A STUDY ON WALKABILITY FOR SUSTAINABLE DEVELOPMENT IN CENTRAL BUSINESS DISTRICT MOTIJHEEL, DHAKA

By

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DEDICATION

To my **Father**,
(Late) Emdad Ali Akand

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All admirations go to Almighty Allah, the most gracious and most compassionate.

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ABSTRACT

'Walkability' within the urban context is one of the prime issues for a sustainable city. In the context of Bangladesh, walkability is considered a fundamental factor for sustainable urban development as per rule. But the strategic measures here are limited only to a few paragraphs and are not context specific. Still, the standing guidelines in Bangladesh conferring on the existing user demand have not been followed practically in most cases. The Motijheel, Dhaka's core business center, where the city's walkability is gravely endangered, exhibits little distinction from the rest. Though a substantial share of users prefers to walk for daily transit, regrettably, a lack of adequate infrastructure, discontinuity, surface deformation, and obstructions creates a greater inefficiency in the walkable context. The walkability agenda regarding sustainable development constitutes the parameters of physical features, legibility, and individual perceptions. Among these, this research concentrated on investigating the physical attributes concerning the user's experience to explore the current walkability situation. However, retrofitting the walkable network within the built-up area is challenging but not impossible. This research seeks to identify the challenges and suggest strategic means to improve walking condition within the living commercial CBD context to aid sustainable urban design and alleviate related problems in other local contexts.

A Case Study Research approach including Quantitative and Qualitative analysis has been used here. The level of service (LOS) and sidewalk condition index (SCI) analyses were utilized as a quantitative assessment technique to determine if the Motijheel CBD is sufficiently walkable considering the growing number of pedestrian traffic. As a qualitative assessment technique, questionnaire analysis is considered to investigate the public experience mixed with pedestrian activity. Findings show that, according to the quantitative analysis of Level of Service (LOS), 87% of available walking segments are extremely crowded and incompatible with the volume of regular users. The qualitative survey results are then combined with the observational evaluation for the SCI analysis, resulting in highly obstructed walking circumstances. Among different aspects, the disorganized retail industry (40%) and informal parking (29%) with uneven surfaces (18%) are the major obstructions endangering the current walkability in the study area. Based on these findings, this research suggests the idea of hawking free wide walkways for 53.34% of primary roads to avoid congestion and enhance the walkability of this CBD area. In addition, 33.34% of streets are recommended for being shared walkable spaces with vending activities for prioritizing walkability considering local regulations.

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LIST OF ABBREVIATIONS

RAJUK	Rajdhani Unnayan Kartipakkha
DMR	Dhaka Metropolitan Region
DMDP	Dhaka Metropolitan Development Plan
CBD	Central Business District
DIT	Dhaka Improvement Trust
DSP	Dhaka Structure Plan
DTCA	Dhaka Transport Coordination Authority
GIS	Geographic information system
DAP	Detailed Area Plan
MRT	MASS rapid transit
TOD	Transit-oriented Development
POD	Pedestrian Oriented Development
DUTP	Dhaka Urban Transport Policy
DHUTS	Dhaka Urban Transport Network Development Study

CHAPTER 01
INTRODUCTION

1.1 Introduction

Walkability is the basis of sustainable development for a city. The vital issue of any community is providing easy access to the transportation network for the community members. Walking is a 'green' type of transportation with a low environmental influence and energy conserving without air and noise pollution (Moayedi et al., 2013) (Rafiemanzelat, Emadi, & Kamali, 2017). The degree to which a place or neighborhood is pedestrian-friendly is known as walkability (Spoon, 2005) (Baobeid, Koç, & Al-Ghamdi, 2021) The increased residential and commercial densities, integrated street networks, public amenities like squares, parks, and other gathering spaces, as well as wide footpaths, street lighting, street furniture with trees, all of these are designed to promote walking (Spoon, 2005). Development for sustainable walkability has already expanded considerably within the past few decades. Municipal developers have also comprehended the walkability concept as a means of urban sustainability (Cysek-Pawlak & Pabich, 2021) (Spoon, 2005). At the macro level, the local government policy initiatives affect the evolution of land use, transportation networks, and environmental sustainability align with the urban design approaches emphasizing walkability. However, at the micro level, the arising urban walkability issues are small-scale local neighborhood features, like street lighting, signage, public transport stops, street furniture, and calming traffic measures which demand to be inspected appropriately for a sustainable built environment. The degree of mixed-use zoning with higher densities (such as commercial and residential) adjacent to one another can be used to quantify the level of walkability. Walkability is ensured by the connectedness of walkable networks, which specifies how directly a person can travel from one location to another (Hajrasouliha & Yin, 2015). Walking for transportation, travelling to and from locations, running errands, getting to and from work, and going to and from transportation stops, all these contribute to walkability in any CBD context. Thus, walkability and the built environment have a direct and robust correlation (Southworth, 2005).

The effectiveness of walkability depends on the parameters categorized in Physical Sidewalk Configurations (including the sidewalk width, street width, traffic volume, the number of walkable users, and tree canopy), the Urban Design Quality (defines imageability, legibility, enclosure, human scale, transparency, connection, complexity, rationality), and finally the Individual reactions (describes a sense of safety, comfort, and level of interest (significantly transform how people move or experience) (Hamidi & Moazzeni, 2019) (Ewing & Handy, 2009). Reviewing these issues for a better walkable impression is significantly required for future urban sustainable development. Though all the traffic and travel starts and ends up as pedestrian, unfortunately, the adequate pedestrian provisions are not generally visualized in urban areas' planning and design frameworks in Dhaka, Bangladesh (JICA & DTCA, 2015). Even though the walkability infrastructure makes a city good by definition, the walkers are the most vulnerable users of the road space with an enormous functional deficiency in Dhaka city (Southworth, 2005). Densely established spatial arrangement within an urban context is more challenging to retrofit for walkability and more so in the congested CBD (Baobeid et al., 2021). So, it is critically important to investigate to ensure sustainable walkability for Dhaka CBD at first. This research intends to focus on high percentage walkable user context for assessing this phenomenon, while the Motijheel of Dhaka has been notified for high pedestrian traffic generating location for being the earliest CBD area (Islam, Ahmed, Manabe, & Akito, 2019).

It is important to comprehend the physical pedestrian dynamics comparing with domestic regulatory extents and the global evaluation parameters along with practices for sustainable development especially in the case of the CBD Motijheel. The availability and accessibility and the excellence of walkable surface have recently been the main issue that affecting the Motijheel CBD's entire walkability circumstance. Mass rapid Transit (MRT Line-6) (JICA & DTCA, 2015) (Tariquzzaman, 2019)s implementation on this specific route will also significantly touch the entire mobility system. Responsive actions must be taken to improve this situation. Without sufficient walking space linked with the road system and land use pattern, it will obstruct efficient passenger transit and create a bottleneck situation (Mahmud, Hoque, & Qazi, 2009) (Tariquzzaman, 2019). This research intends to go through the domestic regulatory extents and global practices to identify the deficits in theoretical framework as well as will recommend propositions according to this commercial context specific demands.

1.2 Statement of The Problem

In terms of urban architecture, a walkable city places more emphasis on its pedestrians than on its motorized vehicles. The standard of living in a municipality is directly correlated with how individuals choose to live there. A walkable community is regarded as being one that is actually livable in this highly vehicle-oriented period. The commercial business hub of Bangladesh, Dhaka, is a rapidly expanding metropolis with a high population density. In this region, chaotic urban expansion with negligence regard for the surrounding environment is the most common situation. Due to its inherent system flaws, the current transportation system has proven hazardous for the entire city system. At The Motijheel CBD, large percentage of mobility depends on walkability, but walkability conditions are not yet supportive enough to be effective. The primary problems influencing the Motijheel CBD's walkability status are the inadequate accessibility and pitiable surface condition. The majority of walkable space have exposed to utility holes or are uneven or crooked. Most busy streets lack of foot-over bridges; and available are both filthy, and taken over by homeless people, or deemed that unsafe for pedestrians. In addition, the MRT Line-6 intervention through the main arterial route (near Bangladesh Bank, Shapla Chattar Node) will have a substantial impact over the whole transportation system and will put a great pressure (Alighting and Boarding of 1,13,000 pers. /day) on walkability (JICA & DTCA, 2015) (Tariquzzaman, 2019).

Recent updates to the Dhaka Structure Plan (DSP 2016–2035), Detail Area Plan (DAP 2022), and Revised Strategic Transportation Plan (RSTP) include significant specifications for mobility management and accessibility improvement to ensure the effectiveness of walkability. Challenges with accessibility, convenience, and the character of walking have a negative effect, along with decreasing the number of individuals who use transit (Mahmud & Rahman, 2015). So, evaluating the walkable network in the Motijheel CBD zone concerning the local pedestrian traffic around the urban transit radiuses is crucial. As part of a sustainable mobility strategy, numerous towns, including Madrid in Spain, Chengdu in China, Brussels in Belgium, Bogota in Columbia, and Hamburg in Germany, are currently converting from "automobile-centric" to "pedestrian-friendly" cities. This technique has already been put into effect in Ho Chi Minh City and Hanoi, the capital of Vietnam, where specific portions of the city have been designated as being off-limits to automobiles on a temporary or permanent basis. As a result, there are more people walking and more tourists are visiting the country. End-to-end pedestrian connectivity for the ideal Level of Service condition [i.e., LOS_A (most ideal), LOS_B (reasonable condition), LOS_C (basic condition), LOS_D (poor condition), LOS_E (unsuitable), LOS_F (severely unstable)] is required to effectively operate a sustainable city form (Jabareen, 2006). It is important to define CBD walkability, its goals, and the influencing factors of walkability. For assessing the variables impacting walkability, the literature offers multiple notions based on environmental, social, and economic criteria. In that case, several important "Physical Infrastructures" such as traffic volume, sidewalk width, connectivity, attractive environments for walking, cycling, parking, and metro utilities, continuity and directness of route, social norms and cultural preferences, activity locations, trip duration, and affordability should be taken into account when designing an urban area for walkability. Moreover, the 'Urban Design Aspects' measure the imageability, legibility, coherence, transparency, linkage, enclosure, and human scale, and the 'Individual Reactions' include a sense of safety, comfort, and level of interest (Hasan, Rahman, & Siddika, 2022).

Among these, the most important physical factor for walkability, identified as a major problem is the accessibility, convenience, and appealing features within the walkable network. The research has focused on urban design aspects. Hence, among the three factors that determine walkability, the "physical infrastructure analysis" of the CBD's walkable grid has been explored as a fundamental need to support mass pedestrian traffic. The Motijheel commercial zone along MRT line-06, the city's economic hub that has evolved over time into the Central Business District, has been examined for case analysis in the study.

1.3 Research Aim and Objectives

Research Aim

This research attempts to identify the problems of the walkability in the Motijheel CBD area and suggest some physical adjustments to improve future urban sustainable development. The amendments conferring the local policy measures and global practices will promote sustainable walkability within the densely built environment of Dhaka, Bangladesh. Following the research objectives stated below, pedestrian passenger transfer is expected to be easier.

Research Objective

I. To identify the existing characteristics and shortcomings of the pedestrian environment and understand their impact on urban sustainability considering the local and global perspectives.

II. To investigate the public experiences concerning the existing physical parameters affecting walkability in the study area

III. To suggest strategic measures to improve walkability.

1.4 Rationale of the Research

Walkability is very popular as a sustainable transport mode. A proper walkable network integrated with public transport station will help to ensure efficient passenger transfer. In this regard, the current state of walkability in the central business district's context, considering local movement patterns, accessibility, conveniences need to be determined. Understanding the essential components of a community's walkability will also be helpful for ensuring smooth operation. Before including such aspects in the urban planning process, this research will help to improve upon the current situation and offer guidance to improve any plan.

1.5 Scope of The Research

Various researchers have already documented the retrofitting guidelines for pedestrian facilities in the global context (IRC, 2012); (Azmi et al., 2013); (Gill & Zissler, n.d.). Walkability in an urban context is the challenging issue in Urban Planning Division, Urban Design Practice, and Transportation Planning Sector. However, the knowledge gaps suggest that future study should use behavioral and context-specific walking outcomes to differentiate between "walking for transport" and "walking for recreation." Moreover, research should involve further experiments that entail transport policies' effects (e.g., roadway design) and practices (e.g., path provision) on walkability with different levels of self-efficacy. Research can involve evaluating opportunistic and planned revitalization programs that might influence walkability among residents. Potential funding sources must be responsive enough to set recommendations for the interaction between the environment and walking in order to improve walkable areas with effective interventions. This research has considered the Motijheel Commercial CBD context within ward no—32 Motijheel Thana boundary as the study area. A potential element for improving walkability is the Motijheel CBD's very high commercial land values and pedestrian traffic. The scope of this research is comprehensive to ensure good walkability within the Motijheel CBD context of Dhaka. The study is based on the speculation of shortcomings of the walkable space, which immensely affects the overall walkability phenomena in the Motijheel CBD area. The study only takes into account the 'Physical Attributes' (traffic volume, sidewalk width, inviting environment for walking, continuity, and public preferences) with regard to urban design aspects rather than urban planning principles in order to interpret that. This research has not been regarded as specific building-based investigations (like user density and number of floors.). However, the study's findings will offer some incentives for interpreting and anticipating potential changes to increase walkability in the context of the local area.

1.6 Limitations of The Study

The findings of this research will explicitly contribute to the literature on urban design towards the sustainable development process regarding walkable conditions about the local spatial structure, user movement, and pedestrian conveniences. However, the scope of the study has been limited due to the following facts:

First, the overall walkability phenomenon constitutes the physical features (i.e., pedestrian traffic volume, walkable width, green canopy), the urban design qualities (i.e., imageability, transparency, enclosure), and the individual reactions (sense of safety and comfort). This research only investigates the physical features to assess the existing walkable proficiency because the most important physical factor for walkability, identified as a major problem is the accessibility, convenience, and appealing features within the walkable network.

Second, due to the time restrictions and movement limitations for the MRT Line-6 Construction, the pedestrian transfer scenario in the catchment area differs at each gate point within the field survey period. The site was divided into a 100-meter grid (the smallest distance that may be walked in one minute is 100 meters long) in order to locate the survey gates, of which 91 have been discovered. sTherefore, based on a pedestrian movement survey on 91 gates (covering the majority of the road within a 5-minute walking distance) from nodes, an approximation of the entire pedestrian flow scenario has been determined.

Third, the research only considers pedestrian movement and conveniences within the local spatial arrangement to assess the physical scenario of the existing walkable environment. Daily data collection has not considered the specific building-based surveys (like user density, building height, and individual access point), vehicular traffic analysis, and parking unavailability on individual segments.

Fourth, the research area's total sample size for the questionnaire survey was restricted to 190 people due to resource constraints, which may not have provided an accurate picture of the situation but provided a peek of pedestrian behavior as a whole.

1.7 Structure of The Thesis

This research has been designed and structured in six chapters.

Chapter One introduces a brief discussion on the background of this research incorporating the significance of walkability in Dhaka city context, conceptualizes the research problem, aim and objectives, and rationale for assessing the walkability, including the future scope and limitations in the study area of Motijheel CBD.

Chapter Two, based on a theoretical foundation relevant to the research work, i.e., the concept of walkability, sustainable urban development with relevant case studies and pilot projects, benefits of walkability, and influencing measurable indicators. This review also includes the local urban guidelines in the Revised Strategic Transportation Plan (RSTP), Dhaka Transport

Co-ordination Authority (DTCA), Dhaka Structure Plan (DSP 2016-2035) and Detail Area Plan (DAP 2022-2035) to analyze the strategies for walkability to execute the required amendments in the CBD context.

