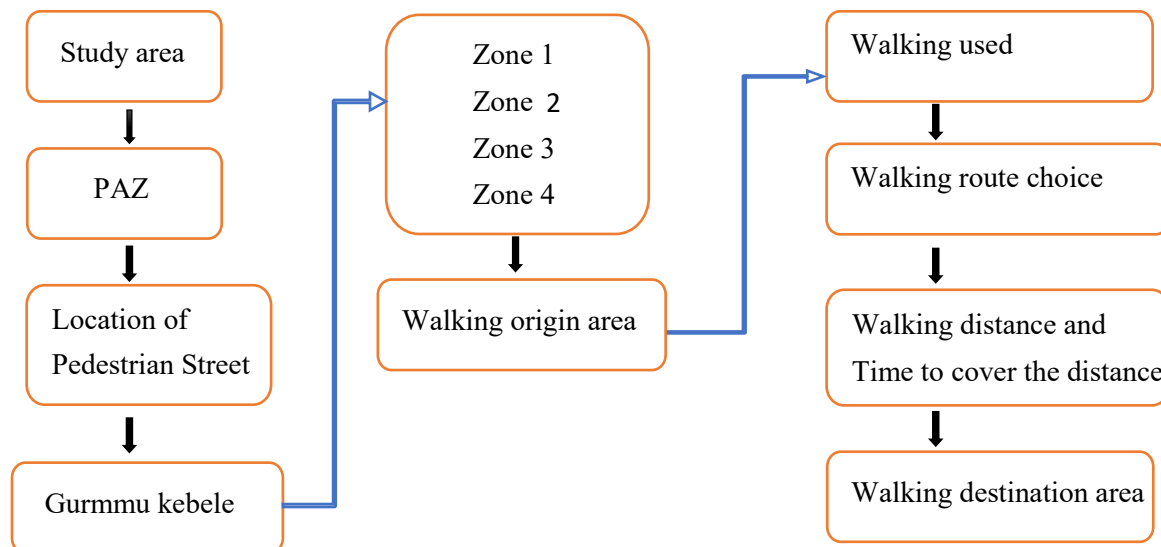


Figure 3.2 Workflow for Analyzing of pedestrian Behavior

3.2.2 Data type and source

The study area in Adama town has been collecting data on the routes of Route from Franco to Posta Bet, Route from Mebrat Hail to Posta Bet, Route from Amede Gebeya to Posta Bet, Route from Peacock to Posta Bet, Route from Tikur Abayi to Posta Bet, Route from National to Posta Bet. For this study, the student researcher has been using both primary and secondary data sources; such as Traffic accident data from the Adama Traffic Management Agencies. To collect data wisely, the necessary methods and techniques have been established. For example, survey data has been obtained by distributing formal questionnaire papers for representative pedestrians to obtain information about their pedestrian behavior and obtain the pedestrian flow of the study area. The necessary data for each objective of the study are categorized as follows: For the first objective, information on pedestrian density on the selected route of the PAZ is needed. The second objective requires essential data including pedestrian walking times of day for walking, walking purposes, and people entering the central area of the city information. Lastly, the Third objective relies on data related to pedestrian density level in the selected street by using the Analogic model. These are the primary data types used and required by this research.

The primary source of data

The primary data was gathered through a survey and an interview. Both street users and key informants complete the survey in the research areas. Interviews have been conducted by the researcher with important informants who have been in charge of creating and carrying out the city's street designs. These people include planners and designers of traffic, roads, and transportation, as well as civil and architectural engineers, and other concerned office staff members.

The secondary source of data

The collection of secondary data Population data, number of pedestrians, Pedestrian Traffic accident data from the Adama Traffic Management Agency, and census data which are counted and surveyed at a particular period has been collected from the Aba Gada sub-city. These have been used as input for pedestrian volume study in the area of research, this is based on population number. Examples Map data like the boundary of the study area, street network number, and name of selected routes.

Study population

While writing the proposal, the researcher conducted a pilot study and performed physical observations on this pedestrian's street. Through these assessments, researchers have verified that these pedestrian's street are extensively utilized by pedestrians and exhibit a higher level of pedestrian service. For the ease of the research study, several sample techniques have been selected, each with a separate explanation. Data from the census has been used to calculate the population size and number of pedestrians in the study region. Has been identifying how many pedestrians in the study woreda, Aba Gada sub-city, Gurmmu Kebele. The study's representative target pedestrian count is that of Gurmmu Kebele in the Aba Gada sub-city. The study has concentrated on people who actively use walking as a means on public streets. The study took into account the viewpoints of Pedestrian users with various street layouts. Their judgments of walkability and experiences with it can offer important insights into how street design affects pedestrian behavior. Designers and Planners of Cities The representative goal is to include experts in street design and urban planning. The results of the study benefit from their knowledge and comprehension of the connection between pedestrian walkability and street design. The study's findings can help guide the creation of policies that enhance pedestrian walkability by implementing changes to street design.

Sample Size

The researcher decided on six pedestrian streets in Aba Gada Sub City, which are situated in Adama's downtown. According to the 2015 census, the total population of the study woreda, Aba Gada sub-city-Gurmmu Kebele, is 11,114. The four kebeles that make up Aba Gada Sub City are Badahatu, Gurmmu, Gadaa, and Odaa. The four zones that make up Gurmmu Kebele were another choice made by the researcher.

To create a sample size within the stratum (zone), a representative target is chosen at random from these zones according to their geographic location and high pedestrian density and movement. To ensure proportional representation across the 4 zones, the researcher should divide the total sample size by the number of zones.

The researcher's goal is to obtain 386 representative samples from the target populations of Gurmmu Kebele residents, pedestrians, and urban planners and designers. This equates to a total

of 386 sample sizes from an 11,114 population that represents each stratum (zone). IA Ismail and NL Pernadi (2022) state that the stratified sampling principle approach has been applied to determine sample size. To get representative targets, a stratified random sampling technique has been employed. The stratification process used in the study area is depicted in the following diagram.

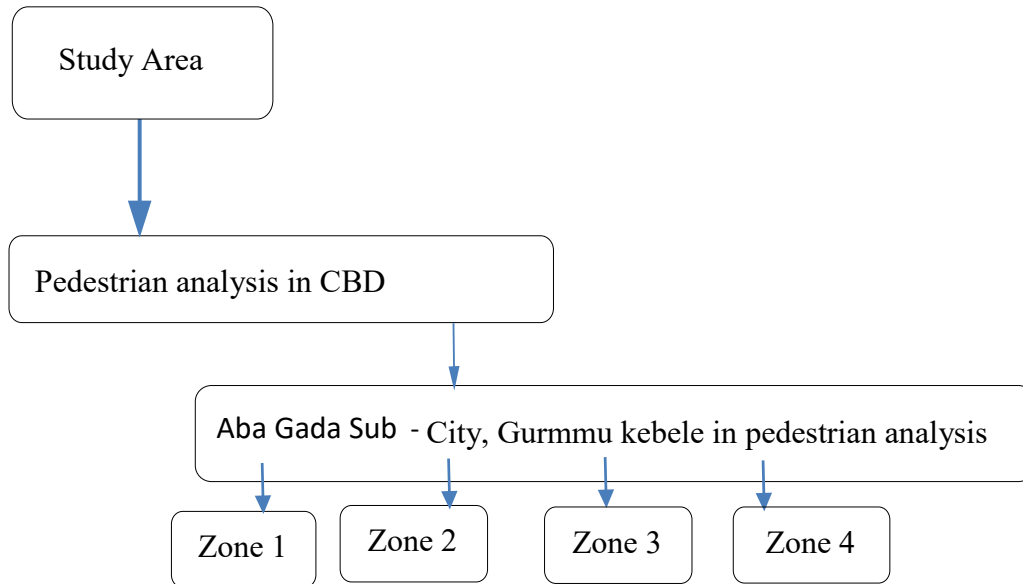


Figure 3.3 Sample Determination of Representative Target by Stratifying Study Area to Zone.

The sample size determination for stratified sampling by IA Ismail and NL Pernadi (2022) was utilized to select samples from Gurmmu kebele in each stratum or zone using the subsequent formula.

Slovin's formula

n = sample size

N = population size

e = Margin of Error

if there is no margin error, then use 5%

$$n = \frac{N}{1 + Ne^2} = \frac{11147}{1 + 11147(0.05)^2} \quad n = 386$$

$$\begin{aligned} \text{Zone 1 Respondent population size} & \quad \frac{RPS}{N} \times n = \frac{3457}{11147} \times 386 = 120 \\ \text{Zone 2 Respondent population size} & \quad \frac{RPS}{N} \times n = \frac{2653}{11147} \times 386 = 92 \\ \text{Zone 3 Respondent population size} & \quad \frac{RPS}{N} \times n = \frac{2213}{11147} \times 386 = 76 \\ \text{Zone 4 Respondent population size} & \quad \frac{RPS}{N} \times n = \frac{2824}{11147} \times 386 = 98 \end{aligned}$$

Finally, the sample size of=120+92+76+98=386, for each target group

Table 3.1 Stratified random sampling result

Kebele-Gurmmu	Total population	Percentage %	Sample
Zone 1	3,457	31%	120
Zone 2	2,653	24%	92
Zone 3	2,213	20%	76
Zone 4	2,824	25%	98

N = 11147

n = 386

In this case, the researcher wishes to collect a total of 386 representative samples from each target group in Gurmmu Keble, which includes residents, pedestrians, and urban planners and designers. This figure was probably selected by the researcher using their best judgment, taking into account the size of the population, the availability of resources, and the desired degree of precision for the study.

Sampling technique

Stratified random sampling techniques have been used to get the sample size. This technique has been used by dividing the population into geographical locations, or strata. It involves random selection from each stratum (zone) proportionately, allowing you to make strong statistical inferences about the whole group. Taking a sample from a sample frame of Residents, Pedestrians, and Urban Planners and Designers (UPD) to gain relevant data.

3.2.3 Method of data collection

For the primary data source, quantitative data gathering has been used in the following ways: Data from primary and secondary sources has been gathered to address the inquiry's specific goal and provide an answer to the question. The suggested method and procedures have been followed for the primary data source collection to reduce questions.

The following methods have been used to gather primary data: questionnaires, surveys, manual pedestrian density counts, interviews, manual walking time measurements, and pedestrian count photography.

To learn more about how pedestrian street users perceive the amount of pedestrian density, questionnaires have been sent at random to residents, road users, pedestrians, and urban architects and designers. The answers to the questionnaire aid in identifying the six busiest routes on Pedestrian Street, the major business district, as well as potential sources of congestion.

The actual data one way to manually count pedestrian density on the field is to perform a manual field count. For the analysis zone, data on walking times, pedestrian flow, and pedestrian densities has been manually collected. A field survey sheet, a timer, and a driver and recorder were used to collect these measurements. Additionally, the material has been recorded by the researcher utilizing the pen-and-paper approach.

Secondary data, including traffic accident data of the Gurmmu Kebele study zone. The researcher chose the Aba Gadaa sub-city as it is situated in the central business center. Furthermore, in terms of walkability and pedestrian activity, it is an important and representative urban center. It could serve as the focal point of many pedestrian activities, whether they be residential, commercial, or recreational. The research intends to explore the

unique opportunities and problems associated with pedestrian walkability in a significant urban setting by focusing on this region.

3.2.4 Method of Data Analysis

The following mixed data analysis techniques were used to address the study's goal

The impact of street design on pedestrian walkability in Adama City was evaluated through the use of network analysis and descriptive statistics as data analysis techniques. In Adama City, the field count of data was gathered at various routes and road segments. Based on walking time, the city center into several traffic study zones.

HCM model method

The Highway Capacity Manual (HCM) methods for analyzing pedestrian LOS are based on the measurement of pedestrian flow rate and sidewalk space. In this model, to determine the Pedestrian Space Ratio (PSR), Pedestrian Service Volume (PSV), Pedestrian, Level of Service (PLOS), and Pedestrian flow rate must be conducted. The pedestrian unit flow rate (ped/min) is obtained by taking the pedestrian 15-minute flow rate (ped/15- min) and dividing it by the effective walkway width.

Pedestrian counts were conducted for 3 minutes and later changed to 15 minutes. ((Parma, 2013) This pedestrian count was made on the six sections of the main PAS Street. PLOS of the HCM rating uses grading from A to F.

AnyLogic Model

The AnyLogic model, which is generated through this modeling, was used to identify the research area's pedestrian density's impact on walkability. Variables like sidewalks, pedestrian infrastructure, and population have been used to develop this model.

Using the AnyLogic model, the density in a chosen area was measured to identify pedestrian density hot spots and a Pedestrian density map. Additionally, it entails identifying pedestrian amenities that are accessible to people with disabilities, computing a density index, and evaluating pedestrian flow at various locations in the chosen network utilizing ground truth data and a manual field count of pedestrians at each designated route. For the most part, the study used Excel software to show the results in tabular and graphical form.

Survey design

To meet the objective and provide an answer, primary data-collecting surveys were carried out in the area of study. These surveys were done for the level of service analysis, origin-destination analysis, and pedestrian walking survey. Define the research area and segment it into pedestrian analysis zones (PAZs) to gather the relevant data.

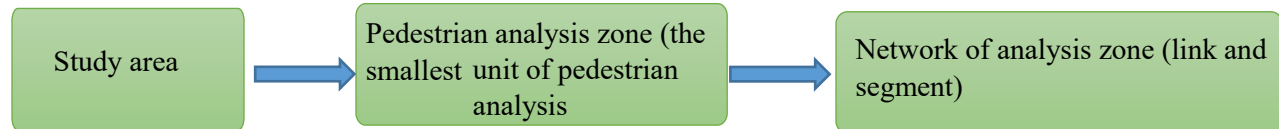


Figure 3.4: Study Area to Pedestrian Analysis Zone

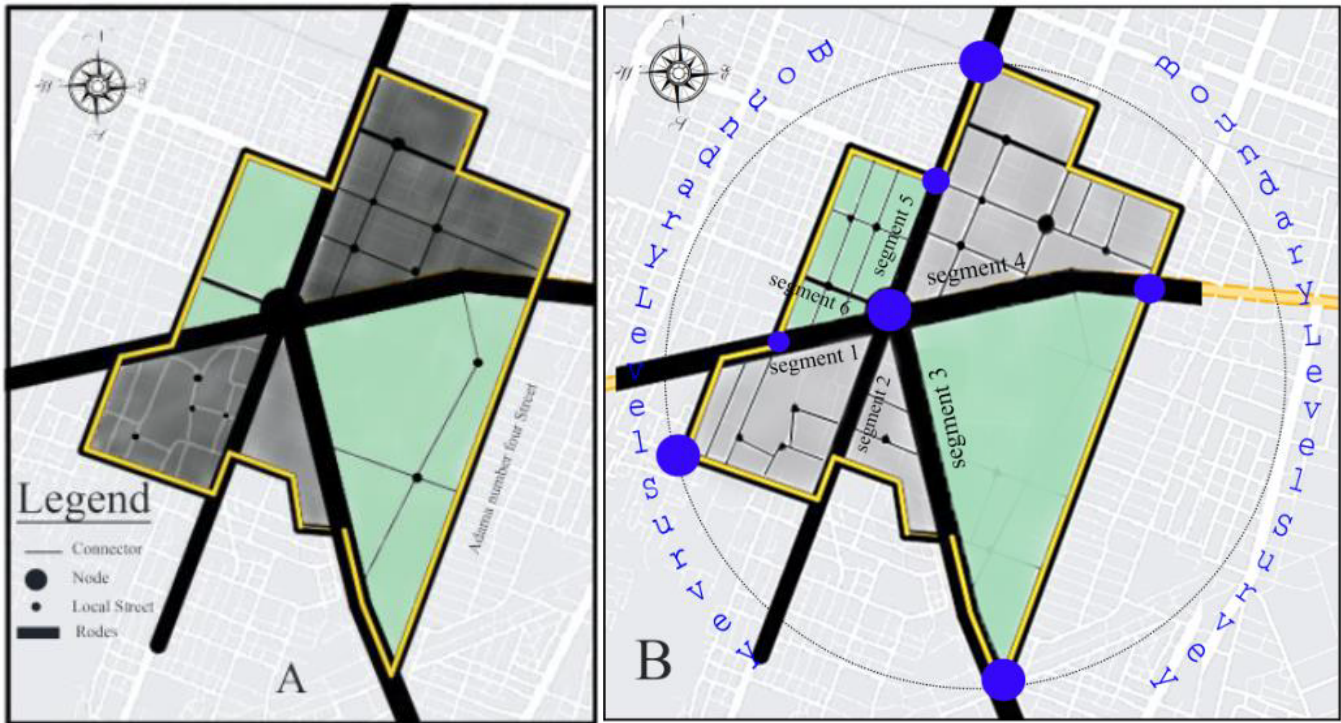


Figure 3.5 Pedestrian Analysis Zone of the Study Area (a) and Boundary Line Survey of the Study Area (b).

The center of the city indicates the pedestrian street around the post office in downtown Adama City. A total of four nodes and six segments are available in the PAZ Zones, particularly pedestrian analysis zones, which should correspond to other administrative divisions. Zones should have homogeneous characteristics, especially in land use, pedestrian activity, etc.

Once the study area is defined, it is then divided into some small units called pedestrian analysis zones (PAZ) or simply zones.

3.2.5 Pedestrian density surveys

Pedestrian density has been inventory of all selected major routes by manual field surveys. The Required pedestrian surveys are described in Table 3.2 as follows.