Chapter Three describes how the methodology was adapted in a practical setting for collecting statistical data relevant to the study subject. It covers the overall research design and its justifications, and the rationale behind choosing the field of study at first phases. The second two phases of the methodology used for data collection on the physical characteristics of walkability, while public perceptions and experiences were collected in the final round.

Chapter Four elaborates the study area analysis and walkability scenario in the CBD context by comparing the related street configurations, Level of Service (LOS) analysis, Sidewalk Index Condition (SCI) Analysis, and Questionnaire Analysis. The pedestrian movement scenario of the Motijheel CBD area is revealed here through fieldwork (Pedestrian Count on selected Gates, Walkable Infrastructural Assessment through Observational Study, and the Questionnaire Survey) based on a relevant assessment checklist. The study attempts to find the prime provoking factors impeding sustainable walkability within the dense Motijheel CBD area through a case study research approach both in Quantitative (Level of Service (LOS) Analysis) and then Qualitative method (Questionnaire analysis).

Chapter Five summarizes all the result discussions addressing the research objectives, from the literature review of local and global strategies for walkability, and the study area analysis through the Quantitative along with Qualitative analysis, to improve the walkable condition.

Chapter Six highlights the recommendations from the findings, states the prevalent shortfall in local strategies, gives a present proclamation regarding sustainable status of walkability, specific recommendations over each identified shortcomings, and generates concluding remarks on certain necessary initiatives for minimizing the inadequacies for being a sustainably walkable condition following evidence-based standards.

1.8 Conclusion

In our modern, automobile-oriented era, a walkable surrounding area is viewed as a true and living community. The quality of existence in a city is intrinsically tied to how individuals choose to move within it. The key factor impacting a city's walkability is the availability and quality of pavements. However, roughly 515 kilometers of pavement are available in Dhaka (Efroymson, Ahmed, & Daniel, 2011). This research illustrates the lack of a walkable urban setting in the capital city of Dhaka, especially in the CBD area of Motijheel. Walkability can be the significant catalyst for future sustainable urban development in CBD, where most trips are on foot for daily necessities (Habibian & Hosseinzadeh, 2018). Therefore, sufficient accessible infrastructure for walkability and integrated network within the local urban fabric (particularly the street network and land uses) must be guaranteed to ensure the efficient transfer of passengers to local destinations and manage mass movement in the Motijheel CBD area. However, such initiatives need concentration and implementation regarding contextual demands that have been seldom investigated. Walkability development depends on numerous physical, non-physical, and urban design aspects. The physical infrastructural attributes, readability, and user perception factors shape the walkable context. In order to evaluate Motijheel's walkability with the movement and infrastructural qualities, this research has focused on the physical attributes such as the effective widths of walkable area, pedestrian volume per hour, obstructions for walkability, and the walk appealing features, inside the commercial urban grid. Before moving on to a comprehensive study analysis in the following chapter, the specific objectives, rationale, scopes, and limits of the subject matter are presented here.

CHAPTER 02
LITERATURE REVIEW

2.1 Introduction

Walkability has become one of the key significant factors to sustainable urban development (Moayedi et al., 2013). (Rafiemanzelat, Emadi, & Kamali, 2017). An urban sustainable vision and objective is to achieve the greatest level of development while minimizing resource use and environmental effect and ensuring the welfare of both people and the environment " (N. Owen et al., 2007). Global sustainable goals have 17 agendas which 'Point No.11, Target 11.2' entails the affordable, sustainable transport system, visioning safe and resilient cities with green and culturally inspiring living conditions (Jones, Wynn, Hillier, & Comfort, 2017) with special attention to the needs of those in vulnerable situations like women, children, older age and a person with disabilities. From the perspective of the sustainable transportation system, the continuous increase in car density (longer distances are traveled by more vehicles with fewer people on proportionally shorter routes) has added sufferings to the urban mobility pattern (Cao, Handy, & Mokhtarian, 2006), (N. Owen, Humpel, Leslie, Bauman, & Sallis, 2004).

By 2050, 69% of the world's population is predicted to move to urban regions, according to UN DESA (2010) (United Nations Department for Economic and Social Affairs, n.d.). Fast-growing cities face several interconnected urban issues, including unplanned urban sprawl, inefficient land use, neighborhoods where cars are the norm, traffic congestion, high carbon emission levels, and segregation of functions and use—making it difficult to be sustainable for any neighborhood that encourages a healthy lifestyle (Emily Talen, 2013). Physical infrastructure, such as streets and paths, is seen as the fundamental component that is essential in developing a society because it connects people and places, which promotes social interaction, trade, and transportation. Accordingly, "a walkable community provides an affordable, comfortable and healthy socio-physical structure to live and work in a while enhancing towards a sustainable environment" (San Schwartz Engineering, and AmericaWalks, 2012). Urban planning provides the foundation for sustainable mobility, resulting in car-free and pedestrian-friendly cities. (Rafiemanzelat et al., 2017). It aims to increase mobility within urban areas so that walking and cycling, which are more environmentally friendly, can become the primary forms of transportation. Banister proposes a new paradigm that places pedestrians and cyclists at the apex of the sustainable transport pyramid (Banister, 2008) (Fig 2.1).

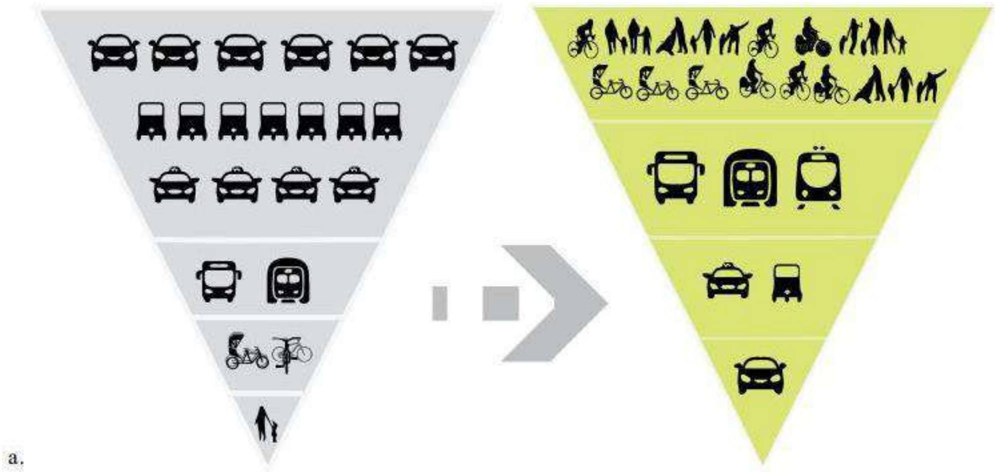


Figure 2.1: Diagram expressing the importance of transforming streets and their vehicles for attaining sustainable communities (Ogryzek, Adamska-Kmieć, & Klimach, 2020)

If the car-friendly infrastructure (e.g., wide roads, car parking, flyovers) and the related urban land use (e.g., no restrictions on car use and speed) increase, the mode share of cars increase, resulting in congestion, pollution, and traffic crashes, and vice-versa. Hence, ensuring walkability can be beneficial to changing travel behavior (fewer private cars and more people as the dominant form of transportation) in any city to less hazardous environmental impact in the long run. Thus sustainable walkability creates community interaction and reduces automobiles use to improve public health and safety (Baobeid, Koç, & Al-Ghamdi, 2021). As well as it reduces transit costs and provides other economic benefits (Lakshmanan, Nijkamp, Rietveld, & Verhoef, 2001). More details related to sustainable walkability are explained in the following sections.

2.2 Walking and Walkability

In an urban setting, walking typically involves moving quickly from one location to another. Moreover, walkability is a concept that measures the degree of walking within an area. The built environment's response to the presence of individuals walking, shopping, visiting, enjoying, or spending time in an area is characterized as walkability (Rafiemanzelat et al., 2017). In the early 1990s, urban designers and spatial planners published the first idea of walkability in a scholarly publication. (Southworth, 2005); it classified the aspects of walkability into two main groups in the review around 27 books and scholarly papers, which are demonstrated in the following figure 2.2.

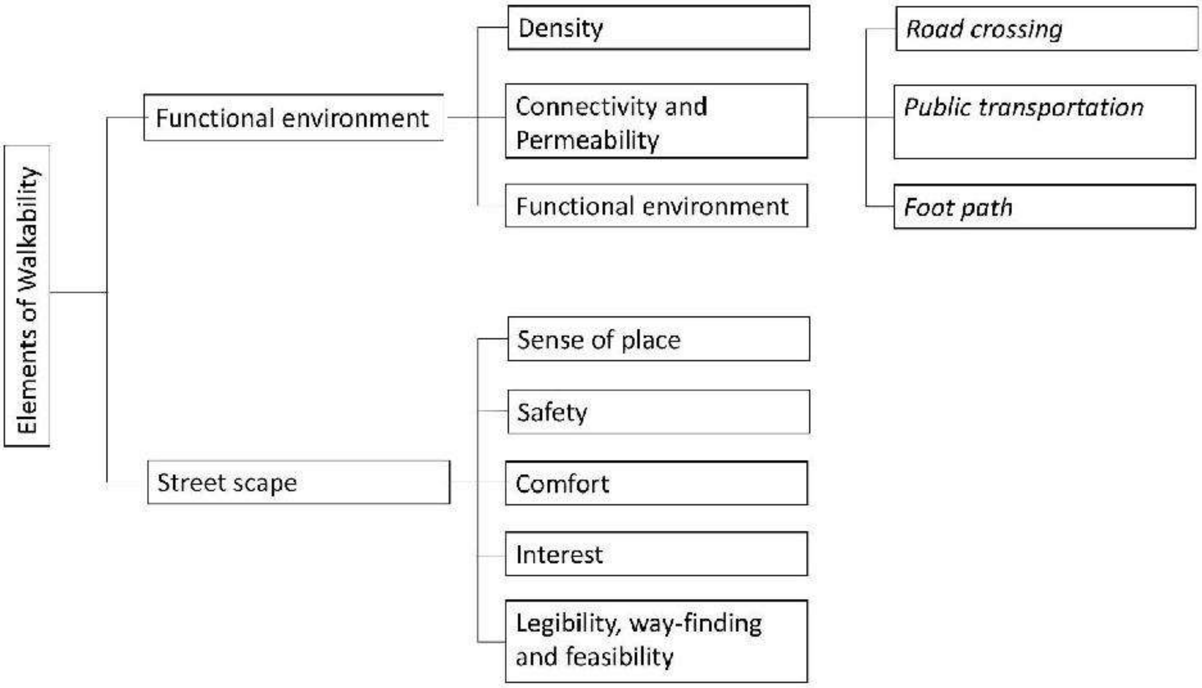


Figure 2.2: Elements of Walkability (Rafiemanzelat et al., 2017)

1. **Functional environment**

   According to the city's structure, a functional environment consists of density, connectivity, permeability, and land use. (D'Arcy, 2013). Contributing elements of connectivity and permeability include crossing, public transport, and footpath, which greatly impact the walkability of an urban area.

2. **Streetscape**

   For transportation, the streetscape concept mostly focuses on walking facilities, physically such as; footpaths, level of essential services, and pedestrian protection from vehicular traffic (Loo, 2021). The streetscape consists of a sense of place, safety, comfort, open spaces, green areas, and basic aspects of the street environment are created by street furniture. (Edirisinghe & Hewawasam, 2020). Overall walking is an interactive kind of transportation that allows for experiencing and participating with society in ways that other forms of transportation cannot. (Shay, Spoon, & Khattak, 2004). Walkability was defined by London's mayor as "the extent to which walking is available to the consumer as a safe, connected for pleasant activity" in the research titled "Making London a walkable City 2004". The research stated that the walkable city is: Connected, Convivial (friendly, positive, and enjoyable), Conspicuous (attracting notice or attention), Comfortable and Convenient (Rafiemanzelat et al., 2017). Hence, walkability can be defined as a street environment quality that allows pedestrians to walk throughout the complete metropolitan network to reach their goals, which may have a favorable or bad effect on its users during a journey (Fonseca et al., 2022).

2.3 Compromises in Walkability

Walkability is always coupled with the public-transportation facilities, pedestrian infrastructure, and non-motorized transportation (e.g., rickshaw, bicycle). A street may have to convert an area for pedestrians only to be walkable by excluding or discouraging all motor vehicles. However, making a walkable environment is tough. Compromises must be made to continue the urban system's proper functioning; and make the walkability scheme acceptable and popular among citizens (Soni & Soni, 2016). For example, emergency vehicles, like police, firefighting trucks, and ambulances, must enter any area when needed. Delivery vans and freight trucks must be permitted during specific off-peak hours of the day if a walkable area has business operations. Based on the level of compromises, there can be three types of the walkable area as follows:

Full-time walkable: Within this scheme, the walkable space demands absolute priority. Access to vehicles is limited here, but emergency vehicles may be permitted during certain times and in some places for certain uses.

Part-time walkability: This scheme allowed for part-time walkability only. Vehicle access is restricted to specific times. There is no street-level parking available. However, cargo ports can be provided for loading and offloading.

Walkability through traffic calming:

a) Speed Tables b) Curb Extensions c). Narrowed Lanes

Figure 2.3: Traffic Calming Measures (J. Owen, 2021)

Here, On-street parking spots are typically minimized while walking spaces are typically widened. If relocation is not feasible, taxi stands and green minibus stands can be available. Access for vehicles is unrestricted. By traffic-calming devices like speed tables (a), curb extensions (b), sharpened corners, and narrowed lanes (c), are made the vehicles go more slowly (Fig 2.3).

2.4 Benefits of Walkability

The majority of the public depends on affordable transportation systems like public transport, walking, and NMT (Non-Motorized Transit Vehicle) in our local context (roughly 60–80%) (JICA & DTCA, 2015). Pedestrian traffic volume is the most significant walkability indicator (Moayedi et al., 2013). According to US Department of Transportation research from 1994, 30% of commuters would switch to a different mode of transportation if suitable facilities for walking and bicycling were offered. In locations like Chandni Chowk (Old Delhi), pedestrian users are high in mode share. In the Dhaka city context, the walkability scheme can help to reduce car dependency and traffic congestion. A pleasurable shopping experience works as an influential mobility factor in this context and can make a significant shift from personalized vehicle mode to walkability. Research indicates that pedestrians tend to increase double after the walkable area is created enough (Bahari, Arshad, & Yahya, 2014).

Research in the UK and Europe showed many positive impacts of walkability on the environment. First off, air quality monitoring shows that certain pollutants in pedestrian streets can have their emissions reduced by as much as 40% (Sánchez, Ortega, López-Lambas, & Martín, 2021). After walkability was implemented, carbon monoxide (CO) concentrations decreased from 8 parts per million to one in Cologne, Germany, and from 35 parts per million to less than five in Gothenburg. (Sweden) (Emmanuel, 2013). AQI (Air Quality Index) above 200 creates breathing discomfort for most people, and the acceptable range should ideally be 0–200 AQI. Environmental improvement and walkability are closely associated, according to a survey of cities throughout the world about their walkability programs (Baobeid et al., 2021). 6 dB of noise reduction corresponds to a 50% reduction in perceived noise levels. The research shows that walkability can reduce noise levels up to 15–20 dB (A). By lowering warmth, noise, and dust, prohibiting motor traffic in an area improves the microclimate. On the other hand, walkable areas have enough space to develop green spaces like roadside trees and parks instead of pedestrian-only areas.

Walkability makes a major difference in economic growth and store turnover. According to studies on pedestrianization, the number of nearby pedestrians directly correlates with retail sales and customers at a store (MONHEIM, 1986). In Dallas (Texas), office buildings with good pedestrian facilities and landscaping typically have greater occupancy rates. (Fiocchi & Fiocchi, 2014). In Toronto, buildings not on the street side (the underground pedestrian corridors) get half the annual rent than analogous Buildings connected to walkable streets (City of Toronto, 2017). Walkability increases land values, increasing rent (Lakshmanan et al., 2001). Due to increased competition for storefronts and a 10–20% annual increase in sales, pedestrianization raised shop occupancy, property prices, and shop rentals in five French cities: Metz, La Rochelle, Rouen, Grenoble, and Strasbourg. (Lakshmanan et al., 2001). The US Department of Transportation (1994) survey suggested that proper walkable infrastructure and facilities would increase public transport users by almost 100%. More people are drawn to and encouraged to use walkable areas as a result of these enhancements, which increases income.

2.5 Sustainable Urban Development

According to the "Brundtland Commission" sustainable development should upkeep the necessities of the present day without conceding future needs, where sustainability should be simultaneously holistic and follow long-term prosperity (Jabareen, 2006). A city, via effective planning, creates a dynamic, beautiful, secure place for people to live, work, and play. It also involves strong governance and environmental sustainability, according to The Centres for Livable Cities (2011) (Shamsuddin, Hassan, & Bilyamin, 2012) (Ferrão, 2016). Three key phases can be used to categorize the governance requirements for creating plans for smart, sustainable city initiatives: Planning is followed by implementation, adoption, and monitoring (*Sustainable Design*, n.d.). Good urban design is contextual and ensures safety with physical elements of buildings, public spaces, streets, transport, and landscape (Refaat, Elsamaty, & Waseef, 2019) (Khashim, Ismail, Hassan, & Al-Ashwal, 2017). The Sustainable Urban Development Principles enumerated below have been tried, evaluated, and refined on initiatives around the globe for many years (Webb, 2021). These are universal components of successful sustainable urban development.

- **Human-centric design and activity**

  The focus of designs at the city scale must be on the requirements and preferences of persons who live, work, and play in urban environments. Infrastructure, places, and facilities must be easily accessible and easy.

- **A return to squares**

  Space can be choreographed at the threshold level in squares and courtyards, with leisure activities and gardening opportunities. The streets' layout and design must consider the community's daily demands while providing landmarks and clear references. For people to feel "comfortably lost" and "reassuringly found," way-finding should appear natural, with familiarity with street signage and furniture. Layering should be accomplished by clearly defining the areas designated for cycling, autos, mass transit, pedestrians, and public transportation. They create a unified, distinctively styled, commercially viable retail, food, and business environment. In addition, it adds value by enhancing local civic amenities and cultural experiences in desirable residential and commercial areas.

- **Parks, plazas, and the public realm**

  Locations should be diversified, sequential, and connected to enable a range of interactions and experiences. Most significantly, these areas must provide networks of a walkable public realm, vital for future cities that wish to promote more sustainable daily movement patterns by decoupling mobility from cars and public transportation. The idea of "streets in the sky," which refers to elevated pedestrian networks of bridges, lobbies, corridors, and tunnels, has also finally come. People can avoid traffic and congestion by using these connected walkways, which also provide stunning city views and add another layer of topography and public space.

- **First and last mile mobility: integrated walkable infrastructure**

  Integrated first and last-mile solutions are necessary for communities to be more connected and cities to become more walkable. The infrastructure for walking and bicycling must be connected with public transit so that people can blend their personal and professional life through more practical linkages at the first and last miles. Also, the additional foot traffic benefits local businesses by boosting consumer spending. Infrastructure must be designed with the ease and comfort of pedestrians in mind. Enhancing opportunities for walking, running, and cycling, which creates a sustainable urban environment, can reduce the usage of cars.

As a result, integrated walkability is a key concept for sustainable development that reduces reliance on automobiles for mobility.

2.6 Factors Contribute to Sustainable Urban Development

In the previous section, integrated walkability has been mentioned as a principle for sustainable development. Most Urban designers and local governments have already practiced sustainable strategies to make cities environmentally responsible. Cities have initiated walkable communities, bike lanes, and public transportation to reduce transportation-related greenhouse gas emissions. Though not every city has achieved success, plans do not always turn out as they were intended when they are written down. In Vienna, 70% of people commute to work every day on public transportation, bicycle, or foot. (Vienna: A city in the fast lane of the smart mobility revolution, n.d.), Although Chicago boasts the second-largest public transportation system and one of the biggest networks of bike lanes in the country, while more than 60% of its residents still drive to work (The Public Transportation Network in Northeastern Illinois : An Analysis of Existing Conditions, 2013). An urban sustainability project's success is influenced by user preferences and behavior in addition to technical viability. The user's choice to pick a sustainable or an unsustainable alternative is influenced by the five variables. We must include these five elements in our planning procedures for urban sustainability projects in order to encourage people to make sustainable decisions and deter them from making unsustainable ones. These factors are Availability, Accessibility, Attractiveness, Affordability, and Awareness of sustainable options (the five A's) (Fenton, 2014). In the following, each of these five factors is explained.

(a) Availability

First, sustainable solutions must be available. It is necessary to provide the appropriate infrastructure system for making people use sustainable options, not just where they live but also where the public transit ends and starts to walk. For instance, even if a city has the most extensive public transportation system, individuals cannot use it if there is no bus stop or station within walking distance. People will automatically look for alternative options if unsustainable options are no longer available. Available suitable sustainable infrastructure influence people to select sustainable alternatives.

(b) Accessibility

Sustainable solutions must be both physically and legally accessible (Wegener, 2010). Such as proper crossing at the pedestrian level ensures clear accessibility within the entire walkable network. Most of the time, foot-over bridges are discouraged by footpath passengers for excess time consumption, which is also hazardous for aged people and children. Moreover, the long distances between pedestrian crossing points have limited the provision of mid-block crossings. Pedestrians should take the most direct and least strenuous routes. Additionally, crossing signals are required to boost the visibility for all road users and provide pedestrians sufficient time to traverse the crossings from one safe point to another, considering different walking speeds. A change in policies, maintenance, and redevelopment work regarding connected walkable networks can make accessibility possible as a sustainable option.

(c) Attractiveness

Sustainable options must be more alluring than non-sustainable alternatives. In addition to beauty, attractiveness can also relate to comfort, safety, and high-quality services. The user will undoubtedly choose to drive there if taking public transportation involves waiting for a long time in an unsanitary and unsafe terminal that is too hot in the summer and too cold in the winter, being crammed into a crowded vehicle with people who are unable to breathe, and arriving at the destination late. People are more likely to walk if the provided infrastructure and services are attractive. Misplaced pedestrian infrastructure limits connectivity and reduces the integration between the pedestrian and transit systems, impacting the entire walkability phenomenon. A shaded walkway is also the most demanding feature to maintain comfortable walking to the destination.

Pedestrian plazas may convert underutilized areas into valuable community resources on a budget. Unstructured or disused dead zones can be revitalized with the aid of paint, planter boxes, artwork, street furniture, and lighting and landscaping that are durable and require low maintenance. These modifications affect the psychological comfort of pedestrians, which can encourage neighborhood interaction. The intervention also intends to reduce informal parking zones into functional pedestrian plazas and promenades within urban commercial spaces.

(d) Affordability & Awareness

The benchmark for sustainable solutions must be that they are more cost-effective and accessible than non-sustainable ones. In that case, walkability is the most affordable transit in our local context. People need to be aware that sustainable options are more alluring, accessible, and cost-effective than non-sustainable ones.

The most underestimated factor for successful sustainability projects is educating people about the accessibility, attractiveness, availability, and affordability of sustainable solutions. Higher acceptance of sustainable urban design will result from incorporating all five A's, allowing its technical feasibility and successful implementation.

2.7 Walkability and Sustainability

In order to reduce air pollution, travel expenses, time expenses, and dependence on automobiles, cities should build connected street networks and enhance pedestrian-friendly street design (Shamsuddin et al., 2012). The urban form of cities is now being changed in two ways to promote walkability: by establishing roadways and placing squares close to construction of pavilions (Khalaf, Nor Haslina, & Afar, 2020) (Baobeid et al., 2021). The more linked walkability the city gives the better the permeability and legibility. Shorter distances allow for more flexibility when walking, whereas longer distances call for a combination of walking and using public transportation (Daniels & Mulley, 2013). In order to make a city more sustainable, urban design techniques should identify ways to make it convenient for people to enjoy walking within reasonable distances. Roads and walkway conditions, public transportation programs, safety, accessibility, and & land use patterns all influence how walkable a place is. Therefore, developing or changing each of these elements in an urban setting contributes to sustainable design and benefits the neighborhood.

2.8 Measurement of Walkability

How walkable a place is influenced by the presence or absence of suitable walkways, pedestrian rights of way, traffic conditions, land use patterns, building accessibility, and safety (Speck, 2012). Many non-design determinants in urban design practice have been found to have a vital control, such as land use, housing density, and street patterns, rather than design factors defining walkability (N. Owen et al., 2007) (Jones et al., 2017). Changing the street layout in an established urban area is difficult and typically not within the scope of the urban designer (Cao et al., 2006) (Schmitt, 2020). 'Opportunity and Motivation' are two categories that describe walking behavior (Willmott, Pang, & Rundle-Thiele, 2021) (Table 2.1). The manmade and natural environments that make walking safe, comfortable, and convenient make up "opportunity" as an external element. And "Motivation" stems from the impulses of individuals with varying ages, professions, lifestyles, behaviors, views, and preferences. (Baobeid et al., 2021).

Table 2.1: Walking Activity Considering Users' Environment and Walking Behaviour

(Baobeid et al., 2021)

Opportunity (external)	▪ Distance ▪ Topography ▪ Cost-time and money to travel ▪ Traffic volume and speed ▪ Transportation alternatives ▪ Other factors (e.g., dogs, crime) ▪ Pedestrian facilities (presence, condition) ▪ Access – proximity to destinations ▪ Access-connectivity ▪ Street lighting ▪ Infrastructure
Motivation (personal)	▪ Physical condition (age, health) ▪ Cultural (ethnic, social, peer group) ▪ Educational (formal and informal) ▪ Profession ▪ Family circumstances ▪ Habits, attitudes, and values ▪ value of money ▪ value of exercise and health ▪ value of time ▪ value of independence ▪ appreciation of nature

It should be emphasized that the walkability's physical characteristics both directly and indirectly affect the standard of the walking environment. (Ewing & Handy, 2009). The work by Jane Jacobs has largely inspired urban design literature relating to walking. At the same time, instead of focusing on how efficiently traffic moves, the questions have instead focused on the value and enjoyment of walking. More subjective characteristics of walking, such as visual interest, intricacy, or human scale, have been investigated at for that aim. The built environment's suggested qualities are discussed in the conceptual framework for the function of perceptions in the mediation of physical elements of the environment and walking behavior in urban planning that is important to walking (Figure 2.4), including the following points (Ewing & Handy, 2009):

- Legibility: the simplicity with which the overall spatial structure can be comprehended and navigated;
- Imageability: the ability of a location to stand out and be remembered;

- Enclosure: The degree to which buildings, trees, fences, and other features visually define streets and other public places;
- Human scale: physical elements that are the same size, texture, and articulation as people, as well as matching their proportions and, more importantly, walking speed;
- Transparency: the extent to which individuals can see or perceive what is located beyond the edge of a street or other public place, and, more particularly, the extent to which they can observe or sense human activity;
- Linkage: Physical and visual linkages between buildings and the street, between structures, between spaces, or between the two sides of a road;
- Coherence: A sense of visual order;
- Complexity: The visual richness of a place;

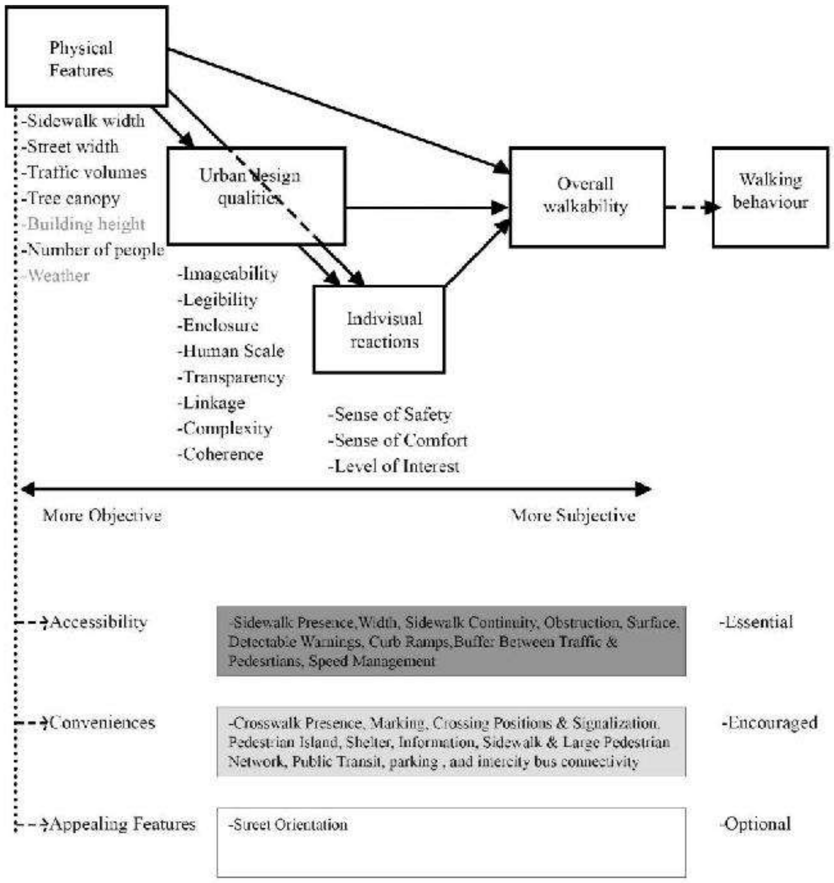


Figure 2.4: Conceptual Framework for the Role of Perceptions in the Mediation of Physical Features of the Environment and Walking Behaviour (Ewing & Handy, 2009)**.**

Essential variables are the very minimum conditions that need to be met in a setting in order to create for adequate walking. In planning and public health, the four components—mixed land use, accessibility, the provision of pedestrian facilities, and connectedness—are well-known and extensively discussed in literature (Bansal, Goyal, & Sharma, 2018). A comprehensive and optimum definition of walkability should include all the characteristics in the three ranking categories.

Walkability can be measured objectively using the distinction between standard service delivery and currently available services (Grasser, Dyck, Titze, & Stronegger, 2012). Additionally, it can be evaluated subjectively by asking people how they view the features of the street environment. Examining one's own perception as a subjective indicator of level of satisfaction is necessary because users' levels of satisfaction are key to understanding how well the walking environment functions (Wang, Li, Wang, & Namgung, 2012). It conveys the degree to which the user is content with the objective conditions offered. (Moayedi et al., 2013).