Table 3.2: Survey Items for Pedestrian Surveys

Survey method	Description
Manual counts Survey	A manual counts Survey is a manual field pedestrian count survey on a major boundary line or point that shows the density of pedestrians entering or departing a target area or a city center.
Survey of route movement	Measures pedestrian movements at selected routes during the morning, midday, and evening peak hours.
Walking Time Survey measure	Walking time surveys are conducted on strategically significant streets and key corridors in PAZ to evaluate the effectiveness of the road network during peak and off-peak hours.
Pedestrian Level of service of the existing pedestrian street system	Levels of pedestrian density or quality of pedestrian flow have been checked by measuring the PLOS of the selected route.

Source: Own computation 2016, E.C.

Manually counting the density of pedestrians entering or leaving a target region or Adama city center is shown by a pedestrian count survey conducted on a significant boundary line (point). The mobility both inside and outside the center business district (CBD) is counted manually in the field. It is crucial performance data is used to track changes in how people enter and exit the central area of the city. The field data has been manually collected at the designated site (see Figure 3.6 below). Five more data collectors will record 15-minute time intervals during the morning, lunchtime, and evening peak periods of the six-day study period using a pen-and-paper counting method. Sunday has not been included in the data collection for the five normal working days from Monday to Friday and Saturday from non-working days as it is not a

working day and not many people commute to work on Sundays. Weekdays are the main focus of the pedestrian count.



Figure 3.6: Adama Town Central Business District Field Count Collection Point

Description of the Pedestrian level of service of a major selected street of the study area

Pedestrian Level of Service (PLOS) is a measure used to assess the level of service offered to pedestrians in a certain location or along a specific route. Pedestrian LOS examines the performance of the walking environment based on numerous elements that impact pedestrian experience and comfort, similar to the idea of the Level of Service used for Pedestrian traffic. As shown in Table 3.3 this data helps identify hot spots of pedestrian density or congestion.

Table 3.3: Major Selected Segments of the Analysis Zone for PLOS Analysis

Segment	Name of the route
From National Street to Posta bet (segment-1)	Aba Jifar Street
From Franco to Posta bet (Segment -2)	Nuho Gobena Street
From Peacock to Posta bet (Segment -3)	Abebe Bikila street
From Mebrat hail to Posta bet (Segment-4)	Arora Street
From Tikur Abayi Street to Posta Bet (segment 5)	Mamo Mazamir Street
From Amede Gebeya to Posta bet (Segment -6)	Jara Aba Gada street

Source: Own computation 2016, E.C.

Description of the selected street in the pedestrian analysis zone of the study area

The researcher selected these six footpaths for analysis due to two primary reasons. Firstly, they are located within the city center or central business district (CBD). These areas are known for their high concentration of commercial activities, public amenities, and significant pedestrian movement. By focusing on footpaths within the CBD, we can assess the design and functionality of pedestrian infrastructure in areas of intense urban activity.

Secondly, these footpaths were chosen because they experience substantial pedestrian traffic. The level of pedestrian activity is an important factor in evaluating the effectiveness of a pedestrian path. By studying footpaths with high pedestrian volumes, we can gauge their capacity to accommodate large numbers of pedestrians and assess their level of service. Understanding how well these footpaths handle pedestrian flow can provide valuable insights into their design and potential areas for improvement.

A Pedestrian Analysis Zone (PAZ) is a designated area within an urban environment where pedestrian movement, behavior, and walkability are specifically studied and analyzed. These streets help analyze walking patterns, high pedestrian activity, pedestrian Flow, and efficiency. The major selected streets are found in the central business district of Adama, as listed in Table 3.4 Below.

Table 3.4: Name of Major Selected Street in Downtown the City of Pedestrian Density

No	Name of Street	Level of Density
1	From National Street to Posta Bet (Aba Jifar Street)	1st
2	From Franco to Posta Bet (Nuho Gobena Street)	2nd
3	From Peacock to Posta bet (Abebe Bikila street)	3rd
4	From Mebrat hail to Posta bet (Arora Street)	4th
5	From Tikur Abayi to Posta bet (Mamo Mazamir Street)	5th
6	From Amede Gebeya to Posta bet (Jara Aba Gada street)	6th

Source: Own computation 2016, E.C.

Based on a questionnaire administered to walkway users in the research zone, Table 3.4 presents the pedestrian density rankings of the six major pedestrian routes. The study's main objectives are to identify significant route decisions and to understand how road users perceive pedestrian density. To gather information about road conditions and assess routes based on their experiences, everyday commuters to the CBD are given questionnaires. The information obtained reflects the opinions of users, the dependence of pedestrians on the street, and their actual experiences.

The basic motivation for providing a request to communities to engage in the research is based on the recognition that the definition of pedestrian density is heavily dependent on the opinions and actions of specific pathway users. Throughout interaction with these individuals, researchers learn more about how they see and move through pedestrian environments, which helped to further our knowledge of pedestrian density (Litman, 2017).

By analyzing the behavior of these important pedestrian routes, the study examines mobility at these locations. Within the pedestrian density analysis zone, data was gathered by measuring the number of pedestrians on important routes that were chosen. To effectively capture people's movement behaviors, surveys were performed during peak hours.

An explanation of the pedestrian path from Franco to Posta Bet: One of the busy roundabouts in the city of Adama is located in Franco. Because of the street vending and taxi station, the

area is flooded with large numbers of pedestrians. According to responder value, this is the busiest pedestrian route in the CBD. This 1.5-kilometer route connects many routes bypassing using a popular roundabout close to the city center. Located 250 meters from the roundabout, the Posta Bet neighborhood is a hub of government offices, businesses, and services. During peak hours and on public holidays, be prepared for high pedestrian traffic and potential delays. Moreover, several things on this walkway make it difficult for people to walk freely, such as tiny roadside sales, broken tiles from improper installation, and poles standing in the middle of the walkway. Figure 3.7 provides a plain view of the pedestrian route.



Figure 3.7 Pedestrian Route from Franco to Posta bet

Source: By a researcher from Google Earth

An explanation of the pedestrian route from Peacock Meneharia to Posta Bet (Abebe Bikila Street). The second most congested pedestrian route is the narrow and one-way lane. Bajaj is the common mode of transportation on this route. At peak hour mobility pedestrian traffic volume reaches higher and several Bajaj are observed crowding the sidewalk. Figure 3.8 provides a plain view of the pedestrian route.



Figure 3.8: Pedestrians route from Peacock Meneharia to Posta Bet (Abebe Bikila Street)

Source: By a researcher from Google Earth

An explanation of the pedestrian path on the major road moving to Assela, which is somewhat busy and crowded, from Tikur Abayi to Posta Bet. The flow of pedestrian traffic on this route is extremely backed up during peak hours. During peak times, there is an increase in the number of people, buses, and private cars. There isn't an appropriate sidewalk on this route, which causes a lot of pedestrian traffic. Figure 3.9 provides a plain view of the pedestrian route.



Figure 3.9: Pedestrians route from Tikur Abayi to Posta bet

An explanation of the path that leads from Posta Bet (Jara Aba Gada Street) to Amede Gebeya. According to respondent rank and field traffic volume count, this route is the fourth most crowded for walker. When comparing this route to the one mentioned before, the level of pedestrian traffic is modest. It's a two-way street with moderate pedestrian activity during rush hour. Figure 3.10 provides a plain view of the pedestrian route.



Figure 3.10: Pedestrians route from Amede Gebeya to Posta bet (Jara Aba Gada Street)

Source: By a researcher from Google Earth

An explanation of a rather busy path that runs from Mebrat hail to Posta Bet (Derartu Tulu Street) that links residential neighborhoods with businesses like the Post Office (Posta Bet) in Adama. The amount of traffic increases with the time of day, with peak hours seeing the most congestion as people head to and from work or school. Compared to the first four, the pedestrian path has less traffic flow. The results of the questionnaire indicate that this route is the fifth most crowded. Figure 3.11 provides a plain view of the pedestrian route.



Figure 3.11: Pedestrians route from Mebrat hail to Posta Bet (Derartu Tulu Street)

Source: By a researcher from Google Earth

An explanation of a path that connects residential neighborhoods with commercial establishments like the Post Office (Posta Bet) in Adama, running from National Street to Posta Bet (Aba Jifar Street). The fact that the footpath's drains aren't blocked or open is one of the primary reasons it's busy; this leads to several unpleasant odors, accidents, and congestion. Appropriate walkways have not been constructed since this footpath is a hub for trade and major business activities. The results of the questionnaire indicate that this route is the sixth most crowded. Figure 3.12 provides a plain view of the pedestrian route.



Figure 3.12: Pedestrians route from National Street to Posta Bet (Aba Jifar Street)

Source: By a researcher from Google Earth

3.2.6 Pedestrian Walking Time

Pedestrian walking time were conducted on the main corridor of the Pedestrian analysis zone to check the efficiency of the road and the quality of Pedestrian flow based on Pedestrian walking time. The data collector has set significant initial points on the selected Pedestrian route and pedestrians' Destination Street with the help of the stopwatch control to measure the Pedestrian walking time by traveling from the initial area to the destination place in peak hour and off-peak hour

Data was recorded using a pen and paper and electronic devices like smartphones. A stopwatch was started when the chosen vehicle passed the starting point to measure Pedestrian walking time. The collected data was then analyzed to determine average Pedestrian walking times for the chosen pedestrian routes.

The recorded data for each route in weekday walking are collected both in peak hour and off-peak hour Pedestrian movement to identify long walking time routes this implies that the route having a narrow sidewalk with high pedestrian walking time indicates there is congestion on that route. The walking time recorded data in typical weekday walking.

Questionnaire

The questionnaires were simple and direct, took the least amount of time, and placed the least amount of burden on the respondent.

Table 3.5: The basic Questionnaire for Data Collection about pedestrian sidewalk

	Questionnaire
Personal Characteristics	Personal Characteristics according to the following aspects: Name, sex, age, current work status, disability, and activity.
Trip data	use this pedestrian sidewalk, pedestrian walking facilities, walking purpose, trip start and end times, walking distance, Pedestrians route is more congested

Source: Own computation 2016, E.C

3.2.7 Reliability and validity of data

In order to evaluate the pedestrian movement modeling method used to determine walkability, the study takes a comprehensive approach. The researcher evaluated the model's construct and discriminant validity in accordance with Kothari's (2004) emphasis on validity to make sure it appropriately captures pedestrian walkability and notices the impacts of street design features. Validating modeling parameters are the expert judgments of transportation engineers and urban planners. In line with Kothari's theory of validity as utility, the study seeks to guarantee that the differences in walkability that have been observed really represent Downtown Adama City. This thorough validity examination strengthens trust in the modeling technique's dependability, guiding smart choices for street design and urban planning strategies that improve pedestrian walkability.

For the AnyLogic pedestrian simulation model to be trusted to appropriately assess how street design affects walkability, a thorough evaluation of its validity and reliability must be conducted. To make sure the model accurately represents pedestrian walkability, construct validity is examined, and discriminant validity is examined to distinguish between different street design impacts. Expert judgments support the modeling parameters. The study makes sure that variations in walkability accurately represent Downtown Adama City's reality, all in

line with validity as usefulness. Assessing input data dependability and consistency in delivering consistent outputs are probably part of the reliability evaluation process. Through the consideration of these factors, the study establishes a solid basis on which the model may successfully advise urban planning and street design. To properly parameterize and calibrate the AnyLogic model, extensive and dependable data on street design components, pedestrian circulation patterns, and other pertinent parameters must be obtained. Overcoming any biases or restrictions in the data might be quite difficult.

3.3 Ethical Consideration

The study participants guarantee the privacy and confidentiality of any information they provide in the surveys. They were asked not to identify their identity when responding to the questions to assure them of this. Furthermore, the participants were notified that the study is solely intended for academic purposes and that the advantages arising from the investigation surpass any potential hazards.

3.4 Methodological framework

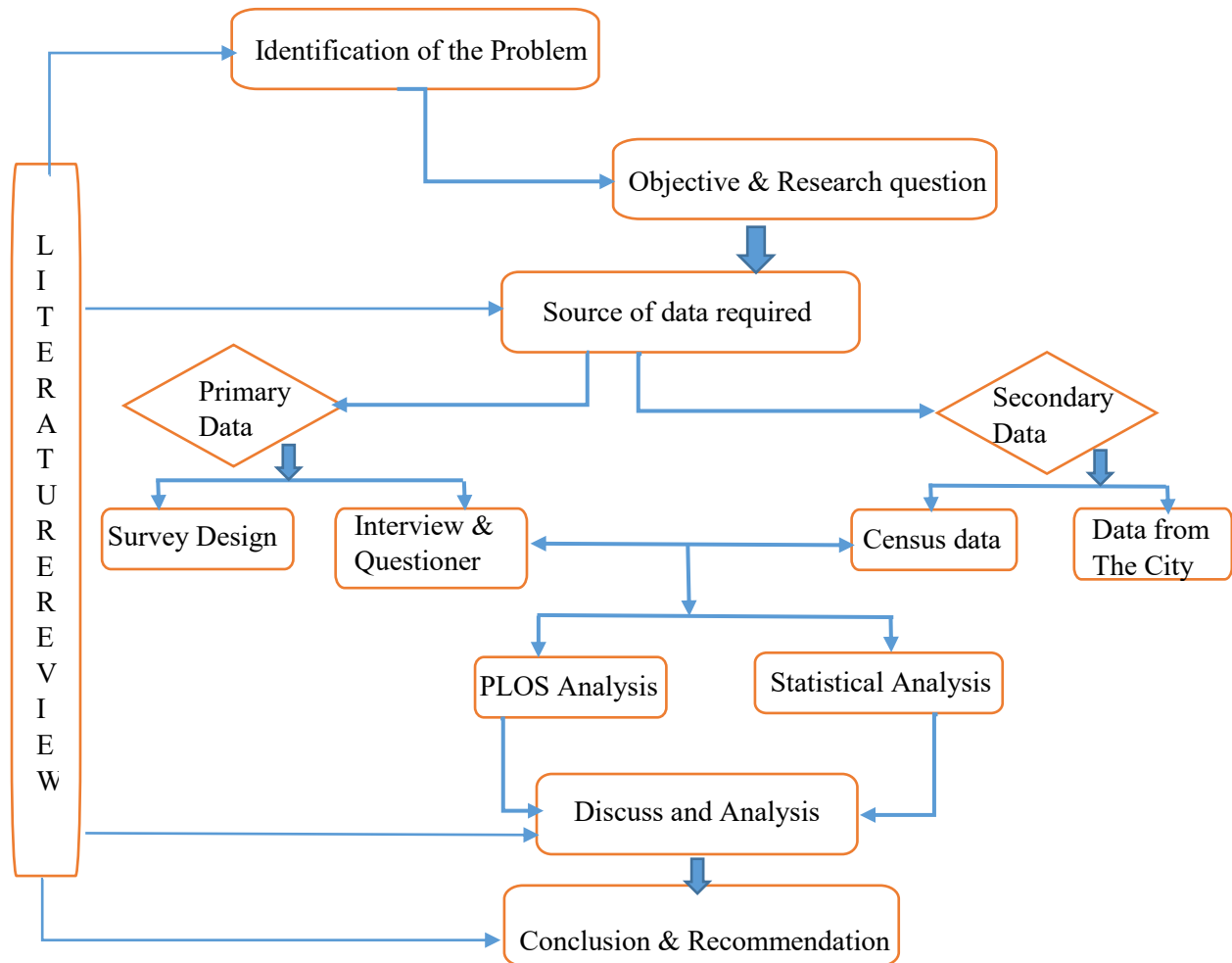


Figure 3.7 Methodological Framework of the study

CHAPTER FOUR

4 RESULTS AND DISCUSSION

The analysis was carried out on major chosen routes within the Pedestrian analysis zone and Gurmmu kebele in the Aba Gada sub-city, which is part of the PAZ for household walking surveys. The appropriate and most effective methods were applied for analyzing the collected data. The findings from this analysis are presented and briefly discussed in the following sections.

The questionnaire was distributed randomly to the representative households to evaluate Current Pedestrian Walkability, and Identification of Pedestrian Density Hotspots and to examine their pedestrian behavior by the pedestrian road users. Out of the distributed 386 questionnaires 91.3% of it was returned.

4.1 Social - Demographic Characteristics of Respondents

4.1.1 General Information

Gender

According to the respondents' demographic characteristics, Table 4.1 shows that the majority of the respondents are male representing 62.7% and the remaining 37.3% are female respondents.

Table 4.1: Gender information of the participants

Variables	Gender	Number	Percentage
Sex	Male	242	62.7%
	Female	144	37.3%
	Total	386	100%

Source: Own survey (2024)

4.1.2 Age profile of respondents

The age of the respondents in the study can be divided into five groups. In total, approximately 386 participants engaged in the study by completing questionnaires. The breakdown of ages is as follows: 8% were between 15-20 years old, 24% were 20-30 years old, 35% were 30-40 years old, 21% were 40-50 years old, and 12% were over 50 years old. Having this age distribution data allows the researcher to analyze any potential differences in pedestrian behavior, perceptions of walkability, and other factors across the different age groups represented in the sample.