Transportation researchers have traditionally focused on institutionalizing the space design for the pedestrian mode of transit (Karndacharuk, Wilson, & Dunn, 2013). These ideas covered walking speed, the distance between pedestrians, the flow of pedestrian movement, and techniques for estimating the supply (primarily the sidewalk as the fundamental pedestrian infrastructure) and the demand (the number of people) (Kang, Xiong, & Mannering, 2013). In other words, the goal is to plan a sidewalk that is wide enough to allow a certain number of pedestrians to go around without any restrictions (US Department of Transportation, 2006). Concerns about biased motorized transport have stemmed from the pedestrian planning guidelines in the Highway Capacity Manual (HCM) (Board, 2016), proposing techniques for leveling the infrastructure for pedestrians according to LOS (Itami, 2002) (Tanvir, Hossain, & Idris, 2016). This research potentially deals with the essential variables of physical features regarding walkability as sustainable urban development.

2.9 Walkability Assessment Checklist

This discussion aims to assess the issues regarding walkable environments contributing to essential physical features, accessibility, conveniences (crossing and connectivity), and the appealing matters for walkability (significantly identified from the previous section). Walkable infrastructure and transportation facilities cannot be designed as "one-size-fits." Planning should be done for pedestrian infrastructure and facilities, organized, and constructed considering the urban land use, landscape, and roadway contexts. Consequently, the necessity for "context-sensitive solutions" must be taken into account while assessing walkability (Scott, 2016). Context-sensitive solutions assume the existing and future context walkability and land use balancing the needs of pedestrians. An appropriate walkability assessment checklist is important for correct design. The major identified walkability assessment variables in this research have been detailed (Table 2.2) in the following sub-sections.

Table 2.2: Major Identified Walkability Assessment Variables

Walkability Assessment Checklist	Physical Attributes	Accessibility	Sidewalk presence	Essential
			Width	
			Sidewalk continuity	
			Obstructions	
			Surface	
			Detectable warnings	
			Curb ramps	
			Spaces between vehicles and pedestrians	
			Speed management	
		Conveniences	Presence	
			Marking	
			Crossing positions and Signalization	
			Pedestrian Island	
			Information & Shelters	
			Pedestrian Network	
			Public transit, parking, and Inter-city bus/rail connectivity	
		Appeal Features	Connect Sidewalks	Encouraged
			Install Physical Barriers	
			Provide Adequate Lighting	
			Calm Traffic in Pedestrian Zones	
			Create Inspiring Spaces	
			Create A Natural Sense of Enclosure	
			Separate Walkways from Parking Lots.	
			Build Parks	
	Urban Design Qualities		Imageability	Encouraged
			Legibility	
			Enclosure	
			Human scale	
			Transparency	
			Linkage	
			Complexity	
			Coherence	
			Identity, Equity, and Enjoyment	
	Individual interest		Self-experience	Optional
			Sense of place	
			Comfort-vibrancy interaction	
			Personal safety security	

2.9.1 Accessibility

Accessible walkable neighborhoods include the appropriate planning, building, and maintenance of sidewalks, crossing signals, curb ramps, and other amenities concerning public rights (U.S. Department of Transportation, 2004). They must be usable by differently aged people and capabilities. Because most transit-oriented journeys end up walking, the lack of connectivity and maintenance in the sidewalk zone directly affects the users. Providing "first and last mile" continuity (i.e., passenger transfer to/from public transportation) is dominant in improving accessibility. During the walkability assessment period, the sidewalk accessibility issues must be observed that may appear to be lacking, marked as follows:

- **Sidewalk presence**: Depending on the street type, well-designed sidewalks must be on both sides.
- **Width**: Sidewalks need to be at least 5 feet wide to enable two people strolling side by side or someone in a wheelchair.
- **Sidewalk continuity**: The entire pedestrian network must confirm the first- and last-mile travel connectivity. The sidewalk networks should be continuous and free from gaps, including visual impairments or physical disabilities, to ensure proper accessibility.
- **Obstructions**: The sidewalks must be free from billboards, garbage cans, non-motorized vehicle parking, utility points or boxes, vegetation, and other objects that restrict the access of passengers traveling safely.
- **Surface**: Sidewalk surfaces must be stable, leveled, clear of impediments and cracks, easily accessible, slip-resistant, and separated from motorized traffic to provide unobstructed accessible routes.
- **Detectable warnings**: In order to make it easier for pedestrians who have low vision or other visual impairments to distinguish between the sidewalk and the street, sidewalks should be given a specialized surface treatment and clearly visible signs.
- **Curb ramps**: In order to create a seamless transition from the sidewalk to the roadway, curb ramps should be positioned perpendicular to crosswalk crossings. The locations of on-street parking, bus stops, loading zones, and mid-block crossings need curb ramps with maneuvering areas for users using assistive mobility devices.
- **Spaces between vehicles and pedestrians**: To improve safety and comfort, space between automobiles and pedestrians must be provided by the buffers (such as planting, street furniture, bike lanes, and on-street parking) between sidewalks and the roadway.
- **Speed management**: The regulatory warning signage for calming traffic measures (i.e., roundabouts, curb extensions, roadway narrowing treatments) must ensure traffic speed management on secondary roads.

2.9.2 Walkable Conveniences

While walking, check to determine if the following components that encourage walkable conveniences for all users are present or absent. (Brown, Werner, Amburgey, & Szalay, 2007).

Crosswalk Issues

- **Presence**: To provide pedestrians with safe crossing areas, the pedestrian environment must include marked crosswalks, traffic-calming measures, and signalization and signage.
- **Marking**: In order to successfully assist pedestrians and frequently notify drivers to a crossing site, each crosswalk should be constructed with the appropriate layout of pedestrian features, such as highly visible crosswalk markings.
- **Crossing positions and Signalization**: Each corner should have curb ramps aligned with crosswalks with detectable warnings for those who have poor vision or other visual impairments. An accessible pedestrian signal (APS) system is required to communicate information about the Walk/at signalized intersections, avoid walking in between pedestrians.
- **Pedestrian Island**: To offer a safe location for crossing on bigger streets, the pedestrian island should be in the median strip. Mid-block crossing or curb extensions minimize pedestrian exposure to traffic when crossing.

A person can go to and from a place via walking, driving, cycling, or, in many circumstances, by a combination of transportation modes. Barriers including insufficient pedestrian infrastructure, long walking distances to transit stops and stations, hazardous crossings, poor illumination, and safety and security concerns must be addressed, to enhance connectivity to the entire network. During the in-field walkability audit, observations must be on the following features that foster walkable connectivity.

- **Shelters**: The bus stop/station should include a well-lit shed, often with an accessible wheelchair bay and there is a lift area for people who need to use mobility aids.
- **Information**: Timing and way-finding information should be displayed at each stoppage to ensure correct details to pedestrians about available routes and destinations.
- **Sidewalk and Large Pedestrian Network**: Walking should be ensured as the "first and last mile" for transit trips, and that must be continuous, accessible, and connecting

to/from more extensive networks of footpaths and off-road, multi-use trails (McNeil et al., 2017).

- **Public transit, parking, and Inter-city bus/rail connectivity**: Primarily, the walkable movement should have sufficient first- and last-mile connectivity to the local transportation modes (e.g., bike parking, public transit, and private transportation). Moreover, to improve pedestrian access, the transit stops must be reachable from park and ride areas with crosswalks and curb ramps. Secondly, safe pedestrian access should also have connectivity to private intercity bus/rail transportation.

2.9.3 Ideal Walk Appeal Attributes

Attractive and cozy walking paths significantly upsurge the possibility that more people will decide to walk during active transitions. Several Active Research specifies economic, social, and specific street-scale safety benefits to encourage (L. M. Braun, A. Read, 2015). It is possible to attain comfort in walkability through a variety of uses, access to daily-use locations, and multi-modal connection (Steuteville, 2019). During the audit, observation should be on whether features are present or nearby that can be added to the comfort and appeal of an area. Ideal walk appeal features can be assessed by following aspects identified from several empirical studies (Hall & Ram, 2018).

- **Connect Sidewalks**: Sidewalks are fantastic, but their usefulness drops dramatically when they are not connected. Pedestrians need a continuous route to reach their destination safely.
- **Install Physical Barriers**: Busy streets are problem areas for speeding traffic and can result in close calls for pedestrians. Protect pedestrians while maintaining the aesthetics of the surrounding environment by using bollards or trees as a barrier.
- **Provide Adequate Lighting**: Walking does not end after sunset. Keep walking routes safe and comfortable for pedestrians with plenty of light.
- **Calm Traffic in Pedestrian Zones**: Side-routes are meant to be pedestrian friendly, but distracted drivers can still be a hazard. Remind drivers to slow down with traffic calming initiatives such as speed humps, signage, and crosswalk lights
- **Create Inspiring Spaces**: People want to be entertained during their walks and are more likely to spend time in areas with visually interesting buildings, art, and infrastructure.

- **Create A Natural Sense of Enclosure**: Enclosed spaces make people feel more secure. Bushes, trees, and flower beds are effective landscaping tools to make pedestrians feel comfortable in an outdoor space.
- **Separate Walkways from Parking Lots**: Parking lots can be an eyesore and look out of place in an otherwise pleasant walking environment. The influx of cars driving in and out of the lot can be noisy, distracting, and even dangerous. Avoid intersecting major walking routes with parking lots wherever possible.
- **Build Parks**: Parks serve as a peaceful space for pedestrians to visit or walk through on their way to their destination. This also works to increase the number of walking trips.

2.10 Local Guidelines for Walkability

For attaining safe, affordable, sustainable, and integrated communities, the Dhaka Structure Plan DSP 2015, Revised Strategic Transport Plan (RSTP 2015), Dhaka Transport Coordination Authority (DTCA), and Detail Area Plan (DAP 2022) have addressed some objectives and strategies to improve inter-connected communication in urban centers, where any mentions of walkability are typically only a few paragraphs.

2.10.1 The Urban Transport Policy (2004) by DTCA

Dhaka Transport Coordination Authority is the primary government agency in charge of public transportation in Dhaka division. Within several pages of research, reports, and policies in Bangladesh, very little has been practical about walkable pedestrians. The Urban Transport policy by DTCA has identified 14 key issues relating to the transport system for policy documentation to guide future megacity development. That includes creating a 'pedestrian priority' system to enhance pedestrian provisions. Among 69 policies under different transportation issues, the following approach no; and 34 (point no. 02) addressed pedestrian priority.

- Policy 34: The government will implement a "Pedestrian First Policy" to guarantee the development of suitably planned and continuous footpaths with clearly marked and maintained pedestrian routes in the city. The presence of pedestrian crossing facilities ensures that pedestrians have priority over all other traffic and forbids unauthorized use of the footpath by others, such as hawkers. (The Urban Transport Policy, 2004).

In the vision of providing transport for people experiencing poverty and being differently able, policies 49 and 50 have been stated in Urban Transport Policy by DTCA in Chapter 11.

- Policy 49: The Government will amend the city roads' construction standards and incorporate adequately planned walkways into their designs, especially on principal and minor roadways and in denser metropolitan areas (The Urban Transport Policy, 2004).

- Policy 50: All city roads will be redesigned to include continuous footpaths, and where possible and necessary, the pathways will be equipped with built-in ramps to make it easier for people with disabilities to move around. (The Urban Transport Policy, 2004).

Though these policy initiatives and statements in Urban Transport Policy has written, the Context-based issues have not yet been identified by focusing on these policies to initiate construction standards. The DTCA has also initiated the Pedestrian Safety Policy Draft 2021, summarized in the following paragraph.

2.10.2 Revised Strategic Transportation Plan (RSTP 2015) by DTCA

A number of transport development policies have been identified by RSTP 2015 (JICA & DTCA, 2015). Urban transportation's overarching objective is to: "Ensure mobility and accessibility to its people and society, through safety, amenity and equity – towards the development for more than 60% share of the total urban transport demand." Directly walkability issues are not initiated in RSTP, but the environment-friendly effective accessibility management mentioned in the RSTP planning objective can be attainable enough through comprehensive development of walkability. A condensed area of mixed-use development known as a "transit oriented development" (TOD) is created to maximize access to public transportation located within a radius of 400 (around a 5-minute walk) to 800 m from a transit stop (around a 10-minute walk). Due to its heavily populated metropolitan areas, Dhaka is a good candidate for TOD. As intended, Dhaka's goal is to transform the CBD into well-designed areas with reliable public transportation and easy access to a variety of retail services, and recreational facilities while maintaining a cultural and historical value. Hence, improvement in walkability can be the initial effective part of this total transport development goal. Within these development measures of Road Network by RSTP (JICA & DTCA, 2015), the improvement of the walkable phenomenon is interconnected with two issues: functional road classification, and supporting public transportation. Hence the issue of functional road classification needs to identify first.

a. Classification and Cross-Section of Road Configuration

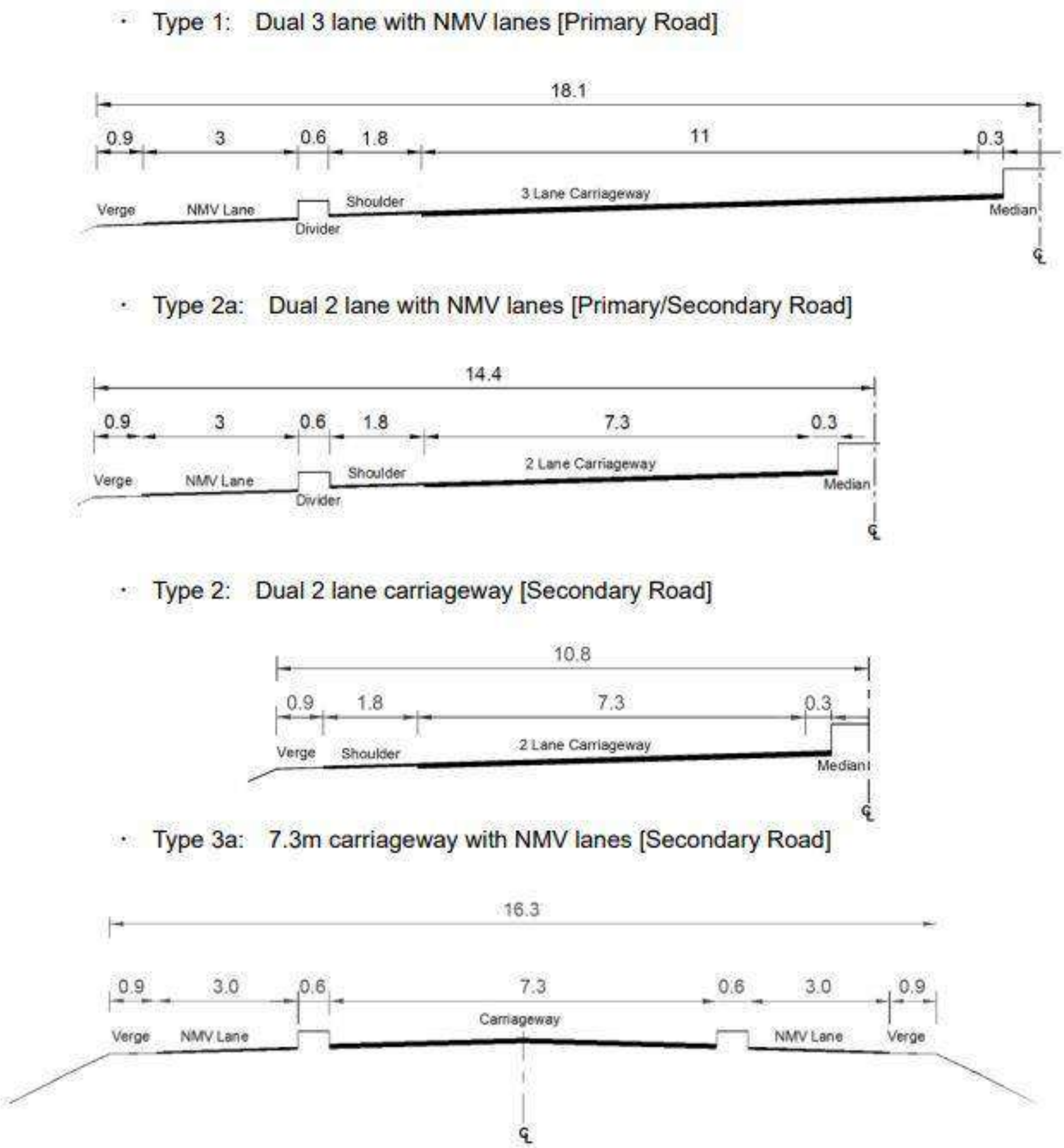
Future land use scenarios, forecasted traffic demand, and challenges with the current road system are used to generate the development plans for the road network. As part of the Dhaka Urban Transport Project (DUTP), a road referencing database for the DCC road network was developed in 2002. In order to prepare the database, 1,286 kilometers of survey roads were divided into the following five groups based on a functional hierarchy (JICA & DTCA, 2015):

- **Primary Roads**: Inter-zonal roads; access control; full restriction of non-motorized traffic and grade separation at major intersections.
- **Secondary Roads**: Intra-zonal roads; access control; segregating motorized and non-motorized traffic.
- **Connector Roads**: Intra-zonal roads; full frontage access; partial segregation of motorized and non-motorized traffic; and segregation of opposing traffic flow.
- **Local Roads**: Full frontage access; no segregation of traffic; and provision for using some calming traffic measures.
- **Narrow Roads**: The road should only be used as a one-way street because it is too narrow for cars to pass each other. In addition, the width of the narrow road must be less than 4.75 meters, and if it is less than 3 meters, it must be pedestrian-only.