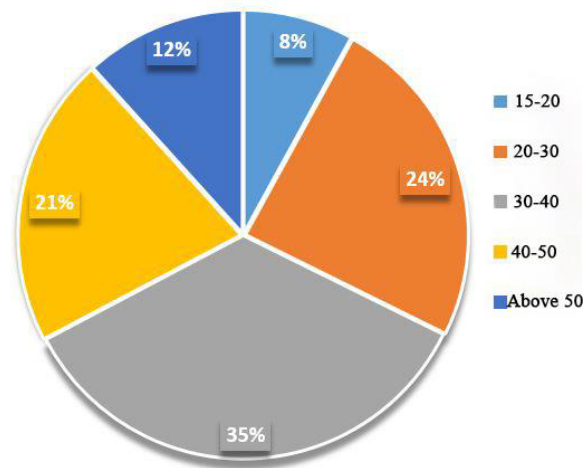


Figure 4.1: Age profile of respondents

Source: Respondent survey

4.1.3 Work status

Among the 386 respondents, 44 % of the respondents are working class of the society who are active and mostly have the chance to experience the real situations of sidewalks. 27% of the Students, 16% were Unemployed, and 13 were Pensioners.

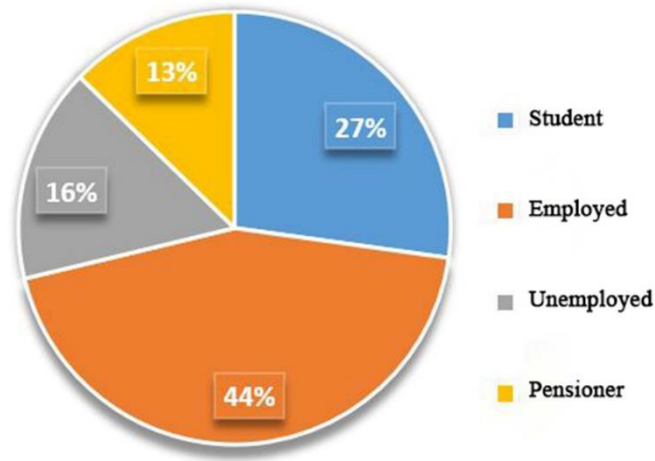


Figure 4.2 Respondents' work status

Source: Respondent survey

4.1.5 Disability status

More than half of the total respondents are not disabled. However, among the disabled groups respondents with waking disability are the highest. The disability status data provides valuable insights into the accessibility challenges faced by different segments of the population in the study area. This information can help the researcher develop more targeted and evidence-based recommendations to improve walkability for all users.

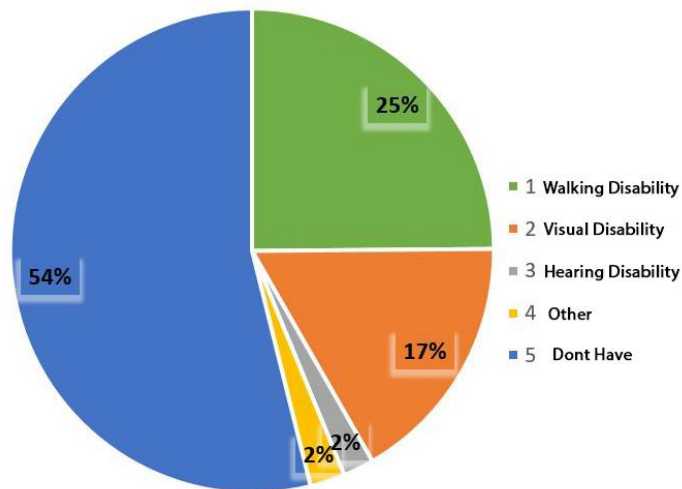


Figure 4.4 Respondents' Disability Status

Source: Respondent survey

4.2 Current pedestrian walkability

An extensive analysis covering a range of pedestrian network aspects was carried out to assess the existing walkability of pedestrians in Adama City. The evaluation examined the state, usability, connection, and functioning of important components such as crosswalks, sidewalks, and pedestrian movements. An assessment of Adama City's pedestrian walkability travel movement was carried out using a mix of quantitative measures, qualitative observations, and community input it was held in four zones.

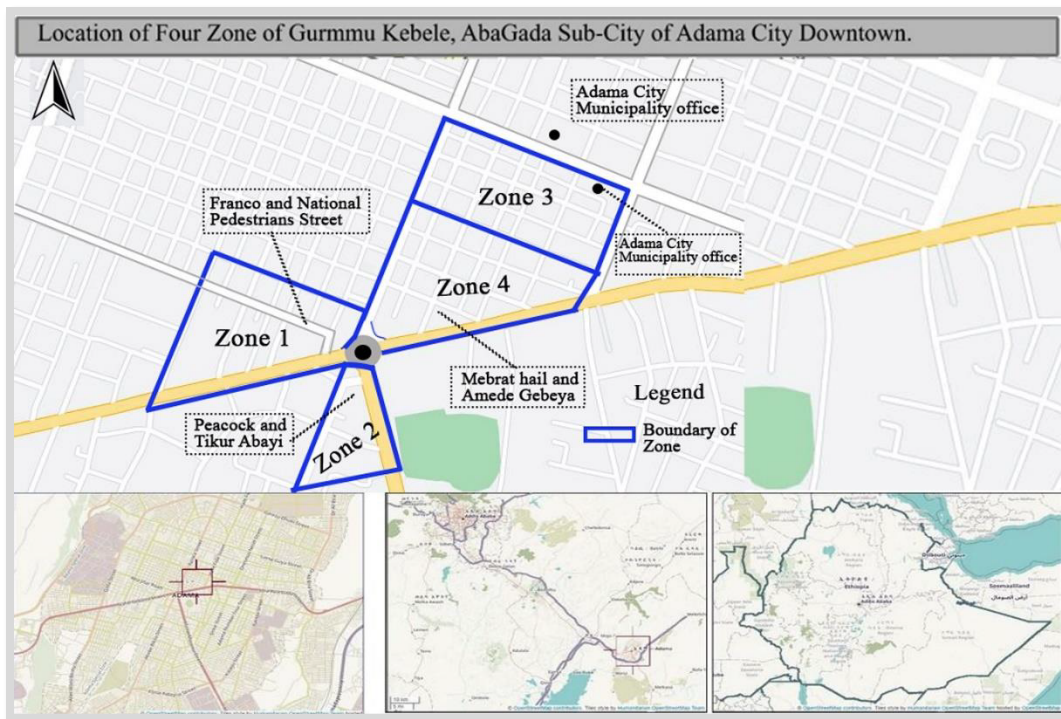


Figure 4.5: Location Map of Four Zones of Gurmmu Kebele of Aba Gada Sub-city, Adama

The above figure illustrates the zone area situated at the center of Adama, between the Posta Bet to Franco, Posta Bet to National, Posta Bet and Mebrat Hail, Posta Bet and Amede Gebeya, Posta Bet and Tikur Abayi, Posta Bet and Peacoke. The boundaries of the study zone include Amede Street to the East, Peacock to the south, National Street to the North, and Meberat Hail to the west.

4.2.1 Field count on major selected Pedestrian routes collection point

The Field count pedestrian volume survey on six major selected pedestrian routes in PAZ is discussed in this section and the recorded row data are found in the attached Appendix A.

Based on the data revealed in Table 4.2, the field count results show that the central business district (CBD) of the study area is primarily accessed through the National routes, accounting for approximately 68% of the total pedestrian travel movements. During the morning peak hours, the total pedestrian traffic volume walking within the CBD reaches around 825 inbound pedestrians within a 15-minute interval.

Table 4.2: Percentage of Pedestrians Travel Movement across all Selected Routes

Source: Manual field count (survey).

Route	Morning Peak 1:30 – 3:30	Midday Peak 6:00 – 8:00	Evening Peak 10:30 – 12:30
Franco To Posta	60%	30%	58%
Posta To Mebrat Hail	47%	25%	45%
Posta To Peacock Meneharia	56%	20%	56%
Posta To Amede Gebeya	15%	7%	15%
Posta To National	68%	30%	67%
Posta To Tikur Abaye	40%	20%	37%

The percentage of each pedestrian's movements was calculated from 100% for the listed across each selected pedestrian's route at peak hours (morning, midday, and, evening).

The data in Table 4.2 provides an overview of pedestrian traffic percentages on different routes during various peak hours. In the morning peak, the route accounts for 60% of the total pedestrian volume, dropping to 30% during the midday peak and rising back to 58% in the evening peak. This suggests significant pedestrian activity in the morning and evening, while the midday period sees lower pedestrian activity. Factors such as sidewalk width and condition influence pedestrian percentages, with wider and well-maintained sidewalks attracting more pedestrians. The presence of key amenities and destinations along the routes also affects pedestrian walking behavior, with routes passing through commercial centers, educational institutions, or recreational areas experiencing higher volumes. Additionally, the design and layout of the routes play a role, as routes with pedestrian-friendly features and clear signage encourage higher pedestrian percentages, while routes with design flaws or safety concerns discourage walking.

According to Field Count data In the Morning and evening- time, there is a large percentage of pedestrians using the National and Franco Route to enter the CBD, so in these two routes, there is high pedestrian volume. Midday peak hour Pedestrian routes in the middle of the day during rush hour, Pedestrian traffic is relatively moderate as compared to the morning and evening peak hours.

4.2.2 Result for the Pedestrian sidewalk level of service of selected routes

HCM model

The Pedestrian Space Ratio (PSR) is a metric used in transportation planning and engineering to assess the adequacy of pedestrian space relative to the demand for pedestrian movement. It represents the ratio of available pedestrian space to the number of pedestrians using that space, providing insight into the level of congestion or crowding experienced by pedestrians in a given area.

Pedestrian Space Ratio (PSR): $PSR = \text{Effective Width} / \text{Pedestrian Count/time}$

Posta Bet to Franco (PB – F) has an effective width of 2.5 meters and a pedestrian count for 15 minutes is 786 pedestrians.

$$PSR = \frac{V_{15}}{W} = \frac{786}{2.5 \times 15} = 20.96 \text{ score is } < \text{ which is E grade}$$

This indicates that, on average, 20.96 pedestrians pass through each meter of the sidewalk segment per 15-minute interval.

Posta Bet to Peacock Street (PB – P) has an effective width of 3 meters and a pedestrian count for 15 minutes is 705 pedestrians.

$$PSR = \frac{V_{15}}{W} = \frac{705}{3 \times 15} = 15.6 \text{ score is } < \text{ which is E grade}$$

This indicates that, on average, 15.6 pedestrians pass through each meter of the sidewalk segment per 15-minute interval.

Posta Bet to Tikur Abaye (PB – TA) has an effective width of 2.5 meters and a pedestrian count for 15 minutes is 423 pedestrians.

$$PSR = \frac{V_{15}}{W \times 15} = \frac{423}{2.5 \times 15} = 11.8 \text{ score is } < \text{ which is D grade}$$

This indicates that, on average, 11.8 pedestrians pass through each meter of the sidewalk segment per 15-minute interval.

Posta Bet to Amede Gebeya (PB – AG) has an effective width of 3 meters and a pedestrian count for 15 minutes is 310 pedestrians.

$$PSR = \frac{V_{15}}{W \times 15} = \frac{310}{3 \times 15} = 6.8 \text{ score is } < \text{ which is B grade}$$

This indicates that, on average, 6.8 pedestrians pass through each meter of the sidewalk segment per 15-minute interval.

Posta Bet to Meberat Haile (PB – MH) has an effective width of 2.4 meters and a pedestrian count for 15 minutes is 386 pedestrians.

$$PSR = \frac{V_{15}}{W \times 15} = \frac{386}{2.4 \times 15} = 10.72 \text{ the score is } < \text{ which is a D grade}$$

This indicates that, on average, 10.72 pedestrians pass through each meter of the sidewalk segment per 15-minute interval.

Posta Bet to National (PB – N) has an effective width of 2 meters and a pedestrian count for 15 minutes is 825 pedestrians.

$$PSR = \frac{V_{15}}{W \times 15} = \frac{825}{2 \times 15} = 27.5 \text{ score is } < \text{ which is F grade}$$

This indicates that, on average, 27.5 pedestrians pass through each meter of the sidewalk segment per 15-minute interval.

Table 4.3 HCM grading values (HCM method estimation 2019).

No	HCM Grade	HCM Flow Rate (Ped/15/m)
1	A	Score ≤ 5
2	B	$5 \leq \text{Score} \leq 7$
3	C	$7 \leq \text{Score} \leq 10$
4	D	$10 \leq \text{Score} \leq 15$
5	E	$15 \leq \text{Score} \leq 23$
6	F	Score $\leq$

Pedestrian Service Volume (PSV) is a metric used in transportation engineering and planning to quantify the volume of pedestrian traffic or pedestrian flow along a particular pathway or pedestrian facility, such as sidewalks, crosswalks, or pedestrian bridges. PSV represents the number of pedestrians passing through a specific location within a given period, typically expressed as pedestrians per hour (ped/hr).

Let's take an example Posta Bet to Franco Street Pedestrian Service Volume (PSV):

Pedestrian Service Volume (PSV): $\text{PSV} = \text{Pedestrian Count} / \text{Time Interval}$

$\text{PSV} = 786 \text{ pedestrians} / (15 \text{ minutes}) = 52.4 \text{ pedestrians/minute}$

Table 4.4 Results of HCM Pedestrian Level of Service (PLOS) Analysis

No	Street Sections	Measured HCM Flow Rate (Ped/15/M)	HCM Grade
1	P to F	20.96	E
2	P to MH	10.72	D
3	P to P	15.67	E
4	P to AG	6.88	B
5	P to NG	27.5	F
6	P to TA	11.28	D

4.3 Adama's pedestrian street design.

The pedestrian street design in Adama exhibits significant shortcomings that have a detrimental impact on walkability and pedestrian safety. The absence of designated zones for street furniture, lack of curbs, and inadequate buffer zones are critical issues that need to be addressed. These deficiencies result in compromised pedestrian safety and diminish the overall quality of the pedestrian experience.

Additionally, the lack of attention to afforestation efforts exacerbates the problems in the street design. The absence of greenery not only detracts from the visual appeal but also fails to provide essential shade and contribute to environmental sustainability.

Moreover, the sidewalk design is inadequate, with improper height slopes and uneven surfaces that pose significant challenges for pedestrians. These flaws make navigation difficult and increase the risk of accidents and injuries. The presence of open manholes and the proliferation of street vending further compound the issue, creating additional obstacles and hazards for pedestrians.

Overall, the pedestrian street in Adama suffers from a myriad of issues that severely compromise its functionality and usability. Addressing these shortcomings by implementing designated zones for street furniture, installing curbs, creating buffer zones, improving sidewalk design, and addressing open manholes and street vending will be essential to enhance walkability, ensure pedestrian safety, and improve the overall pedestrian experience in Adama. Additionally, incorporating greenery and vegetation along the street can contribute to aesthetics, shade provision, and environmental sustainability. Conducting thorough research and analysis to identify and rectify these deficiencies is crucial to creating a pedestrian-friendly environment that promotes safe and enjoyable walking experiences.

Street lighting plays a critical role in enhancing pedestrian walkability in Adama city. Adequate street lighting helps pedestrians navigate pathways, crosswalks, and sidewalks with confidence, reducing the risk of accidents and improving personal security.

Well-designed street lighting enables pedestrians to identify and avoid potential hazards, such as uneven surfaces, open manholes, and other obstructions, thereby improving overall safety. This is particularly important in high-traffic pedestrian corridors like the Posta to National Street and Posta to Franco Street routes.

Proper illumination not only enhances visibility but also contributes to a more inviting and comfortable pedestrian experience, encouraging more residents to choose walking as a mode of transportation, especially during evening and nighttime hours. Figure 4-7 below Illustrates



Figure 4.7: The analysis highlights the specific issues impacting the pedestrian street in downtown Adama. (Researchers)

4.3.1 Pedestrian flow count and walkway width

Table 4.5 shows that the highest pedestrian count during the morning peak hour was recorded on the section from National Street to Posta Bet, with 825 pedestrians passing through a 15-minute interval. The midday peak hour also saw significant pedestrian traffic, with the highest count of 456 pedestrians on the same section. These findings suggest that the PAS is a crucial corridor for pedestrian movement, particularly during the busiest times of the day.

The table also provides information on the existing walkway widths for each PAS street section, which range from 2 meters to 3.5 meters. Interestingly, the master plan proposes slightly wider walkways for most sections, with the exception of the section from Peacock to Posta Bet, where the planned width is narrower than the current one. The standard walkway widths recommended

by guidelines such as the ADA are generally wider than both the existing and master plan widths, indicating potential room for improvement in pedestrian infrastructure.

Table 4.5 Pedestrian flow count, walkway width, Master plan, and standard walkway width and distance

Source: Manual field count (survey).

Section of PAS street	Distance in kilometers	Pedestrian count per 15 minutes Morning Peak hour	Pedestrian count per 15 minutes Midday Peak hour	Existing walkway width (m)	Master plans walkway width	Standard walkway width /ADA/
Franco to Post bet,	0.70	786	392	2.5	3	4.0
From Peacock to Posta bet	0.70	705	307	3	2.5	3.0
From Tikur Abayi to Posta bet	0.8	423	203	2.5	3	4.0
From Amede Gebeya to Posta bet	0.73	310	125	3.0	3	4.0
From Mebrat hail to Posta bet	0.61	386	178	2.40	3	3.0
From National Street to Posta Bet	0.42	825	456	2.0	2.5	3.0
Total	3.86 kilometer	-	-	15.3m	-	-

According to ADA (Americans with Disabilities Act) guidelines, the standard width for a walkway or sidewalk should be at least 3.5 to 4 meter wide to accommodate wheelchair users and other pedestrians with mobility aids. This width ensures that there is enough space for individuals to pass each other comfortably and for wheelchairs to maneuver safely without obstruction. In certain circumstances, wider walkways may be required, especially in areas with high pedestrian traffic or where there is a need to accommodate multiple users simultaneously. Additionally, ADA standards emphasize the importance of maintaining a smooth and level surface, free of obstacles and hazards, to ensure accessibility for all pedestrians (ADA Standards for Accessible Design 2010).