  For creating a functional road network, functional road classification is vital. The standard cross-section is the basic foundation for the current road network in the metropolitan area. According to RSTP and DHUTS, the principal and minor roads have carriageways, a median, walkways, and utility space.

The majority of the lane indicators in Dhaka are decrepit and essentially nonexistent. Because to the unclear lane and shoulder boundaries and the lack of channelization, traffic flow is complicated. Typically, large arterial routes include walkways on both sides. However, the sidewalks' width is insufficient for the existing need for pedestrians. Additionally, street merchants set up shop on the sidewalks, which are frequently used as parking places. This phenomenon results in the propensity towards the pedestrian to walk on the highway, hampering smooth traffic flows.

Following the classification, RSTP 2015 suggests some design requirements and traffic control strategies in accordance with typical cross-section (Table 2.2) (primarily used from "Geometric Design Standards for Roads and Railways Division, RHD 2000"). The abundance of NMVs and pedestrians on Bangladeshi roadways is one of its unique features. Each component of the cross-section should be carefully considered, by taking into account the specifics of the project region, such as the necessary NMV lanes, walkways, bus bays/stopping areas, and carriageway and shoulder width (Table 2.3 and Figure 2.5).



Note: NMV lanes can be replaced with service lanes
Source: Geometric Design Standards for Roads and Highway Department, RHD, 2000

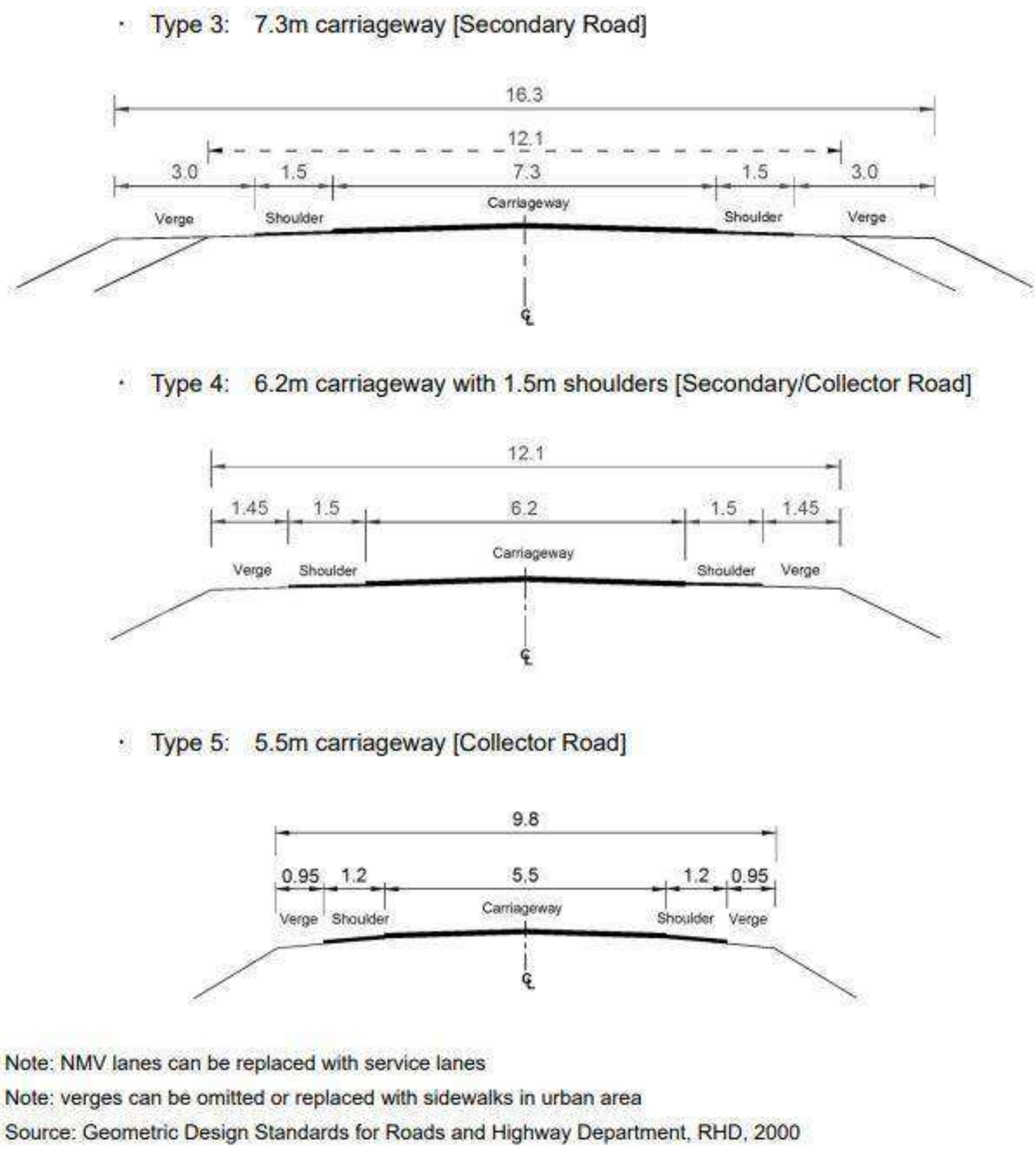


Figure 2.5: Cross-Section of Lane Configuration

Table 2.3: Requirements According to Road Classification (JICA & DTCA, 2015)

Item	Road classification			
	expressway	Primary road	Secondary road	Collector road
Access control	Full-access controlled	Limited-access controlled	Non-access controlled	Non-access controlled
Structure	Embankment/viaduct	AT-grade (flyover)	AT-grade	AT-grade
Design speed (km/h)	100, 80, 60	80, 60	50, 40	40, 30
Number of lanes	4-8	4-8	2-4	2-4
Pedestrian facilities	N/A	Dual sidewalk	Dual sidewalk	If required
Bus lanes	N/A	Possible	Possible	N/A
Rickshaw	Prohibited	Prohibited	Possible	Possible

The capacity of the road for traffic will be greatly reduced if suitable NMV lanes are not provided, especially in areas with high traffic. In most cases, pedestrians are able to share the paved shoulder; however, shoulders must be wide enough and have a smooth surface in areas where there are a lot of pedestrians, or a separate footway must be created.

b. Sidewalk Space Improvement Initiatives

Sidewalks are important not only as a component of road facilities to ensure smoother traffic flow but also as space for various socio-economic activities and as an urban landscape element. Sidewalks have two basic functions - traffic function and space function. For traffic function, sidewalks serve as: (i) space for pedestrian traffic, (ii) access to roadside facilities, and (iii) storage space for vehicles. As for the space function, sidewalks contribute to: (i) urban formation and landscape, (ii) environment improvement, and (iii) provision of space for utilities. With increased motorization and economic development, Dhaka's sidewalks have become motorcycle parking lots with significant encroachment from roadside businesses. The fundamental direction of the city's future policies should be toward a public transportation-based metropolitan region. The urban landscape of Dhaka should be enhanced by tree-lined sidewalk, improved sidewalk surface with asphalt, concrete, and concrete block pavement, along with street lights, planting, and signboards, ensuring proper maintenance. At the very least, a good walking environment must be restored along with urban area rehabilitation.

a. Pedestrian Safety Policy (Draft 2021) by DTCA

A pedestrian network for movement requires uninterrupted easy access to reach destinations and must be constructed coherently. Initially, walkable space constructions are guided in DTCA (giving utmost priority to the pedestrian) within three zones separately (considering the usability of the footpath) with ramp facilities for all the users, especially for the differently abled, sick, and aged people, following the Urban Transport Policy no. 50. These are the frontage zone, passer-by zone, and the street furniture zone.

During the construction of the footpath, the level of the entry of the adjacent building and the footpath are recommended to be maintained in the same plane. The footpath must be continuously wide with a separate place for street furniture, utility service, and green furnishing adjacent to the primary road so that the users are not discouraged from using it. Based on the land use and user density, the footpath land and width should be considered based on the following measurements mentioned in Schedule- 1, Table 2.4, in DTCA.

Table 2.4: Standard Walkable Space Dimension Introduced ((DTCA), 2021)

Land use type	Frontage zone min. width (m)	Pedestrian zone min. width (m)	Furniture zone min. width (m)	Total min. width (m)	Pedestrian capacity per hour (pers.)	Footpath height
Residential area	0.5	1.8	1.0	3.3	1000	Up to 15cm
Commercial area	1.0	2.5	1.5	5.0	2500	Up to 15cm
Busy and greater commercial area	1.0	4.0	1.5	6.5	5000	Up to 15cm

N.B: International standard was followed to fix the minimum width of the footpath. However, this can be changed due to the actual scenario and the safety of the pedestrians.

Adequate lighting, sign signal, and markings are recommended for an attractive, safe, and uninterrupted walkable environment. The pedestrian crossing should be designed considering the pedestrian's age, type, and physical ability and based on the ease of movement. Apart from the signal for pedestrian crossing, a proper location like a zebra crossing, foot-over bridge, underpass, or similar facilities for crossing must be identified with a significant signal. Considering the pedestrian-first policy, the at-grade crossing facility should be given priority. Places where at-grade crossing is not possible, like railway platforms, roads wider than standard four-lane roads where traffic load is high, motorway/ express crossings, BRT station, MRT station, and transit stations, should have grade-separated facilities like a ramp or lift or escalator for underpass or foot over the bridge so that easy and safe movement for all the users can be ensured. Pedestrian crossings shall be designed geometrically (as per schedule_1) following the road level so that the view of the pedestrians is not obstructed by the plants, landscaping, and utility poles installed in the furniture zone of the footpath and the parked vehicles. The following pedestrian crossing facilities can be established near the convenient pace of road intersections or in the middle zone.

- The crossing way should be designed so that the pedestrian can easily and safely cross the road by passing a minimum distance—arrange of electric signal with a pushbutton for pedestrian crossing (pelican crossing) where needed.

- Road dividers or fencing should be used to control random pedestrian crossings and to provide railing or control to both sides of the footpath.

Utility holes, and dustbins, should be placed so they do not obstruct pedestrian movement. Utility-hole openings should always be closed with a lid, and construction materials, goods, and wastes should never be kept in the adjacent footpath. The following section enlarges the proposal of some design guidelines by DTCA with (Accident Research Institute) ARI at different intersections for safe pedestrian mobility (Authority & Institute, 2022).

b. Design Guidelines Focusing on Pedestrian Safety (DTCA and ARI)

The DTCA and ARI presented specific design guidelines for street intersections that prioritize walkability, such as minor and small neighbourhood intersections, such as 4 vs. 2-way intersections, 4 by 4 lane intersections, 4 to 6 lane interactions, 6 to 8 lane intersections, complex and multi-leg intersections with additional space (Authority & Institute, 2022). Some major feasible and practical design guidelines for improving a safe walkable phenomenon has been summarized in the following facts below.

- Raised pedestrian crosswalks or crossings are the main recommendation for neighbourhood intersections in cases with high volumes of pedestrian traffic to slow down traffic.
- The complex crossroads location has been suggested for "expanded sidewalks and central plazas, giving space to street vendors" to improve user flow. Moreover, dedicated separated transit must be made available on all major roadways with the refugee island as a boarding point.
- In 4- to 6-lane crossroads, pedestrian overpasses must be eliminated and replaced with at-grade crossings.
- The turning radius and lane width at intersection corners should be decreased to accommodate increased pedestrian traffic.
- To lessen the number of streets colliding concurrently, residual space at multi-leg intersection places must be transformed into a pedestrian plaza.
- A shorter crossing distance for pedestrians and the ability to move curb-side parking from the intersection to the side road are two benefits of curb extension that can be applied to multiple-lane segments.

2.10.3 Detail Area Plan (DAP 2022-2035)

Suitable for pedestrian movement act as one of the controllers of urban lifeline, while the main subject of the Detailed Area Plan (DAP) is vibrant urban living. In this case, the design of footpaths should be formulated based on the land use after identifying whether there is suitable space for pedestrian movement. Pedestrian movements are vitally generated within urban commercial settlements where transit-oriented development is substantially required. According to the DAP 2022, transit-oriented development guidelines have inaugurated the pedestrian-friendly communication system with the entire mass transit system**.** Subsequently, the creation of public space, the administration of parking at intersections within 10 meters of the station, and the installation of a bicycle rental system were implemented.

These are the issues included in the well-planned transit movement. As part of the urban lifeline, some general guidelines have been given for road segments (stated in the following section) so that the city's people can travel freely. Apart from this, the footpath is designed as a part of the urban lifeline at the cross-section of the road. DAP 2022 and Dhaka Structure Plan (DSP)'2016 initiated a standard pedestrian cross-section of different parts of pavement (Fig: 2.6).

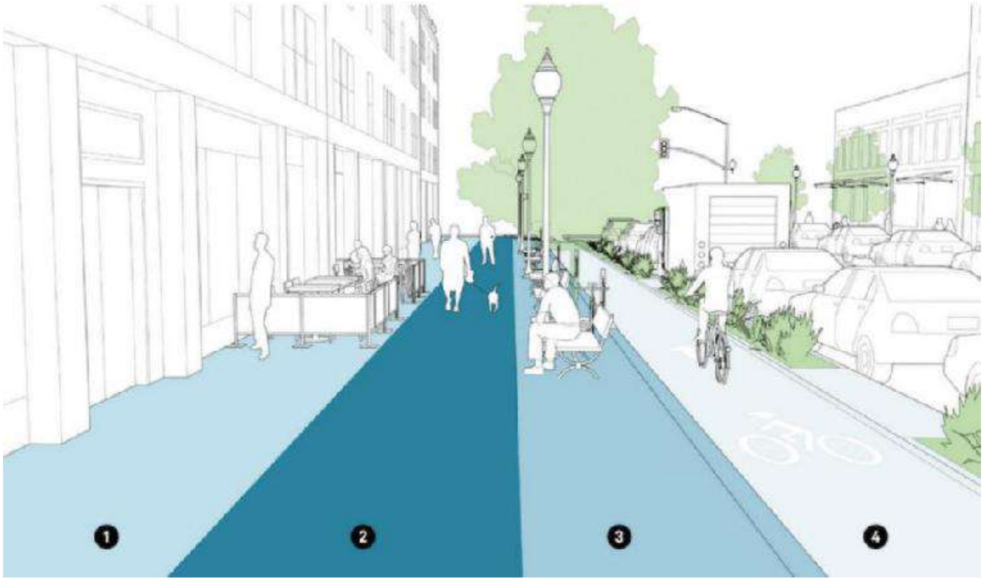


Figure 2.6: Cross Section of Different Parts of the Pavement (Kartripakkha, Works, & Development, 2015)

Dimensions for the width of different zones of the footpath depending on the land use are mentioned in Table 2.5. Different parts of the footpath are shown in the above cross-section.

1. Frontage Zone: Extended area of building connected to the Property line.
2. Through Route: The area parallel to the road which is used for pedestrian traffic only
3. Utility Zone: The space between the elevated sections separating footpaths from roads and pedestrian movement, which is used for electric poles, benches, landscaping, and bicycle parking.

Table 2.5: Recommended Widths of Sidewalks Based on Zonal Land Use (Detail Area Plan, 2022b)

Land use	**Maximum pedestrian Movement**	**Frontage zone, (m)**	**Through the route, (m)**	**Utility zone, (m)**	**Total, (m)**
Central business district	80 people/minute	1	3- 4	1.5	5- 6.5
Parks, schools, and other places, where Pedestrian traffic is high					
Local roads (commercial)	60 people/minute	1	2- 2.5	1.5	4.5- 5
The commercial area outside the central business zone					
Residential area	50 people/minute	0.5-1	1.5- 1.8	1	3- 3.8
Collector/distributor road					

(a) Road Hierarchy with Pedestrian Instructions

In all the previous plans, only the road width is considered to determine the classification of Roads. Various government development organizations undertake road widening and new road planning implementations through unrealistic plans. It can be noted here in the case of planning or implementation for vehicular movement less than 40 feet wide road and pedestrian traffic less than 20 feet wide streets are prohibited under the Authority of Town Improvement Act, 1953 (RAJUK).

Based on the functionality of existing roads in the Detailed Regional Plan (2022-2035), four types of road classification are proposed (Fig: 2.7):

- Inter-Regional Connector Road
- Intra-Regional Connector Road
- Collector/Distributor Road
- Local/Access Road.

Inter-Regional Connector Road

Through which roads from various sub-regions of Rajuk region vehicles will travel in different parts of the country, those roads will be considered inter-regional connecting road. For example, from Gabtali in the capital Dhaka via Savar, the road that connects the southern part of the country will be regarded as an inter-regional connecting road. Pedestrians on both sides of inter-regional connecting roads should be at least 15-25 feet for movement.

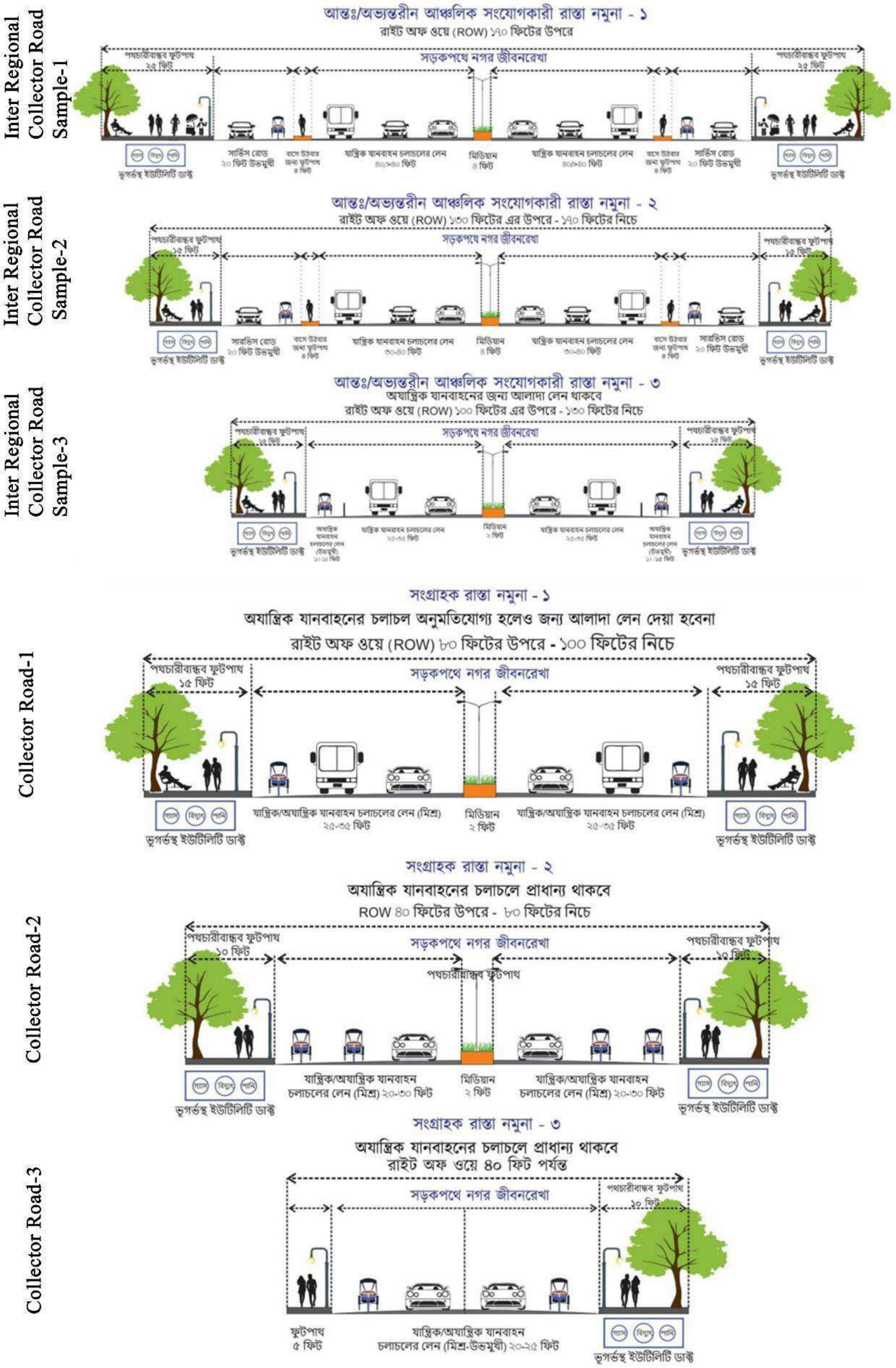


Figure 2.7: Road Classification and Lane Configuration (Detail Area Plan, 2022)

Intra-Regional Connector Road

The roads by which each sub-region of the RAJUK will maintain connections with each other are to be considered as Intra- Regional Connector Roads. For example, the road connecting the Mirpur area of the capital Dhaka with the Motijheel area will be regarded as an Intra-Regional Connector Road. Considerations for the selection of intra-regional connecting roads are as follows: On both sides of the intra-regional connecting road, for pedestrian movement, keep at least 15-25 feet of urban lifeline (footpath, places designated for greening, for pedestrian traffic, other civic Amenities such as seating, small-size commercial activities, and lamp post) and including local connecting lane (at least 10 feet in less densely populated areas/ on narrower roads (Motorized vehicles only) Furthermore, a maximum of 20 ft in densely populated areas/ on wider roads). There must be facilities for at least two lanes for vehicular traffic and adequate provision for non-motorized vehicles in the intra-regional connecting road.

Collector/Distributor Road

Roads from the local area that will link the inter-regional link Inter-Regional Connector Road with the Intra-Regional Connector Road and collect or distribute traffic from access/local roads are considered collector/ distributor roads. Considerations for the selection of Collector/Distributor roads are as follows: On both sides of connecting road (minimum 10 ft)/one side (at least 15 ft) Wide urban lifeline (footpath, places designated for greening, for pedestrian traffic, other civic amenities such as seating, small size commercial activities, lamp post) should be provided.

Local/Access Road

All the roads except the first three mentioned classifications will be considered local/access roads. Provision for footpaths can be kept based on the width of the local/access road, and especially narrow roads should be given more importance for pedestrian movement only.

(b) Connectivity and Shared Walkable Space

Pedestrian connectivity underlines the crossing connectivity within the entire walking network. Road junctions should be pedestrian-friendly to avoid conflict and safely assist in crossing roads. The zebra crossing and foot-over bridge [pedestrian bridge] can be used. DAP entails that the Pedestrian crossing in the middle of the road should be 200 meters for safe crossing. There should be signals in an appropriate place for crossing. In the case of narrow roads, separate instructions for the footpaths may not be provided due to lack of space. In this case, Pedestrians, motor vehicles, and non-motorized vehicles can share the same road. In shared spaces, pedestrians will get priority. These roads will impact changing the overall appearance of the city.

- This zone should be defined by indicating the entry and exit of the traffic movement.
- Motor vehicle speed of 10-15 km/h is ideal for this area. For speed Management and control, different colors and structures can be used on the upper surface of the road. Various speed control mechanisms (Speed bumps) can be used, which should be located at a minimum consecutive distance of 40 meters.
- Common elements that separate different modes of transportation, such as vertical curbs, level differences, signs, colours or pavement markings, shouldn't be present on shared streets. Nevertheless, this intervention can create the scope of features that promote pedestrian priority and widens walkable space with street furniture, landscaping, and gathering spaces. These design cues promote user-friendly walkability where vehicles travel at lower speeds.

(c) Pedestrian Extension Guidelines

Pedestrian extension requirement is quietly related to the space of vehicular transit space. In the case of extending the pedestrian space, designers cannot reduce the vehicular road width while vehicular transitions are increasing aggressively beyond the future prediction. So, in case of extending the existing inadequate mass transit space, DAP 2022 has encrypted some guidelines consulting with the authority of the urban planning department at DTCA stated below.

- ➢ For the road widening, acquisition of individually owned land is allowed without any restrictions to widen existing roads up to 40 feet following the collector road pattern-3.
- ➢ The exact amount of width as identified by the Metropolitan Survey (MS/RS) must be followed (however, maintain the existing road if it is wider than that).
- ➢ In this case, the authority can widen the existing road width to 5 feet without public opinion only for pedestrian movement. It should be noted that this guideline does not mention on which side (vehicular side or property line) this 5 feet can be expandable.
- ➢ However, if more widening is required, 80% of the public opinion is to be considered for widening.

➢ For further widening, adjacent parallel roads can be made one-way to ensure vehicular movement only.

(d) Pedestrian Amenities

Pedestrians must be safe and accessible for all users, regardless of physical abilities or age. They ought to have public art, seats, cafes, awnings, trees, signage, and be at once cozy, scaled for people, and colorful. Simple Maintenance Sidewalks ought to be strong and made of locally sourced and recycled materials where feasible. Walkways should be designed to divert storm-water to the soil rather than to pipes wherever possible, including rain gardens and permeable paving. Trees with shade should be installed for comfort throughout the summer with a certain distance specified in Fig: 2.8 according to DSP 2015-2035, without interfering with the first-floor uses, entryways, loading zones, or within 3m of the bus stop. Table 2.6 explains the dimensions of pedestrian furnishing that can be used ((DTCA), 2021).

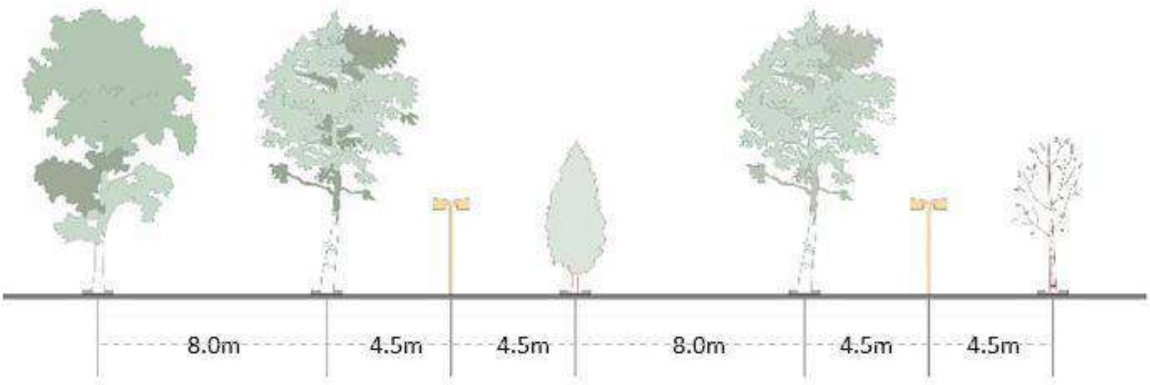


Figure 2.8: Green Furnishing Spacing Guidelines (*Dhaka Structure Plan 2016-2035*, 2016)

Table 2.6: Dimensions of Furnishing Used on Walkways ((DTCA), 2021)

FURNITURE	GENERAL DIMENSIONS	HEIGHT	FIXED PLACE
BENCH	2.4 m to 0.75 m	0.7-1 m	At a distance of 50-60m consecutively, especially at passenger shade.
PASSENGER SHADE	2.6 m to 1.4 m	2.5 m	Depending on the bus service
SIGNS	Pole with a diameter of 65 mm	2.1 m	Based on the bus management company
BICYCLE PARKING SPACE	0.75-1.0 mm	0.75 m	Based on the cyclist
WASTES	Diameter of 0.8 m	1.3 m	Based on the amount of waste

1. Pedestrian Hawker Management

The elements of urban lifelines should be coordinated in the footpaths with the specific zone. Already hawker management has been mentioned in Chapter 6 of Dhaka Structure Plan 2016-2035. Policy-2.1 (Policy ECO2.1) under Objective-2. Hawker management guidelines in the detailed regional plan (DAP) have been formulated in this continuation. This hawker management instruction will apply to all regions. In this case, area-wise concerned administrative bodies can use footpath design guidelines according to their needs. According to this statement, the hawing activity along walkable space has been allowed with other urban lifeline amenities. Specific guidelines mentioned in DAP 2022 based on the type of hawkers at specified places by the City Corporation are mentioned below.

- Buying and selling goods in vans can be done where there is a lack of space on sidewalks and streets.
- The hawkers who have dedicated space will not be treated as mobile hawkers.
- The dedicated area for hawkers must be in the Residential/Commercial/Mixed Use area and adjacent to collector/local road, i.e., where there is likely to be enough customer traffic.
- The maximum area allotted to each hawker (including the buyer's stand) will be determined by the authority to keep adequate space on the footpath for pedestrian movement.
- A minimum 1-meter space is to be kept for the buyer's movement
- Hawkers will not be able to establish any permanent establishment to obstruct the movement of pedestrians.
- A minimum of 60 percent of space without hawkers must be kept for other amenities.
- Thirty percent of space must be reserved for women and differently able hawkers.