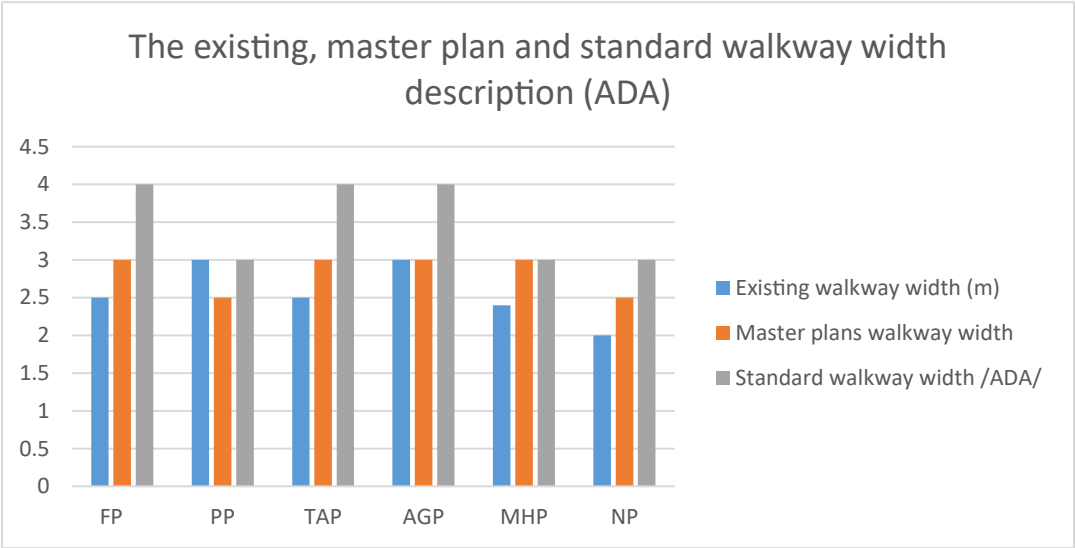


Figure 4.8 the existing, master plan and standard walkway width description (ADA)

4.3.2 The condition, accessibility, and connectivity of the pedestrian facilities

Condition of Pedestrian Facilities:

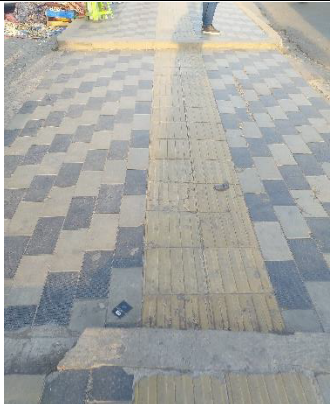
The condition of pedestrian facilities in Adama varies across different areas of the city. While some parts may feature well-maintained sidewalks with smooth surfaces and clear markings, others may suffer from disrepair, uneven pavements, and obstacles like potholes or debris. Additionally, inadequate maintenance can lead to issues such as cracked sidewalks, broken curbs, or missing tactile paving, posing safety hazards for pedestrians, particularly those with mobility challenges.

Table 4.6 presents a thorough evaluation of the pedestrian routes within the study area, assessing the physical condition of the sidewalks and crosswalks along each route. According to the ADA (Americans with Disabilities Act) guidelines, the condition of the pedestrian infrastructure is categorized as Good, Poor, or Fair. The route from Franco to Posta stands out as being in Good condition, with smooth walkways and well-maintained crosswalks that enhance pedestrian safety. However, the situation is quite different for the route from Posta to Mebrat Hail, which is in Poor condition, featuring uneven surfaces and potential hazards like parking issues and inappropriate sidewalk widths. The crosswalks along this route are in Fair condition but may need improvements to boost visibility and safety. Moving on, the sidewalk condition along the route from Posta to Peacock Meneharia is fair, with some minor problems, while the crosswalks are in Poor condition, lacking proper signage and posing safety concerns for pedestrians. In contrast, the route from Posta to Amede Gebeya has Good sidewalk conditions and Fair crosswalks, with room for further enhancements to improve visibility and safety. Notably, the routes from Posta to National and Posta to Tikur Abaye are particularly concerning, with Poor sidewalk conditions characterized by numerous issues such as open manholes, street vending, and uneven surfaces. The crosswalks along these routes are also in Poor condition, with faded or missing markings, significantly increasing the risk of pedestrian accidents.

This comprehensive assessment provides valuable insights into the current state of the pedestrian infrastructure within the study area, highlighting the areas that require immediate attention and potential improvements to enhance overall walkability and safety for pedestrians. This information can guide the development of targeted interventions and policy decisions to improve the pedestrian experience in the region.

Table 4.6 Condition of Pedestrian Facilities

Pedestrian Route	Physical illustration with photos	Sidewalk Condition (ADA)	Crosswalk Condition	Description
Franco to Posta		Good	Good	This route is in good condition, providing a smooth and safe walking surface for pedestrians. Crosswalks are well-marked and maintained, enhancing pedestrian safety at intersections.
Posta to Mebrat Hail		Poor	Fair	This route is poor, with uneven surfaces and potential hazards such as Parking problems, inappropriate sidewalk width cracks, or obstructions. Crosswalks are fair but may require improvements to enhance visibility and safety for pedestrians.

Posta to Peacock Meneharia			Fair	Poor	The sidewalk condition is fair, although some areas may have minor issues such as uneven surfaces or limited width. Crosswalks are poor, there is no crosswalk sign or insufficient signage, posing safety concerns for pedestrians.
Posta to Amede Gebeya			Good	Fair	The sidewalk condition is good, providing a comfortable walking environment for pedestrians. Crosswalks are fair, with adequate markings but potential improvements could enhance visibility and safety.
Posta to National	 		Poor	Poor	The sidewalk condition is poor, with multiple issues such as open manholes, street vending, or uneven surfaces, making it challenging for pedestrians to navigate. Crosswalks are also poor, with faded or missing markings, increasing the risk of pedestrian accidents.

Posta to Tikur Abaye			Poor	Poor	The sidewalk condition is poor, with similar issues as the previous route. Crosswalks are also poor, lacking proper markings or signage, which may compromise pedestrian safety at intersections.
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Source: Manual field count (survey).

Accessibility of Pedestrian Facilities:

Accessibility refers to the ease with which pedestrians, including those with disabilities, can use and navigate pedestrian facilities. In Adama, the accessibility of pedestrian facilities may be influenced by factors such as sidewalk width, curb ramps, crosswalks, and the presence of obstacles. Adequate sidewalk width is essential to accommodate pedestrians of all abilities, including those using mobility aids or traveling in groups. Accessible curb ramps ensure smooth transitions between sidewalks and road crossings for wheelchair users and individuals with strollers or carts.

Connectivity of Pedestrian Facilities:

Pedestrian connectivity refers to the seamless network of sidewalks, pathways, and crosswalks that enable pedestrians to move efficiently and safely throughout the city. In Adama, the connectivity of pedestrian facilities may vary based on factors such as urban layout, street design, and infrastructure planning. Well-connected pedestrian routes facilitate convenient access to key destinations such as schools, markets, public transportation hubs, and recreational areas. However, disjointed or incomplete pedestrian networks can disrupt pedestrian flow, forcing pedestrians to take longer routes or navigate through hazardous conditions.

Addressing the condition, accessibility, and connectivity of pedestrian facilities in Adama requires a comprehensive approach involving urban planning, infrastructure investment, and community engagement. By prioritizing maintenance efforts, implementing accessibility standards, and enhancing pedestrian connectivity, Adama can create a safer, more inclusive, and pedestrian-friendly environment for residents and visitors alike.

4.3.3 Pedestrian Accident History in Adama, Ethiopia

According to the data from the Adama Traffic Management Agency, the most significant safety problem in the city is the abnormally high number of pedestrian deaths. This critical issue results from a large volume of pedestrian traffic and inadequate pedestrian safety measures.

The agency's six-year accident history, covering the period from 2018 to 2023, reveals that while the overall number of traffic accidents has been rising, the growth rate of these accidents suggests a declining trend. However, the survey conducted by the agency indicates that pedestrian collisions have been on the rise, with the increase in urban car ownership and the construction of urban road amenities. This has made the issue of pedestrian safety increasingly severe. Inadequate infrastructure, such as poorly constructed crosswalks or a lack of pedestrian signals, as well as motorist behavior and road conditions, are factors that have contributed to the high number of pedestrian accidents. Pedestrians, being the most vulnerable members of the traffic 'community,' have borne the brunt of these safety issues. To address this pressing concern, the study aims to provide insights into the precise street design components that affect pedestrian movement patterns, safety, and the overall walking experience. By offering these insights, the research can help improve pedestrian walkability in downtown Adama. Urban planners, designers, legislators, and local governments can use this information to better prioritize the requirements of pedestrians and develop more pedestrian-friendly streetscapes, ultimately enhancing the safety and well-being of the city's residents.

Table 4.7 Adama Accident History, 2018- 2023

Year	2018	2019	2020	2021	2022	2023
Total Accidents in Adama	54	67	77	85	92	97
Growth from the Previous Year in %		24%	15%	10%	8%	5%

Source: Adama Traffic Management Agency's Data (2024)

The 5-year accident data from 2018 to 2023 in Adama reveals a concerning pattern of pedestrian accidents occurring in various locations across the city. These locations include pedestrian traffic areas, marketplaces, workplaces, residential and leisure zones, religious sites, schools, and public spaces. The number of accidents steadily increased over the years, reaching 67 in 2019, 77 in 2020, and 85 in 2021, and 92 in 2022, and 97 in 2023. While the growth rate of accidents decreased from year to year, pedestrians remained particularly vulnerable in areas with high foot traffic and inadequate infrastructure. Residential neighborhoods, recreational areas, religious sites, and schools were common sites for pedestrian accidents, often involving speeding vehicles or a lack of designated pedestrian crossings. The data highlights the need for targeted interventions to improve pedestrian safety, including infrastructure improvements, traffic calming measures, enhanced visibility, and enforcement of speed limits. Community education and awareness campaigns on road safety practices can also contribute to reducing pedestrian accidents in Adama.

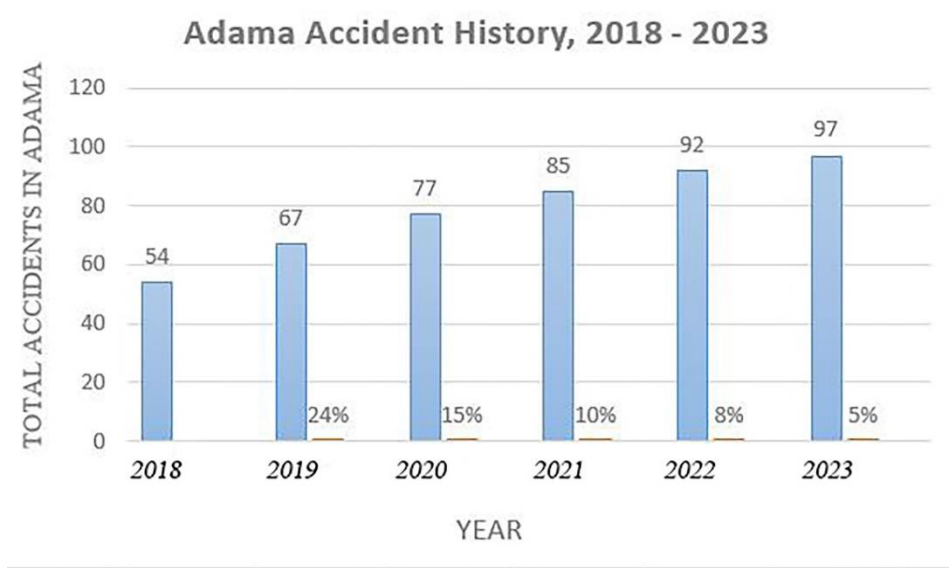


Figure 4.9: Pedestrian Accident History in Adama, Ethiopia

4.4 Influence of Pedestrian Behavior on Walkability

4.4.1 Subjective Evaluation of Pedestrian Behavior and Attitude on Walkability

In evaluating pedestrian walkability in Adama town subjective assessments play a crucial role in understanding user perceptions of pedestrian facilities. Personal assessments based on users' perception ratings provide valuable insights into the quality of pedestrian infrastructure and its impact on pedestrian experience. These assessments involve surveys conducted among pedestrians to gauge their feelings and experiences while walking in different locations within the city.

Pedestrians themselves are best positioned to identify the strengths and weaknesses of pedestrian facilities and suggest improvements that enhance safety and usability.

The distribution questionnaire used for this assessment captures pedestrians' perceptions of various aspects of pedestrian facilities. Rating categories include binary options such as "Yes" or "No" to express agreement or disagreement with specific issues, expressed as percentages. Additionally, a Likert scale ranging from "Excellent" to "Very Poor". This comprehensive approach allows for a detailed analysis of pedestrian perceptions, covering aspects such as sidewalk conditions, crosswalks, lighting, amenities, and overall satisfaction with the pedestrian environment.

Through this subjective evaluation, insights are gained into pedestrians' attitudes toward walkability in Adama. The feedback obtained from pedestrians helps identify areas of improvement and informs decision-making processes aimed at enhancing the pedestrian experience and promoting safer and more accessible walking environments in the city.

a) Pedestrians' Purpose of Walking

In Adama Town, pedestrians are walking for different purposes

This figure (Fig. 4.10) provides insights into the various purposes for which pedestrians are walking in Adama Town, based on a field survey. Understanding the primary reasons behind people's walking habits is crucial for developing effective pedestrian infrastructure and safety measures that cater to the diverse needs of the local community.

The bar graph shows that the most common purpose for walking is to go to work, with approximately 30% of pedestrians commuting to their workplaces on foot. The second-highest purpose is to go to the marketplace, with around 25% of pedestrians walking to access the town's commercial and retail areas for shopping or running errands. Another notable purpose is to go to school, which accounts for approximately 20% of pedestrian activity.

Smaller percentages of pedestrians are walking to visit relatives or friends (10%), for sports or exercise purposes (5%), and to relax or engage in leisure activities (5%).

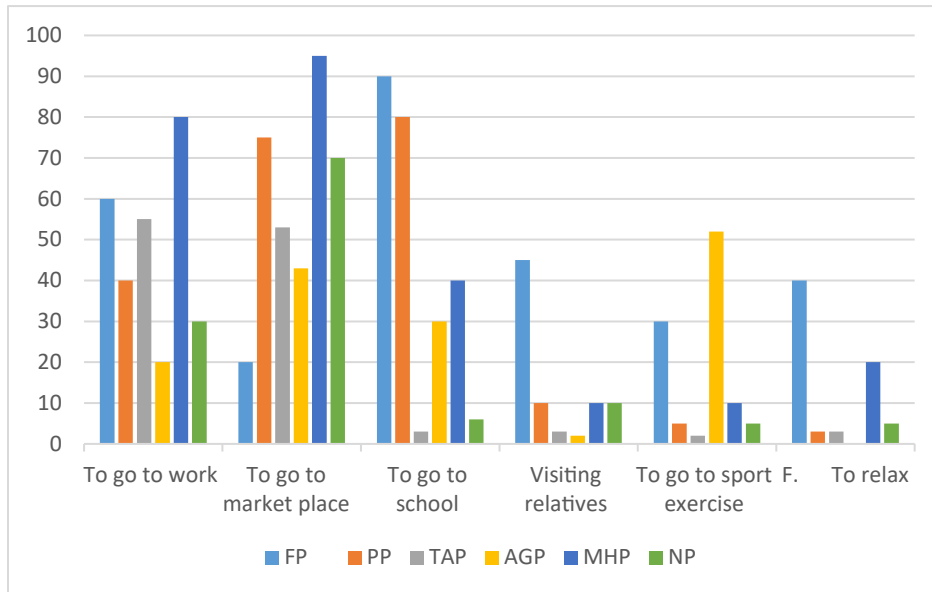


Fig. 4.10: Pedestrians' Purpose of Walking in Adama Town (source: field survey)

b) Pedestrians' Perception of the Sidewalk Condition

The subjects were asked a series of Yes-or-No questions about the present status of pedestrian walking facilities and how it is user-friendly. In general, 30% of the respondents think the sidewalk is user-friendly, and 70% believe not which is saying the sidewalks in Adama town road networks are at risk and need to improve for pedestrian safety.

Table 4.8: Pedestrians' view about the user-friendliness of sidewalks

Pedestrians Street	Sidewalks Are User-Friendly	
	Yes (%)	No (%)
From Franco To Posta Bet	58%	42%
From Posta Bet To Mebirat Hail	35%	65%
From Posta Bet To Peacock	28%	72%
From Posta Bet To Tikur Abay	35%	65%
From Posta Bet To Amede Gebeya	61%	39%
From Posta Bet To National Street	12%	88%
Total Respondents	30%	70%

Source: field survey

c) Pedestrians' Preference for Using the Sidewalk

Pedestrians prefer to use the sidewalks in some locations, but, they do not exist in the other areas as shown in Table 4.9 Overall, 65% of the respondents prefer to use the sidewalk while 35% do not.