2.11 CBD in the Context of Dhaka

Dhaka Sub-Zone 19, according to DAP Vol. 02, the (CBD-Motijheel) region consists of densely populated areas, including DSCC Ward No. 8, 9, 10, 11, and 13 Dilkusha (Motijheel) commercial hub and some of its surroundings. Important areas like Kamalaparu, Fakirapal, Rambagh, Paltan, Shantinagar, Rajarbagh, Khilgaon, Gulistan, Gulistan Park, Maulana Bhasani National Hockey Stadium, Bangabandhu National Stadium, Rajarbagh Palush Lines,

Kamlaparu Railway Station, and many more important government and private establishments, including National Mosque Baitul Mukarram exist in this area.
According to Bangladesh Census 2011, this sub-region population is approximately two lac 18 thousand 578, and per acre, the Population density is 212 (Table 2.7). The population growth rate is low, which will decrease to 1.01% by 2025. According to the population density of this sub-region in 2025, this estimate will stand (per acre) at approximately 254. The special facilities of the area are Kamalapuru Railway Station, Gulistan, and the Motijheel bus hub. The protected areas are Bangabandhu Stadium, Hockey Stadium, and Banga Bhavan.

Table 2.7: Existing and Potential Population of Dhaka Sub-Region 19 (Motijheel CBD) by 2025 (BBS, 2014)

Volume (Acres)	**Population (2011)**	**Population Density (2011) (Per Acres)**	**Population Growth Rate**			**Estimated/Projected Population**			**Estimated Population Density (Acres)**		
			2011-2015	2016-2020	2021-2025	2015	2020	2025	2015	2020	2025
1028.59	218,578	212	1.3	1.35	1.01	233,160	289,329	262,177	226	242	254

It is mainly a commercial area, and something besides Residential and mixed uses also exists. People of this region mainly travel by foot, rickshaw, tempo, and bus. However, many people also travel in privately owned vehicles. Trade and employment make up the majority of people's occupations in this area. Mostly middle and upper-middle-class people live in this region. Due to sedimentation in this region, the level of groundwater flow is high, and without proper drainage and reservoir system, there will be more tendency and risk of flooding here.

The sub-region's maximum existing land use appears to be residential (25.93%), and mixed-use is about 12.03 percent. On the other hand, land use is (27.51%) in transport and communication (Table 2.8). The required amount of open space and social facilities is quite lacking in this area, considering Residential and mixed-use volumes.

Table 2.8: Non-standard Land use of Dhaka sub-region 19 (Motijheel CBD) (Detail Area Plan, 2022a)

Sub-Region	**Land use Classification**	**Area (acres)**	**Area (acres)**	**Percentage (%)**
Dhaka Sub-Region-019	Residential	266.74	107.99	25.93
	Transportation and communication	282.98	114.57	27.51
	Commercial	133.57	54.08	12.99
	mixed-use	123.76	50.11	12.03
	Preserved	97.96	39.66	9.52
	Open space	32.37	13.11	3.15
	Education and Research	31.50	12.75	3.06
	Social facilities	21.96	8.89	2.13
	Institutional /Professional	19.16	7.76	1.86
	Reservoir	10.04	4.06	0.98
	Health facilities	7.61	3.08	0.74
	Industries	0.94	0.38	0.09
	Total	1028.59	416.43	100.0

A maximum of 301.85 acres (29.35%) of land use is proposed for the existing transport and communication network and 126.41 acres (12.29%) as a residential area. It is noted here that about 45.02 acres (4.38%) of the area is proposed for open space. The area has the highest level of paved roads, around 98 percent. On the other hand, this area has fewer unpaved roads (1.1 km.). This sub-region has approximately 13 percent of roads less than 8 feet wide, and about 66% of the road is less than 20 feet wide. 16.99 km in this sub-region with proposed land use is suggested to widen, and no new road is proposed. The car parking problem is prominent in Motijheel commercial area. Except for the main road inside Motijheel commercial area, the entire area can be declared car-free (Detail Area Plan, 2022a). For efficient traffic circulation in the commercial location of Motijheel, hawkers must be effectively managed.

2.12 Local Practices and Initiatives

In the vision of development regarding walkability and pedestrian facilities with the improvement of public transport facilities of Satmosjid Road, Dhanmondi, an interim report for preliminary design development has been initiated by DTCA consulting with Vitti Sthapati Brindo Ltd JV. Troyee Associates (Associates, 2021).

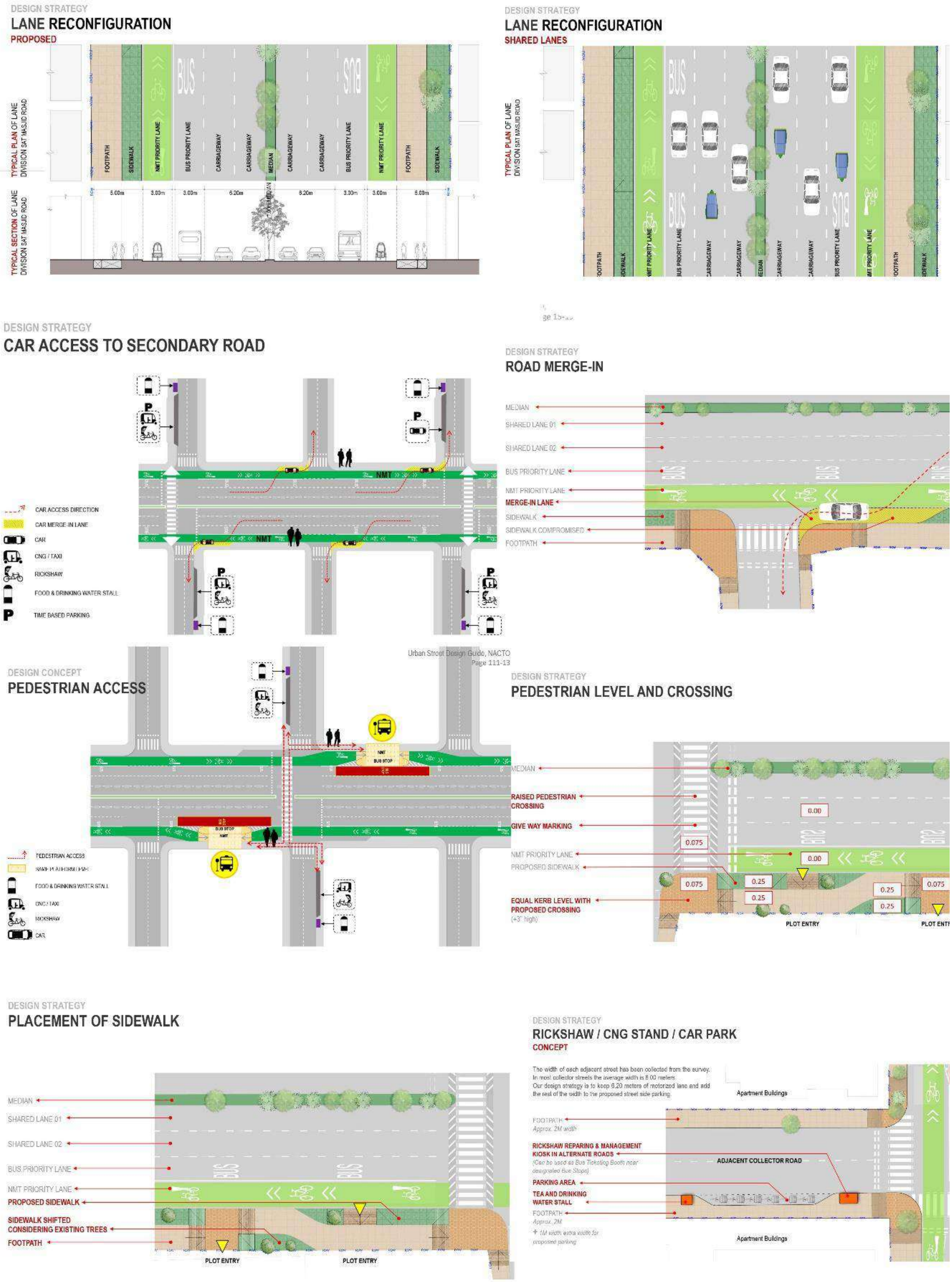


Figure 2.9: Initiated Design Strategy for Walkability Development in Dhanmondi, Dhaka.

In the report phase, the existing walkable situation with catchment area, traffic analysis, and street features has been deeply observed.

Following the project considerations regarding design strategy has been developed, such as Lane configuration, Designated car access to secondary road, NMT priority lane, Road merging treatment, Sidewalk placement and pedestrian access, Plantation management, Shifted sidewalk considering trees, Median shift, Footpath ramp, Raised pedestrian crossing, Equal Curb-Level with proposed crossing, Rickshaw repairing management kiosk in alternate road, Tea-stall provisions with designated footpath, Utility management, Plot access, Bus stoppage, and Parking provisions. Detail illustration of these design strategies on specific street segments has been presented in Figure 2.9.

Street sellers have applauded the Dhaka North City Corporation's decision to provide them with authorized space on walkways instead of evicting them. In the Mirpur Circle 10 neighborhood, street vendors made it nearly impossible for people to walk on the sidewalks, and cars and rickshaws parked next to the road made matters worse. Since the vendors returned after the law enforcement left, evicting them did not end the crisis.

In light of this, the Dhaka North City Corporation and BRAC have started a new project in a pilot phase to control the street vendors and clear space for pedestrians on the footpath, allowing footpath shops to operate five days a week only from 4 pm to 10 pm in designated zones without keeping any goods on the footpath other than the business hours. Maqsud Hashem, chief town planner of Dhaka North City Corporation, and Md Washim Akhter, program coordinator to Brac Urban Development Programme (UDP), said, "The core of the initiative is to create a policy for street vendors. A list of area-based hawkers will be prepared to accommodate them. There will be a specific place marked on the pavement where the shops should be set up, leaving a pedestrian walkway".

Mohammad Fazle Reza Sumon, the president of the Bangladesh Institute of Planners (BIP), welcomed the initiative to control the street vendors, and said "The eviction of hawkers is never a sustainable solution. Almost all countries across the world have hawkers or street vendors. In Thailand, hawkers are permitted to sit on sidewalks during specific hours. Malaysia also has hawker-specific areas. Holiday markets can be found in many nations, and there are designated hawker areas also."

2.13 Global Practices and Initiatives

Numerous cities throughout the world have started to change their mobility from car-oriented toward pedestrian-friendly access, depending on their goals. For instance, several cities, like Hamburg and Madrid, have plans to partially ban the use of cars. Others, like Copenhagen, Milan, and Paris, adopted car-free days, made investments in infrastructure for pedestrians and cyclists, limited parking, and boosted the availability of public transportation (Nieuwenhuijsen & Khreis, 2016). These many methods of implementation have been designed to achieve a variety of objectives, discussed in following sub-sections.

a) Pedestrian expansion

The Berrini Train Station in So Paulo and the city's core business district are connected by Joel Carlos Borges Street, which is home to numerous everyday patrons. Prior to September 2017, the street's confined sidewalks were unable to securely handle the dense foot traffic (about 22.5 persons per vehicle during peak hours). With an additional 3.5 meters of width, the previously cramped and dilapidated sidewalks now have enough room for foot traffic after expansion. The quality of life and safety of everyone are improved by enlarging walkways and narrowing car lanes, which also slow down traffic.

Before After

Figure 2.10: Rua Joel Carlos Borges, São Paulo, Brazil, September 2017 (Venter, Mahendra, & Hidalgo, 2019)

This updated "complete streets" concept creates safer driving conditions and serves as a reminder to drivers that they should prioritize pedestrian safety when operating a vehicle. 92% of those surveyed believed that the roadway had become safer and more comfortable after the pedestrian expansion. The city is now thinking about launching similar initiatives elsewhere.

b) Full-time pedestrian

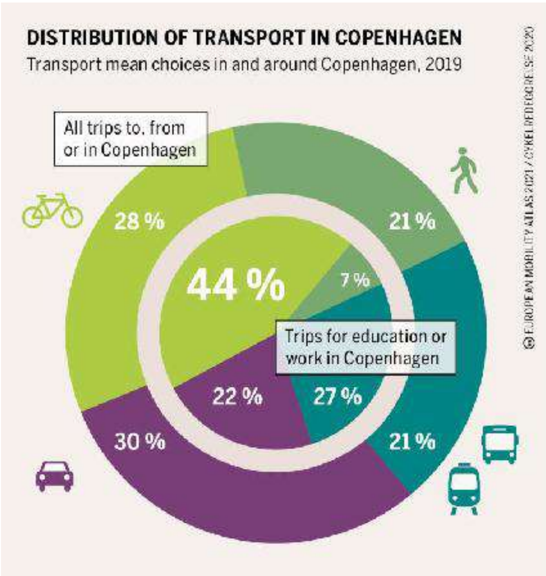
Australian city's aim was related to land use and transport patterns improvements. Closer to the North American scheme, Australia implemented its first pedestrian malls in 1970 by banning cars from the core of three cities; then, the concept was spread over the rest of the cities across the continent. Similar to their North American counterparts, citizens of Melbourne opposed the act of banning cars. Still, they did not face a safety problem, so the municipality assigned the leading architect Jan Gehl to solve the case, who proposed a part-time street closure during lunchtime to re-introduce the public space. After a decade, the Melbourne CBD received an increased average of pedestrians during the day and evening. The same technique was followed by other cities in Australia, like the state of Queensland, which started a temporary pedestrian mall in 1973; after a decade, it was expanded due to its popularity and increased number of visitors, either locals or tourists. On the other hand, research suggests that retailers react negatively to introducing a pedestrian promenade due to their dread of increased rent and overcrowding (Parajuli & Pojani, 2018).

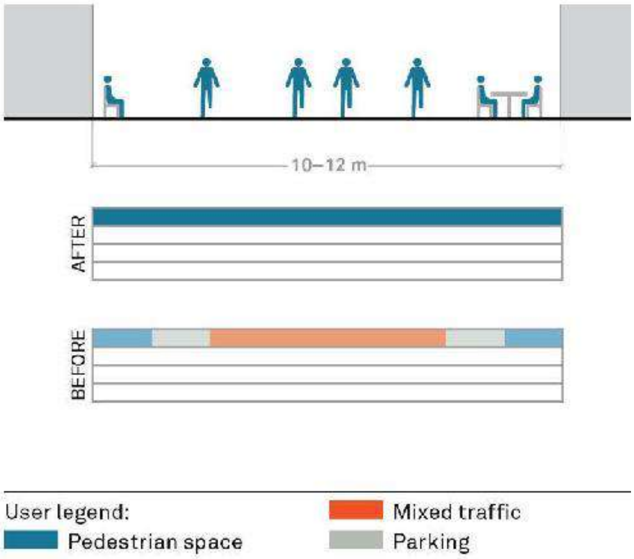
Until 1962, all the streets and squares of central Copenhagen were used intensively for vehicle traffic and parking, and were under pressure from the rapidly growing fleet of private vehicles. The pedestrianization of Copenhagen began with the city’s main street, Stroget, which was converted in 1962 as an experiment. The conversion of the 1.15 km-long main street into a pedestrian street was seen as a pioneering effort, which gave rise to much public debate before the street was converted. Soon, Stroget proved to be a huge success, with businesses realizing that traffic-free environments provide increased financial revenue. Magasin Torv, the square by Nikolaj Church, and Grabrodre Torv were the first squares to be renovated. The Key elements was to Removal of all traffic from the street, Removal of curbs and sidewalks, addition of new paving, and Consolidation of street furniture to facilitate pedestrian movement. The ultimate Goals was to

- Improve connectivity in the city center.
- Provide a high-quality and attractive environment.
- Create a space that supports businesses.
- Encourage a diverse range of people to live and spend time in the city center.
- Revitalize the city’s forgotten alleyways by turning them into vibrant laneways.