Table 4.9: Pedestrians preference for using the sidewalk

Pedestrians Street	Pedestrians' Preference For Using The Sidewalks	
	Yes (%)	No (%)
From Franco To Posta Bet	84%	16%
From Posta Bet To Mebirat Hail	37%	63%
From Posta Bet To Peacock	26%	74%
From Posta Bet To Tikur Abay	14%	86%
From Posta Bet To Amede Gebeya	52%	48%
From Posta Bet To National Street	8%	92%
Total Respondents	35%	65%

Source: field survey

d) Reasons for Not Preferring the Sidewalk

In understanding pedestrian preferences and behaviors regarding sidewalk usage in Adama City respondents were given several options to indicate why they do not prefer using the sidewalk. Fig. 4.11 illustrates the primary reasons cited by respondents for their reluctance to use the sidewalk. Among the top reasons highlighted were the presence of street vendors, discontinuity of the sidewalk, open manholes, excessive pedestrian congestion, and poor sidewalk quality. These findings shed light on the various factors that deter pedestrians from utilizing the sidewalk infrastructure effectively.

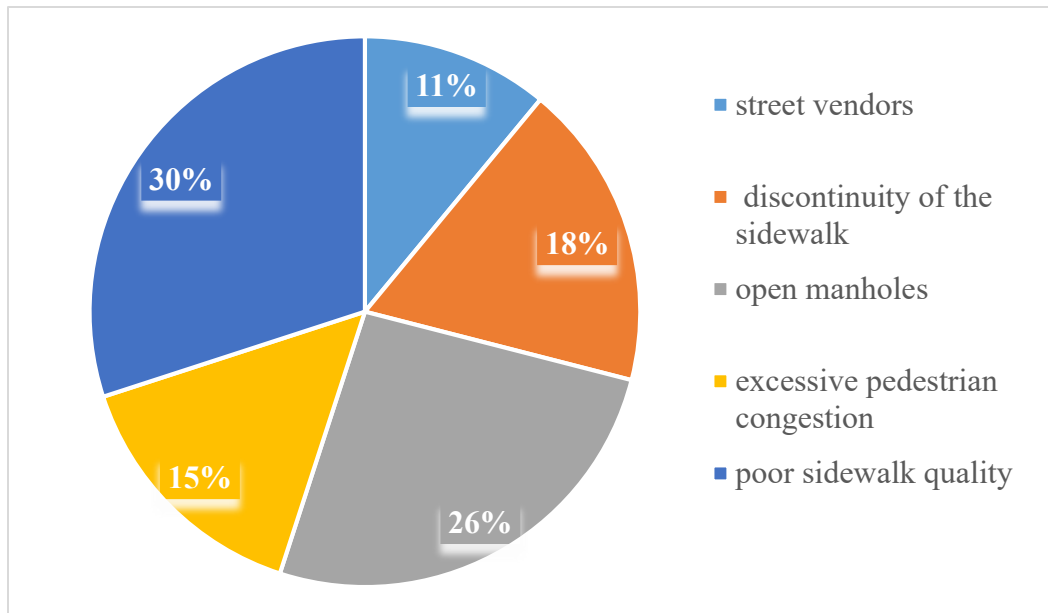


Fig. 4.11: Reasons for not preferring the sidewalk

f) Pedestrians' Perception of the Sidewalk Environment

The table presents pedestrians' perceptions of the sidewalk environment in different locations within Adama Town. Pedestrians were asked to rate the sidewalk environment on a Likert scale from 'very bad' to 'excellent'. The data reveals a mixed assessment of the sidewalk conditions across the surveyed areas.

In the area from Franco to Posta Bet, the sidewalk environment is considered 'acceptable' by the majority of pedestrians, with 50% rating it as 'good' and 34% rating it as 'very good'. However, the sidewalk environment from Posta Bet to Mebirat Hail, Posta Bet to Peacock, and Posta Bet to Tikur Abay is perceived as 'poor' by pedestrians, with a significant proportion rating it as 'bad' (45%, 61%, and 42% respectively) and a notable percentage rating it as 'very bad' (17%, 25%, and 38% respectively).

In contrast, the sidewalk environment from Posta Bet to Amede Gebeya is considered 'acceptable', with 47% of pedestrians rating it as 'good' and 37% rating it as 'very good'. Conversely, the area from Posta Bet to National Street is perceived as 'unpleasant', with 56% of pedestrians rating it as 'very bad' and 44% rating it as 'bad'.

Table 4.10: Pedestrians' feeling about the sidewalk environment

Pedestrians' Preference For Using The Sidewalks %

	Very Bad	Bad	Good	Very Good	Excellent	Results
From Franco To Posta Bet	6	8	50	34	2	Acceptable
From Posta Bet To Mebirat Hail	17	45	24	9	5	Poor
From Posta Bet To Peacock	25	61	14	-	-	Poor
From Posta Bet To Tikur Abay	38	42	12	2	-	Poor
From Posta Bet To Amede Gebeya	-	16	47	37	-	Acceptable
From Posta Bet To National Street	56	44	-	-	-	Unpleasant
Total Respondents						

Source: field survey

4.4.2 Findings on Pedestrian Behavior

The results of the research done in Adama City's downtown provide insight into several areas of pedestrian behavior. The observations centered on following traffic regulations, using authorized crosswalks, and observing how people and cars behaved.

The study found that there was a range in the behaviors related to following traffic laws. While some pedestrians followed the laws of the right-of-way and traffic signals, others chose to walk at dangerous times, including when they crossed the street against the light or jaywalked. This emphasizes how crucial it is to run educational programs to encourage safe pedestrian behavior.

According to survey data the usage of designated crosswalks was also investigated in the study. Although many pedestrians made good use of them, some decided to cross the road in not designated places, which made them prone to accidents. This behavior can be attributed to a few potential factors. Firstly, pedestrians have chosen to cross the road at non-designated locations if it was more convenient and allowed them to reach their destination more quickly, rather than taking the time to walk to the nearest crosswalk. Secondly, some pedestrians not have been fully aware of the designated crosswalk locations or the importance of using them, pointing to a need for better

signage, public education, and awareness campaigns to emphasize the safety benefits of using designated crossings. Additionally, if the designated crosswalks were not located at optimal points along the pedestrian's route, or if the crosswalks were inconvenient or out of the way, pedestrians may have been inclined to cross at more direct, non-designated locations. Interventions intended to encourage safer crosswalk usage can be guided by an understanding of the elements impacting this decision-making.

Analysis was also done on the interactions between cars and pedestrians. It was seen that cooperative behavior existed, with pedestrians giving to cars and drivers giving way to them. Conflicts and tensions were also observed, though, especially in places with high traffic or poor pedestrian infrastructure. Improving visibility, putting traffic calming measures into place, and upgrading signs may all contribute to safer and better pedestrian-vehicle interactions.

The study's overall conclusions highlight the need to encourage appropriate crosswalk usage, encourage responsible pedestrian conduct, and enhance pedestrian-vehicle interactions to create a safer and more pedestrian-friendly environment in downtown Adama City.

4.4.3 Analysis of How Pedestrian Behaviors Impact the Walkability of Downtown Areas

In Adama City, pedestrian behavior has a big influence on how walkable the downtown districts are. It has an impact on walkability in several ways, including accessibility, comfort, efficiency, and safety. Examining these actions offers important insights into the advantages and disadvantages of urban planning and pedestrian infrastructure, as well as chances for development. The usage of marked crosswalks and observance of traffic laws both greatly enhance pedestrian safety. There is less chance of collisions and disputes with cars when pedestrians obey traffic signals and utilize crosswalks properly. By fostering a routine and ordered atmosphere, this responsible conduct improves overall safety. Conversely, actions like as jaywalking and crossing at undesignated sites make it more likely that accidents will occur and cause traffic disruptions, which hurt walkability.

Additionally, pedestrian conduct affects efficiency. By following traffic laws and using designated crosswalks, pedestrians can improve pedestrian movement efficiency and contribute to a smoother flow of traffic. On the other hand, actions that result in collisions with cars or obstruct pedestrian

traffic cause delays and bottlenecks, which reduce the effectiveness of walking routes and reduce their walkability.

Another significant factor impacted by pedestrian behavior is comfort. Walking in downtown areas is perceived as comfortable and enjoyable by pedestrians who feel secure and safe. Comfort and convenience of mobility are enhanced by positive interactions between pedestrians and automobiles, such as yielding at junctions and respecting the right-of-way.

On the other hand, tension-producing or conflict-causing behaviors—like reckless driving or a lack of concern for the safety of pedestrians—make walking more difficult or unpleasant and decrease walkability.

Pedestrian conduct also affects accessibility. Regardless of age, ability, or mode of transportation, pedestrians who can move around downtown areas safely and effectively make a positive contribution to a more accessible and inclusive urban environment. The accessibility of downtown areas and walkability for all inhabitants and tourists are improved by actions that emphasize pedestrian safety and cater to a variety of demands, such as installing accessible crosswalks and pedestrian amenities.

Adama City may improve walkability and provide a safe, effective, pleasant, and accessible environment for pedestrians by encouraging responsible pedestrian behavior, making sure that the necessary infrastructure is in place, and encouraging good interactions between walkers and automobiles.

4.5 Pedestrian Density Analysis

To identify different pedestrian density indicators, the pedestrian density study was conducted utilizing the pedestrian walking time technique, pedestrian density hot spot area, and pedestrian density map. These metrics include the volume-to-capacity ratio (PLOS), average walking time for pedestrians, and walking speed on both good and bad streets. The main focus of the assessment was six selected routes that are located within the Pedestrians Analysis Zone (PAZ): Posta Bet to Franco, Posta Bet to Tikur Abay, Posta Bet to Mebirat Haile, Posta Bet to Peacock, Posta Bet to Amede Gebeya, and Posta Bet to National Street.

4.5.1. Pedestrians walking time

Pedestrian's Walking times measured on any route vary by time of day, day of the week, and month of the year. In general, morning and evening weekday peak hour pedestrian volumes and walking times were higher, than those measured during midday periods or on weekends. Pedestrian Walking time data were collected in 15-minute intervals along 6 major selected networks in the density analysis zone. In this study, pedestrian walking times were conducted from 7:30 AM to 7:00 PM on peak periods. Walking routes are shown in Figure 4.12 and Table 4.8 below. Walking time data were recorded manually, using pen and paper along with stopwatches. In this research “average” or “typical” Pedestrian Walking times, were collected on each pedestrian's route during the morning, midday, and evening peak hours on “typical weekdays” (i.e. Monday, Tuesday, Wednesday, Thursday, and Friday). Figure 4.12 shows the Field data Collection point.

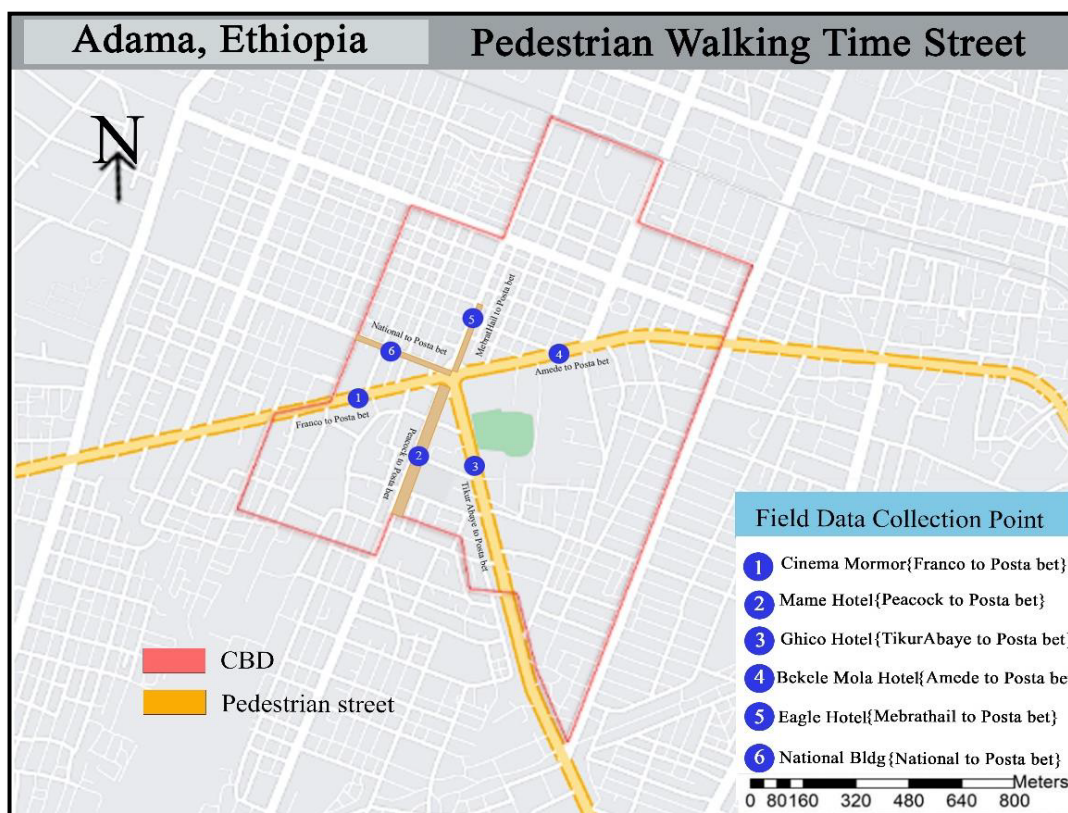


Figure 4.12: Pedestrian Waking Time Street

Table 4.8 below provides an overview of the selected Pedestrian routes for Density measure analysis in the Pedestrians analysis zone. It includes the pedestrians' route names and their respective origin-destination information.

Table 4.11: Pedestrians route for walking time

No	From And To	Route Name
1	From Franco to Posta bet	Nuho Gobena
2	From Posta bet to Mebirat Hail	Derartu Tulu
3	From Posta Bet to Peacock	Abebe Bikila street
4	From Posta bet to Tikur Abay	Mamo Mazamir
5	From Posta bet to Amede Gebeya	Jara Aba Gada
6	From Posta Bet to National Street	Aba Jifar street

Source: field survey

4.5.2 Median peak hour pedestrian walking time

The table provides detailed data on the median peak hour pedestrian walking time pedestrian walking time (PWT) for major corridors in Adama. The information includes the name of the major corridor, the starting and ending streets, the length of each corridor (all 600 meters), and the average pedestrian walking time PWT during both the morning/evening peak hours as well as the midday peak hour.

The data reveals some notable differences between the corridors. The Aba Jifar corridor stands out as having the longest median pedestrian walking time PWT across both time periods - 750 seconds (12.5 minutes) during the morning/evening peak and 420 seconds (7 minutes) during the midday peak. In stark contrast, the Jara Aba Gada corridor boasts the shortest median pedestrian walking time PWT, at 375.5 seconds (6.26 minutes) in the morning/evening and just 120 seconds (2 minutes) during midday.

The other corridors fall somewhere in the middle of this range. For instance, the Nuho Gobena corridor has the second-longest morning/evening peak pedestrian walking time PWT at 680.5 seconds (11.4 minutes), while the Mamo Mazamir corridor has the shortest midday peak pedestrian walking time PWT at 150 seconds (2.5 minutes).

The significant variations in pedestrian walking time PWT between peak and off-peak hours also suggest the need for a more balanced approach to ensure pedestrians can move efficiently and securely at all times of the day.

Table 4.12: Median peak hour pedestrian walking time

Name of Major Corridor	From street	To street	Length in (m)	Average			
				Peak hour PWT in morning and evening in (sec)	peak hour PWT in Midday (sec)	Peak hour PWT in M&E (min)	Peak hour PWT in M (min)
Nuho Gobena	Franco	Posta bet	600	680.5	320	11.4	5.4
Abebe Bikila	Peacock	Posta bet	600	529	200	8.8	3.4
Mamo mazamir	Tikur abay	Posta bet	600	429.2	150	7.15	2.5
Jara Aba Gada	Posta bet	Amede gebeya	600	375.5	120	6.26	2
Derartu Tulu	Posta bet	Mebirat haile	600	500	210	8.4	3.5
Aba Jifar	National street	Posta bet	600	750	420	12.5	7

Source: field survey

The Pedestrian walking time is analyzed by time of day and with the support of pedestrian volume data for each route and its PLOS. The selected route which has measured pedestrian walking has taken an equal length of 600m. Figure 4-13. Illustrate, the route from National to Posta bet has high Pedestrian walking time in morning and evening peak hours as it has high Pedestrian volume. The Pedestrian time from Posta Bet to Amede Gebeya Street has lower Pedestrian walking times which indicates the free flow of movement on this route.

On a poor pedestrian street with suboptimal conditions, such as broken pavement, potholes, obstructions, or uneven surfaces, the walking speed of a normal person may be slower than usual. Typically, individuals tend to walk more cautiously and at a reduced pace to navigate these obstacles safely.

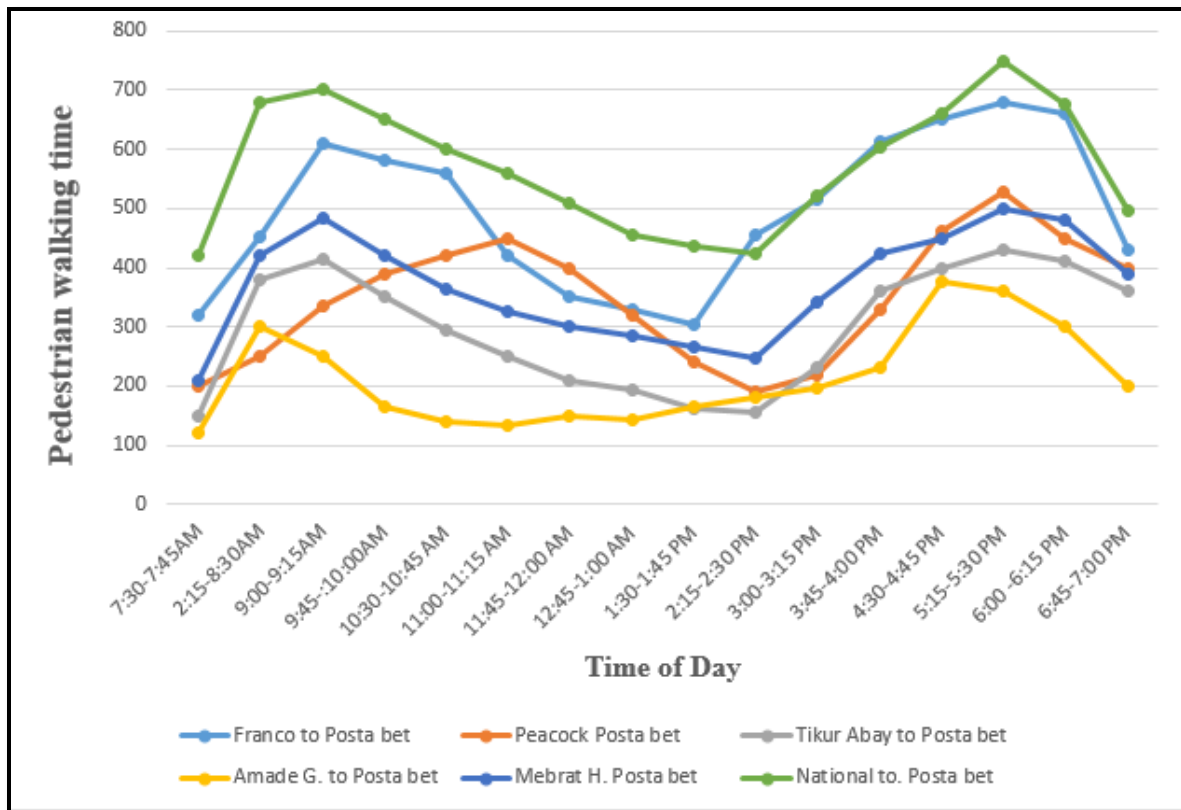


Figure 4.13: pedestrian walking time for the selected routes

The observations regarding the pedestrian walking times on the different street segments in Adama Town imply several key insights about the walkability of the downtown area. The street segment from National to Posta Bet experiences significantly higher pedestrian walking times during both the morning and evening peak hours. This is particularly evident in the evening peak, where it takes pedestrians an average of 750 seconds (12.5 minutes) to cover the distance, suggesting substantial congestion and crowding along this stretch. The elevated walking times during peak periods indicate that this street segment is a key bottleneck for pedestrian movements, negatively impacting the overall flow and walkability of the downtown area.

In contrast, the street segment from Posta Bet to Amede Street had the lowest pedestrian walking times during both the morning and evening peak periods. The relatively shorter walking times on

this segment suggest that it is better able to accommodate pedestrian movements efficiently, with less congestion and more balanced traffic flows. This points to the presence of more pedestrian-friendly infrastructure, wider sidewalks, and a more equitable distribution of space between pedestrians and vehicles along this stretch.

4.5.3 Pedestrian Density Hot Spots area in the study area

Areas of pedestrian density hot spots were identified by pedestrian volume results through filed counts and utilizing time-lapsed photography from the tallest buildings along the selected routes during peak pedestrian walking times as depicted in the above section. Figure 4-14 below Illustrates the density of hot spot areas within the pedestrian analysis zone of downtown Adama.

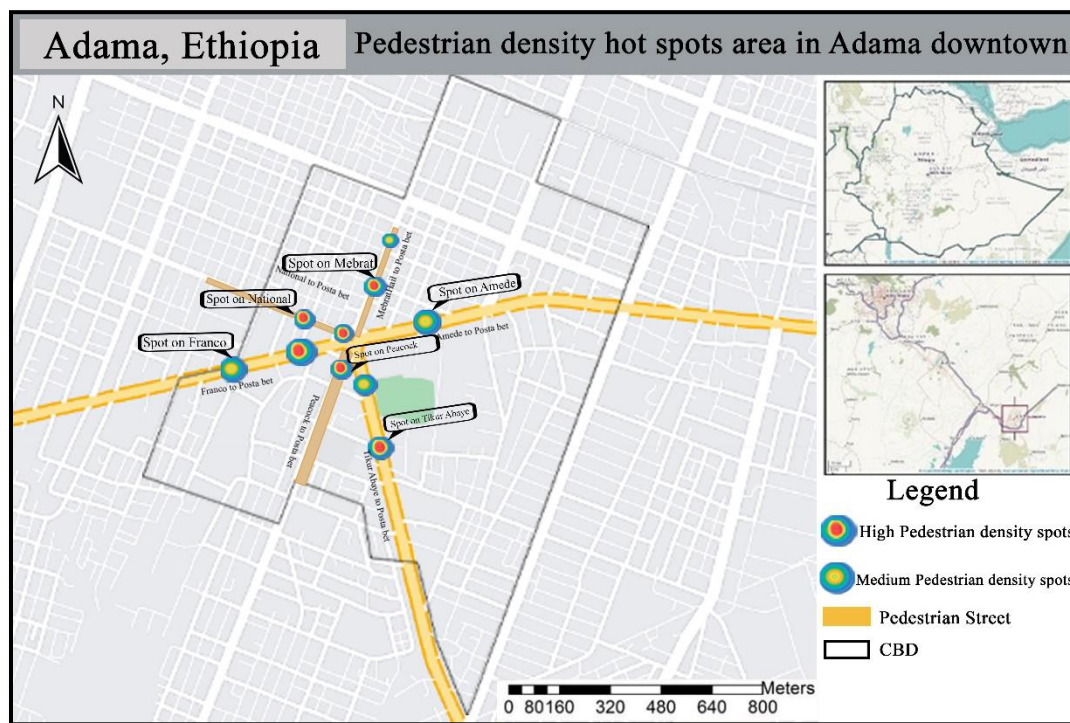


Figure 4.14: Pedestrian density hot spots area in Adama Downtown

4.5.4 Pedestrian Flow Count in Selected Area

Conducting a thorough pedestrian flow count in Adama town provides crucial insights into urban mobility and safety. This study encompasses various urban settings, including commercial districts, residential areas, educational institutions, and transportation hubs, to capture the diverse pedestrian activity within the city. Focus is particularly directed towards key thoroughfares such as the sidewalk street from National to Posta Bet and National Street, where daily pedestrian counts reveal significant foot traffic.

The data from field surveys reveals significant challenges in pedestrian walkability and mobility throughout Adama City. The analysis goes beyond merely identifying uneven pedestrian traffic distribution, and instead emphasizes the fundamental inadequacies of the sidewalk design and infrastructure across the city. Despite the high pedestrian volumes observed in the downtown area, the sidewalk design in these heavily trafficked zones is not optimal. Obstacles such as open manholes and narrow pathways pose serious safety risks and contribute to a high incidence of pedestrian accidents. These infrastructural deficiencies severely compromise the overall comfort, safety, and convenience of the walking experience for residents and visitors alike.

The prevalence of such hazards and hindrances along the city's sidewalks deter people from choosing to walk, as they feel unsafe and inconvenienced.



Figure 4.15 presents data from field surveys that highlight significant challenges in pedestrian walkability.

The map shows that 9,900 pedestrians traverse the National to Posta Bet route per day, while around 8,460 pedestrians use the Peacock to Posta Bet sidewalks daily. This underscores the urgent need for infrastructure improvements and urban planning interventions to enhance pedestrian safety and mobility in Adama. By addressing these challenges, the city can create safer and more accessible pedestrian environments, ultimately improving the overall quality of life for its residents. Pedestrian flow counts are shown in Figure 4.16 below.

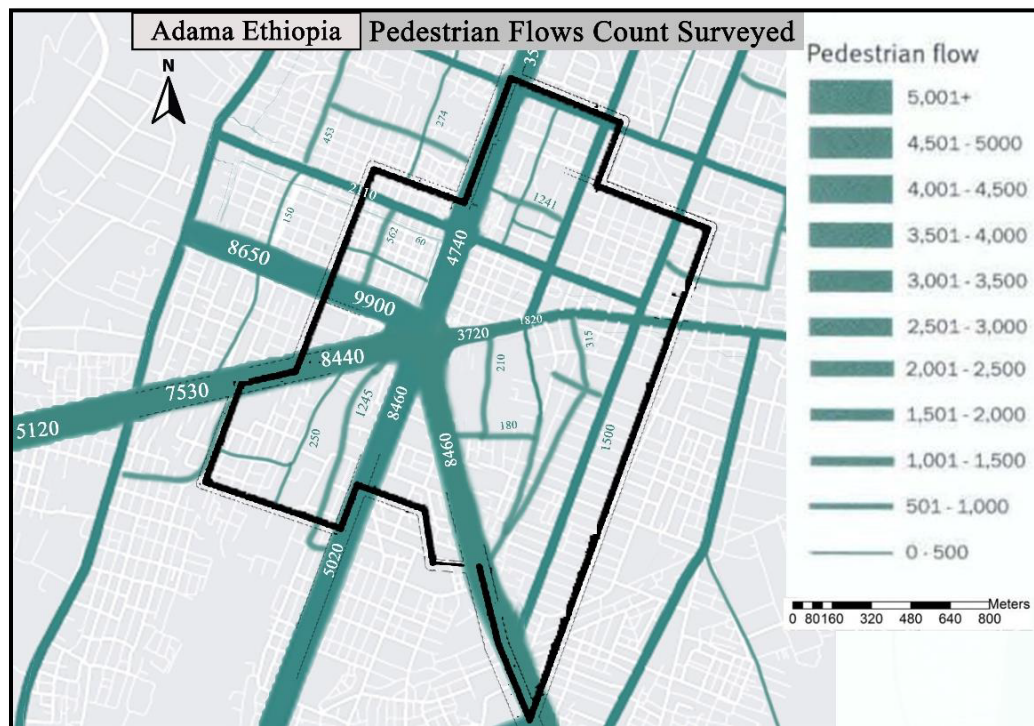


Figure 4.16: Average Daily (24hr) weekday Pedestrian flow map.

4.5.5 Pedestrian Density Map

According to the pedestrian flow count survey conducted in the study, the researcher focused their analysis on the Posta to National Street corridor and the Posta to Franco Street corridor. These corridors were chosen because they exhibited high levels of pedestrian activity compared to from this six pedestrian streets that were surveyed. These maps use color-coded heat maps to show pedestrian traffic intensity, with warmer colors indicating high-density areas. Data for the maps was gathered through field observations, video recordings, and automated sensors. Analysis of the data revealed that these corridors have significantly higher pedestrian activity and better walkability. This suggests they are important public spaces within the community. Further investigation into factors like land use and amenities could help improve walkability citywide.

Pedestrian Density Map of Posta to National Street

Figure 4-17 below the pedestrian density map in AnyLogic indicates the distribution and intensity of pedestrian activity in the Posta to National Pedestrians Street area. The map uses color coding to represent different levels of pedestrian density, with red indicating high density, yellow indicating medium density, and green indicating low density. During the morning peak hour, the map shows a high concentration of pedestrians in certain areas, represented by the color red. According to the Manual field count and HCM's methods for analyzing pedestrian LOS 825 pedestrians are walking in the area within a 15-minute timeframe. This suggests that there is significant pedestrian activity during this period, potentially indicating areas of high foot traffic or popular destinations. In contrast, during the midday peak hour, the map shows a lower concentration of pedestrians compared to the morning peak hour. The color coding may vary, indicating medium or low pedestrian density. The number of pedestrians walking in the area during this 15-minute interval is 456. This suggests a decrease in pedestrian activity compared to the morning peak hour, potentially reflecting changes in movement patterns or a decrease in foot traffic due to factors such as lunch breaks or a shift in commercial activity. By comparing the density values between the morning and midday peak hours, we can observe how pedestrian activity varies throughout the day in the Posta to National Pedestrians Street area. This information can be useful for understanding pedestrian behavior, identifying high-traffic areas, and informing decisions related to walkway design and crowd control strategies. However, it is important to note that the specific values and interpretations may vary depending on the context and parameters of the AnyLogic simulation model used.

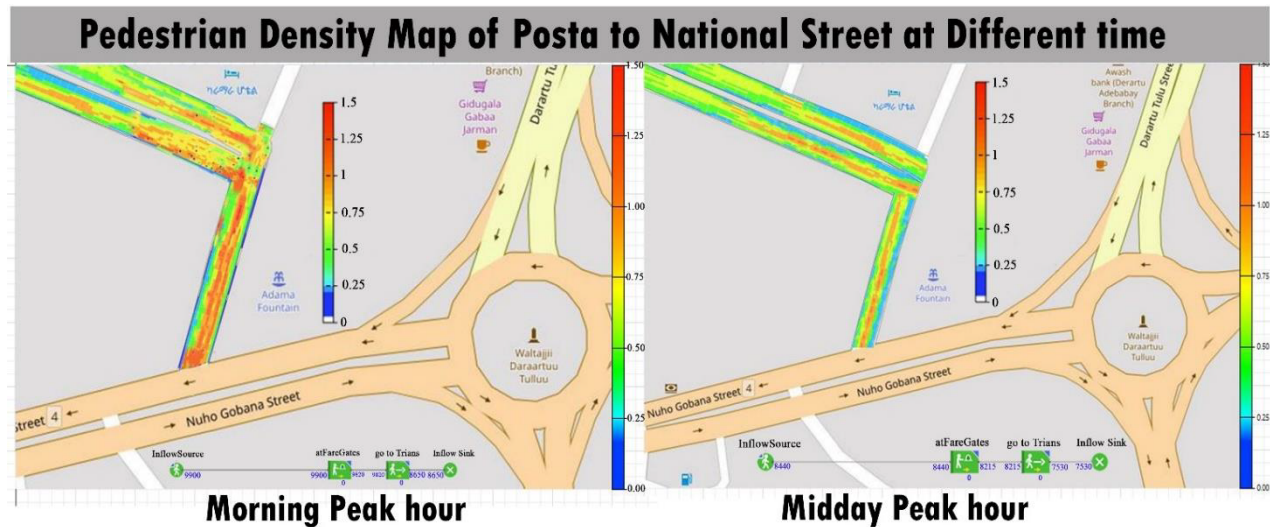


Figure 4-17 Pedestrian Density Map of Posta to National Street at different time

4.5.6 Pedestrian Density Map of Posta to Franco Street

The distribution and volume of pedestrian activity from Posta to Franco Street during the day are depicted in the pedestrian density map. Pedestrians are concentrated during morning peak hours, with 786 pedestrians recorded in just 15 minutes. Areas with high density are shown by the red highlights in this figure. On the other hand, 392 people walked in the same region at the midday peak hour, which is shown by fewer red zones and more yellow or green areas on the map. Urban planners, transportation authorities, and companies can benefit from insights into daily foot traffic patterns by comparing morning and midday peak hours. This helps with infrastructure development and crowd control.

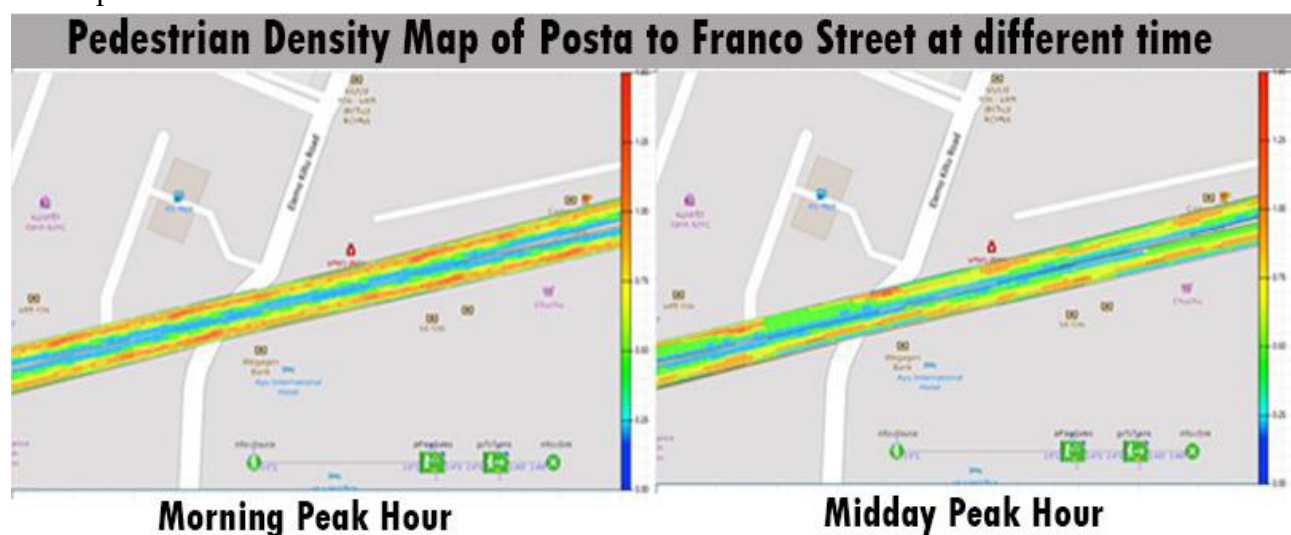


Figure 4-18 Pedestrian Density Map of Posta to Franco Street at different time

4.5.7 Effect of pedestrian density on walkability

The relationship between pedestrian density and walkability.

The relationship between pedestrian density and walkability is intricate and multifaceted, with various factors influencing each other in urban environments. Walkability refers to the ease and comfort with which pedestrians can navigate and access different amenities, services, and destinations within a given area. Pedestrian density, on the other hand, refers to the concentration of pedestrians within a specific space or corridor, typically measured in terms of pedestrian counts per unit area or length (Ewing & Cervero, 2010).

Effect of Pedestrian Density on Walkability Measures:

Efficiency of Movement: Higher pedestrian density often corresponds to more efficient pedestrian movement, particularly in urban centers and commercial districts. A greater number of pedestrians can lead to increased activity, vitality, and economic opportunities, fostering a vibrant pedestrian environment (Gehl, 2010).

Safety and Security: While moderate pedestrian density can enhance safety by increasing natural surveillance and encouraging social interaction, excessively high pedestrian density may lead to overcrowding and discomfort, potentially compromising safety and security.

Comfort and Amenity Access: Pedestrian density influences the availability and accessibility of amenities and services. Higher pedestrian density areas tend to have better access to shops, restaurants, public transit, and other amenities, enhancing the overall walkability experience.

Congestion and Flow: Pedestrian congestion can occur in areas with high pedestrian density, leading to slower movement, bottlenecks, and conflicts. Proper pedestrian infrastructure design and management strategies are essential to mitigate congestion and maintain smooth pedestrian flow.

Perceived Walkability: Pedestrian density contributes to the perceived walkability of an area. Moderate pedestrian density can create a lively and engaging pedestrian environment, while excessively low or high densities may lead to perceptions of desolation or overcrowding, respectively.

Correlations and Interactions: Pedestrian Infrastructure: The design and quality of pedestrian infrastructure, such as sidewalks, crosswalks, lighting, and seating, interact with pedestrian density to influence walkability. Well-designed and well-maintained infrastructure can enhance the pedestrian experience and accommodate varying levels of density.

Land Use and Urban Form: The mix of land uses, urban form, and density patterns also affect pedestrian density and walkability. Compact, mixed-use developments with higher densities tend to support higher pedestrian activity and better walkability compared to sprawling, single-use developments.

Implications for Planning and Design: Understanding the relationship between pedestrian density and walkability is crucial for urban planning and design. Planners and designers should consider the following implications: Designing pedestrian-friendly environments that balance density, comfort, and safety. Implementing appropriate pedestrian infrastructure and management strategies to accommodate varying levels of pedestrian density. Promoting mixed-use, compact development patterns to support walkability and pedestrian activity. Prioritizing pedestrian needs in transportation and land use planning decisions to create inclusive and accessible urban spaces.

Pedestrian density has a significant impact on walkability. Higher pedestrian density tends to enhance walkability in several ways. Firstly, it promotes a sense of community and liveliness, creating a vibrant atmosphere that encourages social interactions and street life. This sense of community can make walking a more enjoyable and engaging experience, contributing to overall walkability. Secondly, areas with higher pedestrian density often offer better accessibility and convenience. With more pedestrians, there is a greater demand for amenities and services, leading to a higher concentration of shops, restaurants, and public facilities within walking distance. This accessibility makes it easier for pedestrians to meet their daily needs without relying heavily on motorized transportation, thereby increasing walkability. Moreover, pedestrian density can positively impact safety. In areas with higher pedestrian density, drivers tend to be more aware of their surroundings, resulting in reduced vehicle speeds and improved pedestrian safety. Additionally, the presence of more pedestrians can create a collective sense of security, making individuals feel safer while walking. However, it is important to note that there can be challenges associated with high pedestrian density that may affect walkability negatively. Congestion and overcrowding can lead to reduced mobility and discomfort for pedestrians. Proper urban planning

and infrastructure design are essential to mitigate these challenges and ensure that pedestrian density does not hinder walkability.

In conclusion, pedestrian density plays a crucial role in determining the walkability of an area. It fosters a sense of community, enhances accessibility, improves safety, and contributes to the overall vibrancy of the walking environment. By managing the challenges associated with high pedestrian density, urban planners can create pedestrian-friendly spaces that prioritize walkability and promote active transportation.

4.7 Discussions

The study conducted an extensive analysis to assess the current pedestrian walkability in Adama City. The evaluation focused on various aspects of the pedestrian network, including crosswalks, sidewalks, and pedestrian movements. The assessment employed a combination of quantitative measures, qualitative observations, and community input to evaluate the state, usability, connection, and functioning of these important components. (Source: Cervero and Kockelman, 2010).

The study discusses the field count pedestrian volume survey conducted on six major selected routes in the study area. The data collected during the survey provides the percentage of pedestrian travel movements across the selected routes during different peak hours.

From the above result, it can be observed that the route from Posta to National accounts for the highest percentage of pedestrian travel movements, accounting for approximately 68% during the morning peak hours. This suggests that a significant number of pedestrians choose to walk through the central business district (CBD) using this particular route. The study also reveals that the morning peak hour experiences the highest pedestrian traffic volume within a 15-minute interval, with around 825 inbound pedestrians.

The percentages of pedestrian movements across the selected routes vary during different peak hours. Factors such as sidewalk width and condition, the presence of amenities and destinations, and the design and layout of the routes play a role in influencing pedestrian percentages. Wider and well-maintained sidewalks tend to attract more pedestrians, while routes passing through commercial centers, educational institutions, or recreational areas tend to experience higher pedestrian volumes. Additionally, routes with pedestrian-friendly features and clear signage encourage higher pedestrian percentages.

The study acknowledges that the midday peak hours see relatively lower pedestrian activity compared to the morning and evening peaks. This is attributed to factors such as working hours, weather conditions, or the availability of transportation alternatives during midday. In this case, it enhances pedestrian density or cognition.

Overall, the findings suggest that pedestrian travel patterns in Adama City are influenced by various factors, including route design, sidewalk conditions, presence of amenities, and time of

day. The study provides valuable insights into the current pedestrian walkability in the city, which can be utilized to inform urban planning and design decisions aimed at improving pedestrian infrastructure and enhancing walkability.

From the above result, it can be discussed that the majority of the sidewalks along the whole path from Posta Bet to National and Posta Bet to Peacock are not accessible. Most of them are dominated by both physical and activity obstructions. Thus using them is not interesting. As it has been checked using the HCM pedestrian level of service, more than half of the sidewalks in this particular section fall under the F and E grades. Shows that they are of poor standard in that they are not equipped with adequate amenities and proper orientation (HCM method estimation 2019).

Most of the respondents of the questionnaire survey were pedestrians, who they were frequently using sidewalks. However, they were facing obstructions more frequently daily. These obstructions include street vendors, shoeshine boys, taxi and bus waiting queues, construction leftovers, and on-street vehicular parking. In addition to these factors, other design factors like lack of curb ramps, misplaced pedestrian crosswalks, open manholes and ditches, and misplaced sidewalk amenities are also factors affecting accessibility.

Moreover, the dominant land use type of the sidewalk is commercial. This creates a very active street interactive environment. However such activities are not placed on their distinct sidewalk corridor zones, distracting other zones and narrowing the standard width. This will lead to the creation of a crowded environment when pedestrians try to use them. This crowd is characterized by difficulty passing one another, turning around and changing direction, and limiting one's walking speed. The other major factor affecting accessibility is below standard design of sidewalks. This can be below standard width, surface material, and width of zones. The biggest problem that sidewalks create is, that it was not used for their intended purpose and also pose safety-related problems like sexual harassment, theft, and physical conflict with others.

Pedestrian spaces should be designed in consideration of human convenience and have to be qualitatively suitable to the needs of human beings.

The research conducted a thorough pedestrian density analysis within a specific area, focusing on selected routes within the Pedestrian Analysis Zone (PAZ). Various metrics, including pedestrian walking time, density hot spot areas, and density maps, were utilized to understand pedestrian

behavior and movement patterns. Pedestrian walking time was measured at different times to reveal higher volumes and longer walking times during morning and evening weekday peak hours. Manual data collection allowed for detailed assessments, recording average pedestrian walking times for each route during peak hours on typical weekdays. Route overview tables provided essential information on selected pedestrian routes, while median peak hour pedestrian walking times were presented, showing the influence of street conditions on walking speeds.

Hot spot areas were identified through field counts and time-lapsed photography, with visual representations provided to highlight areas of high pedestrian activity. Pedestrian flow counts in various urban settings emphasized key thoroughfares with significant foot traffic, underscoring the need for infrastructure improvements to enhance pedestrian safety and mobility. A pedestrian density map visually depicted pedestrian distribution, aiding urban planners and officials in managing pedestrian activity effectively. Overall, the research provides valuable insights for informed decision-making in urban planning and design, emphasizing the importance of infrastructure improvements to create safer and more accessible pedestrian environments.

Pedestrian density significantly impacts walkability. Higher pedestrian density enhances walkability by fostering a sense of community, improving accessibility, and promoting safety. However, challenges such as congestion and overcrowding need to be addressed through effective urban planning and infrastructure design to ensure that pedestrian density does not hinder walkability.

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The pedestrian volume survey conducted field counts and examined the pedestrian patterns and densities (PLOS) along certain routes. Pedestrian volume counts were done by hand to determine the density of hot areas. Peak pedestrian hours were in the morning and evening, when traffic was dense, while midday pedestrian traffic was light.

The research assessed the PLOS of all the chosen routes in PAZ and gathered data on pedestrian density and flow. With 825 pedestrians per 15 minutes and a PLOS grade of F, the route from Posta Bet to National Street was deemed to have a high density. On the other hand, with just 310 pedestrians and a PLOS grade of B, the route from Posta to Amede Gebeya had a lower density. The overall level of service on the chosen network is higher than its capacity.

To assess density and transportation demand in pedestrian study zones, a walking time analysis has been carried out. This research helped identify hotspots, routes with the greatest walking times, and the efficiency of the pedestrian street network. Walking times on the Posta Bet to National Street route are longer in the morning and evening during peak hours, with the evening trek taking longer than the morning. It takes an average of 750 seconds to reach the distance during the evening peak hours.

Based on the HCM and PLOS method conducted above, as well as the findings of the pedestrian questionnaire survey, the primary challenges that pedestrians come across are the inability to choose their walking speed, the difficulty of changing directions, the congestion on the streets, and the limited availability of crossing places. Furthermore, based on the majority of those who responded, it can be assumed that pedestrian safety has been significantly damaged, resulting in theft, sexual assault, and other kinds of physical harassment.

Walking in Adama, is generally not a safe experience, particularly for individuals with disabilities and those using mobility aids. The existing sidewalks in the city are not designed with the specific needs of pedestrians in mind, leading to numerous challenges and hazards.

One of the primary concerns is the lack of consideration for pedestrian safety. Uncovered manholes and ditches are prevalent throughout the sidewalks, posing significant risks and causing accidents.

These accidents are even more detrimental for individuals with disabilities, exacerbating the problem and hindering their mobility.

Although a few tactile pavements are provided along certain pedestrian pathways, their effectiveness is compromised by the presence of misallocated amenities and utilities in the middle of the walkway.

Another significant finding from the examination of the questionnaire survey is that people who walk do not feel safe in less-active regions. The absence of natural monitoring from the surrounding quiet environment is the cause of this. Because of this, pedestrians are more at risk of abuse, especially at night.

5.1 Recommendation

Recommendation to standards

Ensure all pedestrian facilities, including sidewalks, crossings, and pathways, meet ADA accessibility guidelines. This includes providing ramps, curb cuts, and tactile paving for individuals with disabilities.

Design sidewalks to be sufficiently wide to accommodate diverse pedestrian flows, with clear markings for separate lanes where necessary to manage different walking speeds and directions.

Lighting and Visibility: Install adequate lighting along pedestrian routes to ensure visibility during day and night, particularly in areas with high pedestrian density and near crossing points.

Recommendations for planning and construction

Integrated Planning:

Pedestrian Network Planning: Develop a comprehensive pedestrian network plan that identifies priority routes based on pedestrian volume and density. Ensure connectivity between key destinations such as residential areas, schools, markets, and public transport hubs.

Mixed-Use Development: Encourage mixed-use zoning to create vibrant pedestrian environments with easy access to amenities, reducing the need for long-distance travel and promoting walking as a mode of transportation.

Design and Construction Guidelines:

Amenities and Comfort: Integrate seating areas, rest spots, and shade structures along pedestrian routes to enhance comfort and encourage social interaction.

Maintenance Protocols: Establish clear maintenance protocols to regularly inspect and repair pedestrian infrastructure, addressing issues such as uneven surfaces, debris, and signage clarity.

Community Engagement and Education:

Public Awareness: Conduct educational campaigns to raise awareness among pedestrians and drivers about pedestrian rights and responsibilities. Promote mutual respect and adherence to traffic laws to improve safety for all road users.

Feedback Mechanisms: Implement mechanisms for gathering feedback from pedestrians to continuously improve and adapt pedestrian infrastructure based on user experiences and evolving needs.

Plan for the major selected density pedestrian route

The following is the recommended layout for the main congested routes, such as the ones from Posta to National, Posta to Peacock, and Posta to Franco, to increase pedestrian density and reduce demand for pedestrians during peak hours in the CBD area:

Widening sidewalks in areas identified as hotspots for pedestrian density, such as Franco to Posta Bet, Posta Bet to National, and Peacock to Posta Bet. For example, to alleviate congestion on the most pedestrian-congested route from Posta to National, better propose removing the current median of the road and widening the sidewalk.

Master plan design revision by incorporating basic solutions such as street width, and additional lanes.

Create Pedestrian Plazas Designate: When the researcher interviewed some of the respondents, there were some areas where design changes were needed. If the designs of pedestrian plazas are done in the new place. Certain areas as pedestrian plazas, allowing pedestrians to safely enjoy public spaces. These plazas should be car-free zones, providing ample space for pedestrians to gather, rest, and interact. Furnish the plazas with seating, greenery, and amenities to enhance their

attractiveness and functionality. Also, there is a possibility that some of the buildings are obstructing the way of pedestrians because they were not built with setbacks in mind.

Design recommendation

The design proposal for the improvement of design capacity encourages Pedestrian movement and reduces pedestrian density in the CBD area along with the main Pedestrian route from National to Posta and Franco to Posta. The plain view of the proposed pedestrian street design of the congested Pedestrians route is presented in Figure 5.1 below.



Figure 5.1: Proposed Pedestrian route design of the six selected routes in the CBD

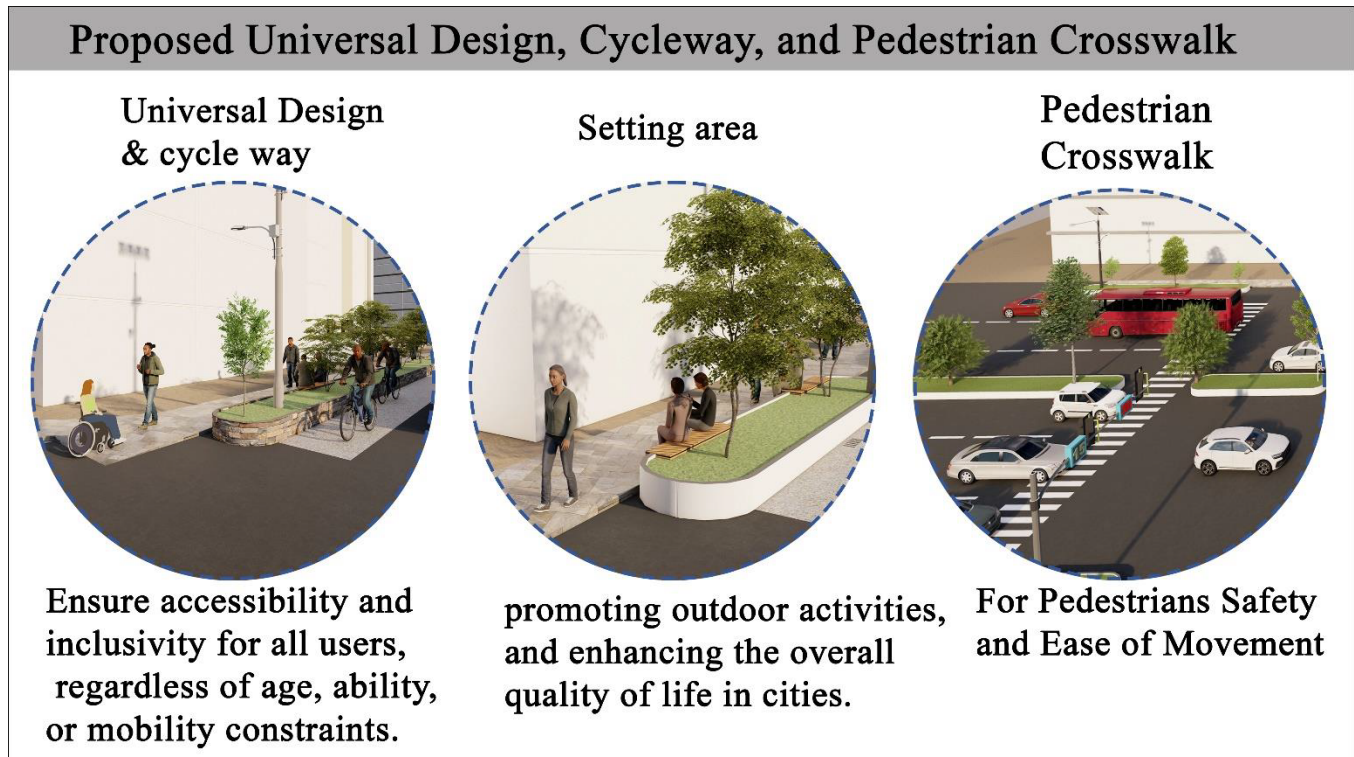


Figure 5.2: Proposed Universal Design, Cycling, Setting area and Pedestrian crosswalk

This proposal design of the congested Pedestrian route reduces the observed Pedestrian density in the CBD area, especially on the pedestrian route from Posta to National and Posta to Franco. To accommodate congestion during rush hour, the design widens the carriage and suggests a comfortable and safe walkway. When there is a safe walking area at the workplace, individuals prefer to take walks, especially during the evening peak hours when most workers are returning home.

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APPENDICES

Appendix-A: pedestrian Flow by Field Count at the Major Selected pedestrian Route in PAZ

Table 1: Average 15 min interval Field count result on selected pedestrian routes collection point

Pedestrians Routs	Data collection day at Peak hours	Time Slot	Average Walking time (Second)
From Franco to Posta Bet	Date 30/07/2016 E.C		
	Morning peak 1:30 AM	1:30 AM-1:45 AM	780
		1:45 AM-2:00 AM	
		2:00 AM-2:15 AM	784
		2:15 AM-2:30 AM	786
		2:30 AM-2:45 AM	788
		2:45 AM-3:00 AM	782
		Morning average	786
	Midday peak 8:00 PM	6:00 PM-6:15:PM	382
		6:15 PM-6:30 PM	789
		6:30 PM-6:45 PM	392
		6:45 PM-7:00 PM	393
		7:00 PM-7:15 PM	790
		7:15 PM-7:30 PM	392
		7:30 PM-7:45 PM	394
		7:45 PM-8:00 PM	396
		Midday average	392
	Evening peak 12:30 PM	10:30 PM-10:45 PM	765
		10:45 PM-11:00 PM	782
		11:00 PM-11:15 PM	765
		11:15 PM-11:30 PM	784
		11:30 PM-11:45 PM	785
		11:45 PM-12:00 PM	786
		12:00 PM:12:15 PM	785
		12:15 PM-12:30 PM	787
		Evening average	785
Pedestrians Routs	Data collection day at Peak hours	Time Slot	Average Walking time (Second)

From National to Posta Bet	Date 05/08/2016 E.C		
	Morning peak 1:30 AM	1:30 AM-1:45 AM	790
		1:45 AM-2:00 AM	
		2:00 AM-2:15 AM	820
		2:15 AM-2:30 AM	824
		2:30 AM-2:45 AM	825
		2:45 AM-3:00 AM	827
		Morning average	825
	Midday peak 8:00 PM	6:00 PM-6:15:PM	440
		6:15 PM-6:30 PM	446
		6:30 PM-6:45 PM	445
		6:45 PM-7:00 PM	453
		7:00 PM-7:15 PM	456
		7:15 PM-7:30 PM	455
		7:30 PM-7:45 PM	456
		7:45 PM-8:00 PM	458
		Midday average	456
	Evening peak 12:30 PM	10:30 PM-10:45 PM	789
		10:45 PM-11:00 PM	811
		11:00 PM-11:15 PM	822
		11:15 PM-11:30 PM	820
		11:30 PM-11:45 PM	824
		11:45 PM-12:00 PM	825
		12:00 PM-12:15 PM	823
		12:15 PM-12:30 PM	821
		Evening average	823

Pedestrians Routes	Data collection day at Peak hours	Time Slot	Average Walking time (Second)
From Peacock to Posta Bet	Date 08/08/2016 E.C		
	Morning peak 1:30 AM	1:30 AM-1:45 AM	698
		1:45 AM-2:00 AM	
		2:00 AM-2:15 AM	701
		2:15 AM-2:30 AM	704
		2:30 AM-2:45 AM	705
		2:45 AM-3:00 AM	707
		Morning average	705
	Midday peak 8:00 PM	6:00 PM-6:15:PM	299
		6:15 PM-6:30 PM	300
		6:30 PM-6:45 PM	302
		6:45 PM-7:00 PM	305
		7:00 PM-7:15 PM	307
		7:15 PM-7:30 PM	309
		7:30 PM-7:45 PM	307
		7:45 PM-8:00 PM	310
		Midday average	307
	Evening peak 12:30 PM	10:30 PM-10:45 PM	697
		10:45 PM-11:00 PM	699
		11:00 PM-11:15 PM	700
		11:15 PM-11:30 PM	698
		11:30 PM-11:45 PM	701
		11:45 PM-12:00 PM	702
		12:00 PM:12:15 PM	701
		12:15 PM-12:30 PM	705
		Evening average	701

Adama Science and Technology University

School of Civil Engineering and Architecture

Post-graduate program in urban planning and design

Postgraduate questionnaire

Questionnaire for households (particularly for workers, who regularly commute to commercial business districts)

Dear Sir/Madam

I am currently pursuing my Master of Science degree in Urban Planning and Design at the School of Civil Engineering and Architecture at Adama Science and Technology University. As a researcher and student, I am actively engaged in my studies within this esteemed academic institution. I am doing my M.Sc. research/thesis entitled “ Assessing the Influence of Street Design on Pedestrian Walkability by using Pedestrian Movement Modeling in Downtown Adama City.” to identify Pedestrian density hot spots by measuring the level of density in selected routes of pedestrians analysis zone in downtown of Adama city.

Your authentic, truthful, and immediate participation in the survey will significantly contribute to the success of the research. Rest assured, your responses will remain confidential and your anonymity will be preserved. Additionally, the information you provide will be used solely for scholarly purposes. Completing the questionnaire should not require more than 10 minutes of your time. I deeply appreciate your time, effort, and thoughtfulness in completing this survey.

If you have any questions concerning the items of the questionnaire, please call on mobile:

09 22 32 25 05, or e-mail behailulalu2505@gmail.com

With Great Respect

Behailu Abebe

Thank you in advance for sacrificing the time to respond to this Questionnaire!!!

Appendix B - SURVEY QUESTIONNAIRES

Pedestrian Walkability accessibility questionnaire

You are kindly invited to participate in a research held to solve the problems related to the accessibility of pedestrian walkways by filling out the following questionnaire.

From Franco to Posta bet, from Peacock Street to Posta bet, From Posta bet to Mebrat hail, from Tikur Abayi to Posta bet, from Posta bet to Amede Gebeya, From National Street to Posta bet

Subjective section Name

1. Gender?

Male ☐

Female ☐

2. Age?

A. 15-20 B. 20-30 C. 30-40 D. 40-50 E. 50-60

3. What type of disability do you have?

A. Walking D. Visual C. Hearing D. Other E. I don't have any

4. What is your frequent transportation choice?

A. Taxi B. walking C. biking D. Bajaj E. Private automobile

5 Why do you use this pedestrian sidewalk?

- A. To go to work
- B. To go to market place
- C. To go to school
- D. Visiting relatives
- E. To go to sports exercise
- F. To relax

Mention if there is another

7. When is a good time for you to walk through this street?

A. Morning (b) Evening (c) Nighttime (d) late in the afternoon

8. How often do you use the sidewalk?

A. daily/frequently B. sometimes/ occasionally

9. Which activities are destructive on pedestrian sidewalks?

A. Taxi and bus waiting area

B. Street vending

C. Street shoeshine

D. Construction work and material leftover

E. On pedestrian street parking

Mention if there is any other

10. What obstructions do find on pedestrian sidewalks that make them difficult to access?

A. Open manholes and ditches

B. Slippery and cracked surface materials

C. Misplaced street amenities

D. Missed (discontinuous) sidewalks

E. Lack of cur ramps

F. Missed and misplaced crosswalks

11. How often do you find obstacles on sidewalks?

A. Always

B. Sometimes

12. Do you think the width of pedestrian sidewalks is sufficient?

A. Yes

B. No

13. Do you believe that marketplaces must exist on this sidewalk?

A. Necessary B. not necessary C. I don't mind

14. About the present status of pedestrian walking facilities how it is user-friendly?

A. Yes B. No

15. Do you think that sidewalk facilities and infrastructure allocation (light and telephone lines, traffic signs, and trash can) on sidewalks lead to insufficient width?

A. Yes B. No

If yes why?

16. Do you feel safe walking on pedestrian sidewalks in the daytime?

A. Safe b. unsafe

Unsafe, why?

17. Do you feel safe to walk on pedestrian sidewalks at the night time?

A. Safe B. unsafe

Unsafe, why?

18 Which part of the street do you mostly feel unsafe?

19 Do you feel safe on pedestrian sidewalks that are adjacent to less active areas?

A. yes B. No

Mention if there is any other

20. What type of abuse do you face while using pedestrian sidewalks?

A. Sexual abuse B. theft C. physical abuse D. falling down

21. Do you think the sidewalks are free from slippery and cracked surfaces?

A. Yes B. No

22 Do you usually face uncovered ditches and manholes on pedestrian sidewalks? If yes, where?

23 While using pedestrian sidewalks at night time, do you find places with no lighting?

If yes, where?

24 What are the most common problems that you face while using sidewalks?

25 What are your suggestions that make pedestrian sidewalks improve?

26 Which Pedestrian route is more congested in the central business district using posta-bet as a reference?

- A. From Franco to Posta Bet C. From Peacock street to Posta bet
B. From Posta bet to me brat hail D. from Tikur Abayi to Posta bet
E. from Posta bet to Amede Gebeya F. From National Street to Posta bet

27. Street amenities

	Rate the distribution and functionality			
	Very good	Good	Fair	Bad
Sitting bench				
Signage				
Trash can				
Vegetation				

For Disabled Users

28 Are there designated lanes and parking lots for wheelchairs?

- a. Yes (b) No

29 Are there adequate curb cuts and ramps?

- a. Yes (b) No

30 Are there adequate, accessible pedestrian signals at intersections?

- a. Yes (b) No

31 Is there a presence of inappropriate sidewalk obstacles?

- a. Yes (b) No

32 Are there tactile walking indicators?

- a. Yes (b) No

33 Are there push buttons accessible to wheelchair users?

- a. Yes (b) No

አባሪ ሀ - የዳሰሳ ጥናት ጥያቄዎች

የአግረኛ መራመድ ተደራሽነት መጠይቅ

ከአግረኛ መንገድ ተደራሽነት ጋር የተያያዙ ችግሮችን ለመፍታት በሚደረገው ጥናት ላይ እንዲሳተፉ በአክብሮት ተጋብዘዋል።

ከፍራንኮ እስከ ፖስታ ውጭ፤ ከፒኮክ ጎዳና እስከ ፖስታ ውጭ፤ ከፖስታ ቤት እስከ መብራት ኃይል፤ ከጥቁር ዓባይ እስከ ፖስታ ቤት፤ ከፖስታ ቤት እስከ ዓመደ ገበያ፤ ከብሔራዊ ጎዳና እስከ ፖስታ ውጭ፤ የኃገሪ መንገድ

የርዕሰ ጉዳይ ክፍል ስም የጋራ

1. ጾታ?

☒ ሀ) ወንድ ለ) ሴት

2. ዕድሜ?

☒ ሀ) 15-20 ለ) 20-30 ሐ) 30-40 ☒ ሐ) 40-50 ☐ ሀ) 50-60

3. አሁን ያለህበት የሥራ ሁኔታ ምን ያህል ነው?

የጋራ

4. ተደጋጋሚ የመጓጓዣ ምርጫዎ ምንድነው?

ሀ. ታክሲ ☒ ለ) መራመድ ሐ. ቢስክሌት መ. ባጃጅ ለ. የግል መኪና

5. ምን ዓይነት የአካል ጉዳት አለብህ?

ሀ. መራመድ ለ. ቪዥዋል ሐ. መስማት መ. ሌላ ☒ ለ. የለኝም

6. ይህንን የአግረኛ መንገድ ለምን ይጠቀማሉ?

☒ ሀ) ወደ ሥራ ለመሄድ

ለ. ወደ ገበያ ቦታ ለመሄድ

ሐ. ወደ ትምህርት ቤት መሄድ

መ. የመጎብኘት ዘመዶች

☒ ለ. ወደ ስፖርት እንቅስቃሴ ለመሄድ

ረ ዘና ለማለት

ሌላ ካለ ጥቀስ

7. በዚህ ጎዳና ለመራመድ ጥሩው ጊዜ መቼ ነው?

☒ ሀ. ጥዋት (ለ) ምሽት (ሐ) ~~ደብዳቤ~~ (መ) ከሰዓት በኋላ

8. የእግረኛ መንገድን ምን ያህል ጊዜ ይጠቀማሉ?

☒ ሀ. በየቀኑ/በተደጋጋሚ ለ. አንዳንዴ/ አልፎ አልፎ

9. በእግረኞች የእግረኛ መንገዶች ላይ የትኞቹ ተግባራት አጥፊ ናቸው?

ሀ. ታክሲ እና አውቶቡስ መቆያ ቦታ

ለ. የመንገድ መሸጫ

ሐ. የመንገድ ጫማ

☒ መ. የግንባታ ስራ እና የተረፈ ቁሳቁስ

☒ ሠ. በእግረኛ መንገድ ማቆሚያ ላይ

ሴላ ካለ ይጥቀሱ

10. በእግረኞች የእግረኛ መንገድ ላይ ለመድረስ የሚያስቸግራቸው ምን እንቅፋቶች ያጋጥሟቸዋል?

☒ ሀ. ጉድጓዶችን እና ጉድጓዶችን ይክፈቱ

ለ. የሚያንሸራትቱ እና የተሰነጠቀ የገጽታ ቁሳቁሶች

ሐ. የተሳሳቱ የመንገድ መገልገያዎች

መ. ያመለጡ (የተቋረጡ) የእግረኛ መንገዶች

ሠ. የኩር ራምፕስ አጥረት

ረ. ያመለጡ እና የተሳሳቱ የእግረኛ መንገዶች

11. በእግረኛ መንገዶች ላይ ምን ያህል ጊዜ መሰናከሎችን ያገኛሉ?

☒ ሀ. ሁልጊዜ ለ. አንዳንድ ጊዜ

12. የእግረኞች የእግረኛ መንገዶች ስፋት በቂ ነው ብለው ያስባሉ?

A. አዎ ☒ ሊይደለም

13. በዚህ የእግረኛ መንገድ ላይ የገበያ ቦታዎች መኖር አስፈላጊ ነው ብለው ያምናሉ?

☒ ሊይደለ ሊ. አስፈላጊ ሊይደለም ሐ. ግድ የለኝም

14. የእግረኛ መራመጃ መገልገያዎች አሁን ስላሉበት ሁኔታ እንዴት ለተጠቃሚ ምቹ ነው?

A. አዎ ☒ ሊይደለም

15. የእግረኛ መንገድ መገልገያዎች እና የመሰረተ ልማት ድልድል (የብርሃን እና የሰልክ መስመሮች፣ የትራፊክ ምልክቶች እና የቆሻሻ መጣያ ጣሳዎች) በእግረኛ መንገድ ላይ ወደ በቂ ያልሆነ ስፋት ያመራል ብለው ያስባሉ?

A. አዎ ☒ ሊይደለም

አዎ ከሆነ ለምን?

16. በእግረኞች የእግረኛ መንገዶች ላይ በአለቱ ለመጓዝ ደህንነት ይሰማዎታል?

☒ ሆ. አስተማማኝ ሊ. ደህንነቱ ያልተጠበቀ

ደህንነቱ ያልተጠበቀ፣ ለምን?

17. በምሽት ጊዜ በእግረኛ መንገዶች ላይ ለመራመድ ደህንነት ይሰማዎታል?

A. Safe ☒ ደህንነቱ ያልተጠበቀ

ደህንነቱ ያልተጠበቀ፣ ለምን?

የአባሪ መንገዶች ገና መሰረተ የተጠናቀቁ ቦታዎች ሕገ
እና ቆሻሻ ቦታዎች፣ ጉዳጆች ላለው ደህንነት ያልተጠበቀ ንግድ

18 በአብዛኛው ደህንነቱ ያልተጠበቀ የጎዳው የትኛው የመንገድ ክፍል ነው?

ግን ፓላት ቦታ ወደ ፍጻሜ
ግን ጉዳጅ ሕዝብ ወደ ፓላት

19 አነስተኛ እንቅስቃሴ ካላቸው አካባቢዎች አጠገብ ባሉት የእግረኛ መንገዶች ላይ ደህንነት ይሰማዎታል?

እዛ

ሌላ ካለ ይጥቀሱ

20. የእግረኛ መንገዶችን ሲጠቀሙ ምን አይነት በደል ያጋጥሙዎታል?

ሀ. ጾታዊ ጥቃት (ሲ) ስርቆት ሐ. አካላዊ ጥቃት መ. መውደቅ

21. የእግረኛ መንገዶች ከተንሸራተቱ እና ከተሰነጣጠሉ ቦታዎች የፀዱ ይመስላችኋል?

ለ. አዎ (ሀ) አይደለም

22 ብዙውን ጊዜ በእግረኞች የእግረኛ መንገድ ላይ ያልተሸፈኑ ጉድጓዶች እና ጉድጓዶች ያጋጥሙዎታል? አዎ ከሆነ የት?

እኛ ግንባሬ ማዘፍ - ወደ ፀሐጣዊ ኔፍ ምንም ዓይነት

23 በምሽት የእግረኞች የእግረኛ መንገዶችን ሲጠቀሙ መብራት የሌላቸው ቦታዎችን ያገኛሉ?

አዎ ከሆነ የት?

እኛ አዲስ ጊዜ ደህንነትና ፍጥነት ምንም ዓይነት