Before

After





Source: Distribution of transport in Copenhagen; Heinrich-Böll-Stiftung European Union.licence: CC-BY-SA 4.0

Figure 2.11: Full time Pedestrianization at Denmark, Copenhegen (*Pedestrian Only Streets: Case Study | Stroget, Copenhagen - Global Designing Cities Initiative*, n.d.)

The Lessons learned that, the pedestrianization of Stroget highlighted the potential for outdoor public life in Denmark. 35% pedestrian volumes has been increased in the first year after the conversion (overall increase in citywide pedestrian volumes to 15 min/day on average) and pedestrian space has also increased from 15800 sqm in 1962 to 99700 sqm in 2005. Increase in outdoor café seating from 2970 seats to 7020 seats in 2006 is also notable. This pedestrianization created peaceful, yet lively, public spaces. Stroget also proved that pedestrian streets can increase revenue for local retailers.

a) Shared Walkable Space

Special separate lanes for pedestrians can define complete walkways. A shared street can also be designed to accommodate daily pedestrian traffic with a maximum vehicle speed limit of 15km/hour. Improving the walking facilities around the transit area create a complete function of urban mobility function. Priority areas that need to be prioritized to support this function: are 500 – 1.000 meters from the center point of the bus stop/ station or the same as a 10-minute walk.

Figure 2.12: 1. Examples of the bollard in Amsterdam (Maas & van Eekelen, 2004)**, 2. Median cut-through – Nagoya** (Iryo-Asano & Alhajyaseen, 2014)**, 3. Pedestrian refuge island – Hongkong** (Saleh, Grigorova, & Elattar, 2020)

To ensure safety, Jakarta NMT guidelines state that physical facilities are bollards, median cuts, and pedestrian refugee islands. A bollard can limit the number of vehicles that enter the sidewalk, preventing damage to the sidewalk's surface. Bollards should be spaced apart by 90 to 100 cm.

b) Traffic calming interim

The first traffic-calming temporary street modification, "City of People," was installed in Fortaleza, Brazil's Cidade 2000, in September 2017. The intervention consisted of removing a traffic lane, reducing the speed limit to 30 km/h, widening pathways, lengthening curbs, and adding five new pedestrian crossings. The transformation also included street art, green infrastructure, and street furniture to create a more defined space for pedestrians and make the street more welcoming. The project has shown residents how tactical urbanism can bring new life to run-down streets. Due to immense positive public feedback, the interim intervention is now being developed into a permanent installation.

c) **Pedestrian refuge or Crossing islands**

The crossings must then be installed at all junctions, spaced every 80 to 100 meters, marked with a width of at least 2 meters, and they must be accessible to those with disabilities. Pedestrian shelter or Crossing islands can be given across more than two lanes of vehicle traffic or in scenarios when the vehicle speed and volume do not allow pedestrians to undertake single-stage crossing. In this consideration, three categories can be used to group sidewalk extensions, namely:

- Corner Alignments that increase the amount of space available to pedestrians at the intersection by decreasing the radius of the intersection. It will boost the prominence of the walking public by reducing the intersection radius. Additionally, this circumstance makes turning motor vehicles slower.
- Bulb-Outs intends to increase the amount of open space for pedestrians next to the on-street parking area.
- Slip Lane Removal is an expansion of the pedestrian area at the intersection that takes up parking spaces and traffic islands.

Figure 2.13: 1. Corner alignment (Sisiopiku, 2019)**, 2. Bulb-out** (Sołowczuk, 2021)**, 3. Slip lane removal** (O'Brien, O'Brien, Liu, Michaux, & Nahlawi, 2012)

d) **The intervention of pedestrian plaza at the intersection**

Like many others in Mumbai, the Nagpada intersection is hectic and difficult to maneuver for all users, both vehicular and non-vehicular. At peak periods, the triangular junction, which joins six main routes, can only handle 3,000 vehicles per hour while being extremely congested. There was little to no pedestrian sidewalk space, and the current sidewalk was in poor condition. These elements combined to create an intersection that was ineffective, risky, and perplexing. In August 2017, In order to direct traffic and create secure pedestrian walkways, the city temporarily changed the intersection's triangle form. Distances between crossings were kept to a minimum, and marked crossings were put in on each side of the intersection. A sizable unlawful parking lot was also reclaimed by the design and converted into a pedestrian plaza. The chaotic crossroads developed become a hub for social interaction. The city has committed to implementing the Nagpada redesign on a long-term basis as a result of its success.

Figure 2.14: Nagpada intersection, Mumbai, India, August 2017 (MMRC, 2017)

e) Active frontage zone

Jakarta, Indonesia guidelines for walkable Jakarta 2022 state that, if at least 20% of the surface area of the building is on one level with pedestrians and is in the form of transparent walls, windows, or rolling door stores, the building's face is said to be dynamic. In terms of constructing a desirable TOD area, the region with more than 90% of the face of an active building has the most value. The area will have the highest value if the average entrance access per 100 meters is five or more. Benches should be provided to facilitate pedestrians to rest for some time (ITDP, 2017).

f) Shaded walkway

The vision for walkable Jakarta 2022 entails that, to ensure comfort, shade facilities can be installed when walking. Shade facilities can be an artificial or natural shade that protects from the weather. This component includes trees, a canopy, or also the roof of a building. After examining the previous cases, it became clear that each city had certain goals, such as restricting vehicular access, reducing the greenhouse effect, revitalizing the urban fabric, boosting retail activity, and reviving the economy.

Artificial Shading Natural Shading

Figure 2.15: Shaded walkway (Ahmad, Ahmad, & Aliyu, 2021)

Each one advocates for a particular pedestrianization method, either long-term or short-term, as well as broader improvements to help the strategy succeed and meet certain goals. As a result, some cities' implementation strategies, particularly the interim scheme, were effective in achieving their goals, while others had difficulties during implementation or failed altogether. These obstacles included resistance from parties other than residents, riders, or merchants, cost recovery, the accessibility of service and delivery trucks, and planning for the altered traffic flow (Parajuli & Pojani, 2018).

2.1 Conclusion

Understanding the sustainable goals with local policies and global agenda is vital to assess the influencing factors regarding walkability for sustainable development. In this framework, among the manifold concept of walkability indicators (physical features, urban design qualities, and individual reactions), this research mainly concentrates on one of the prime indicators, 'physical features' of walkability, to assess the current status for future development. More than a few local policy measures have been gone through to understand the deficits in the observed walkability phenomenon. Walkability is influential in urban development and will ensure sustainable development agenda. It will encourage commuters to reach local destinations through walking, thus would promote a pedestrian-friendly precinct to achieve a sustainable city form. However, the next chapters will discuss the characteristics of the local walkability response concerning pedestrian volume to interpret the pattern of accessibility, convenience, and walk appeal features in the study area of Motijheel CBD.

CHAPTER 3
METHODOLOGY

3.1 Introduction

The research approach provides details on the step-by-step process of organizing and analyzing the study's scattered ideas and views. This study has maintained a case study research approach considering quantitative and qualitative analysis for achieving the desired archive regarding the relationship between physical features influencing walkability status and the movement dynamics within the built environment. The research has gone through the literature-based study (Local policy initiatives, journal articles, web articles), primary and secondary data collection from field survey analysis dealing with observing, recording, compiling key informants' interviews, and interpreting the perceptions from questionnaire-survey-focused on assessing CBD context's walkability status, and several other studies wherever necessary.

This chapter describes how the theoretical framework has been developed to a practical setting to gather statistics relevant to the research subject. This chapter comprises a total of three sections. The overall research design and its justifications are covered in the first and outline the rationale behind choosing the field of study related to the research issue. The second and third section details the stages of the methodology (Quantitative and Qualitative) used for data collection of this research. Quantitative data (pedestrian width, traffic volume, obstructions, conveniences, and other appealing aspects) on the physical characteristics of walkability were gathered throughout the first phase. The Qualitative final round of techniques collected information on public perceptions and experiences to validate the Quantitative records.

3.2 Overview of Research Design

The ideal research approach promotes the generalizability of findings, improves the accuracy of controlling and measuring factors, and assures that participants experience existential realism (Bhattacherjee, 2012). Unfortunately, no single approach was discovered that satisfied each of these demands. The current research used a Case Study Research approach to identify strategic actions to increase walkability (Creswell, 2003). The goal was to determine the characteristics and weaknesses of the current pedestrian environment related to walkability and to look into how the general public feels about the physical factors currently affecting walkability within the study area. In the initial stage, Quantitative data collection techniques were applied to quantify the shortfalls' inadequacies and causes. The final phase employed public experiences to determine their impact on urban sustainability to supplement the quantitative data.

RESEARCH PROCESS DIAGRAM

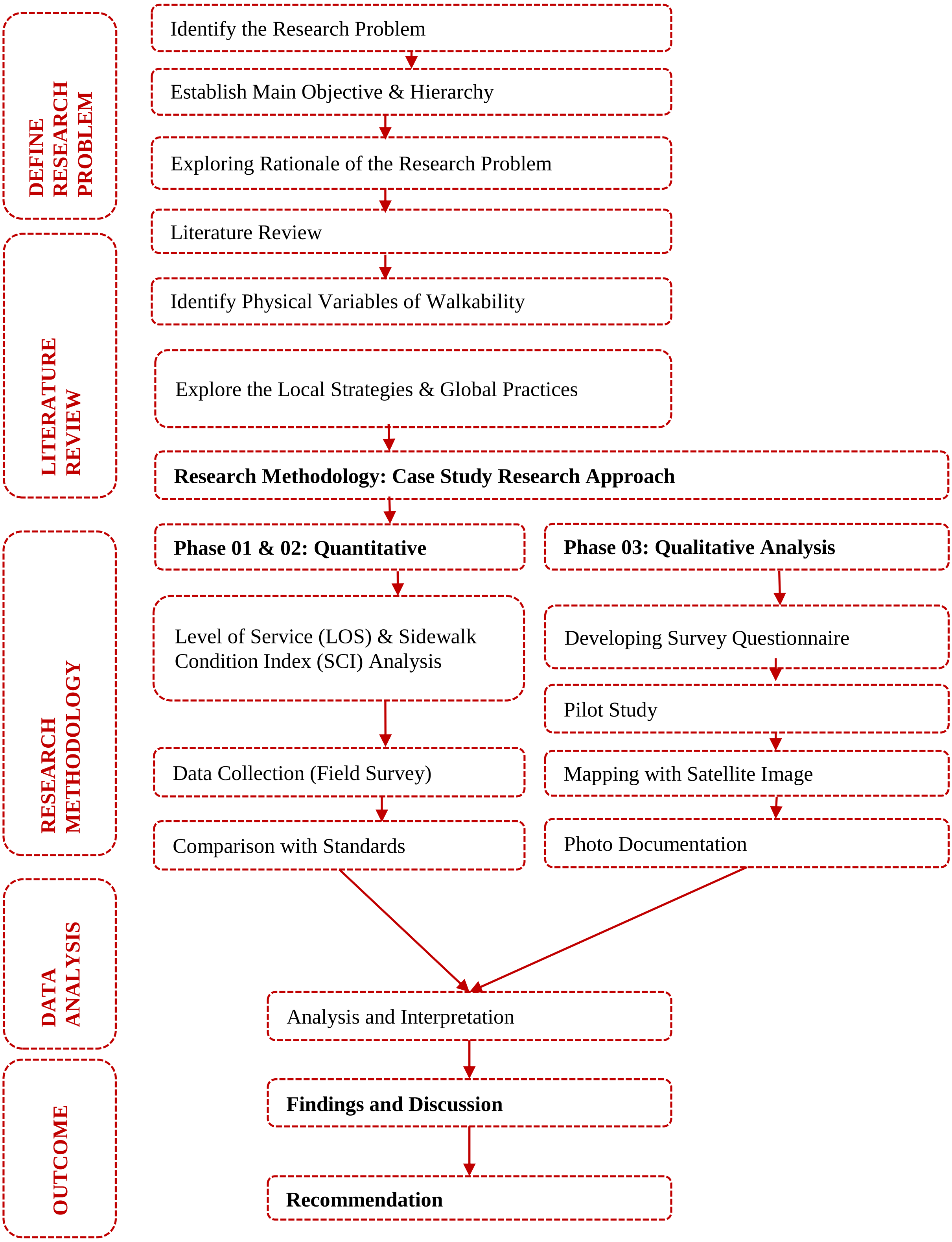


Figure 3.1: Research process Diagram

3.2.1 Why Case Study Research Approach?

The Case Study Research approach is useful when the research problem needs to be explored or needs explanation on established theories and frameworks. This method permits researchers to collect preliminary data and formulate hypotheses. Case studies serve as the basis for more extensive research by providing empirical evidence and informing future research. By analyzing a depth case, researchers can identify patterns and relationships that can aid in refining or developing new interventions. Case study research provides valuable insights into the subject's complexities and dynamics through its distinctive insights. The findings can be applied to real-world situations, provide insights that other research methods may not have captured, and present an opportunity to investigate a particular phenomenon or circumstance in depth.

For this reason, the Motijheel Central Business District (CBD) is used as a case study to investigate the walkability details, contexts, and complexities for a comprehensive understanding of the case. It is essential to observe that case studies also have limitations. Due to its concentration on specific cases may lack generalizability, and researchers must carefully consider potential biases and subjectivity in data collection and analysis. Despite these limitations, case study research remains valuable for obtaining deep insights and expanding knowledge.

3.2.2 Why Central Business District (CBD) of Dhaka for Walkability?

The Central Business District (CBD) of Dhaka, Bangladesh, confronts numerous obstacles threatening its walkability. Dhaka is noted for its traffic congestion, particularly in the central business district. This congestion makes it difficult for pedestrians to safely and securely navigate the area. The central business district of Dhaka frequently needs more pedestrian infrastructure, such as footpaths, crosswalks, and pedestrian-friendly facilities. In many places, the lack of, limited width of, or occupation of the sidewalks by street vendors, parked vehicles, or encroachments forces pedestrians onto the roads. The absence of adequate road safety measures, such as pedestrian-only crossings, traffic signals, and speed limits, makes pedestrians even more vulnerable. When urban areas have accessible green spaces, parks, and public plazas where pedestrians can rest, socialize, and experience a safe and aesthetically pleasing environment, walkability is increased. Unfortunately, Dhaka's central business district lacks sufficient verdant spaces, limiting pedestrians' access to rest and recreation areas. Due to the city's high vehicle density and industrial activities, significant air and noise pollution outbreaks in Dhaka. These factors negatively impact the pedestrian experience and make walking less desirable. Street vending and encroachment are prevalent in Dhaka's central business district. Even though these activities contribute to the local economy, they frequently occupy pedestrian spaces and impede movement, making it difficult for pedestrians to navigate easily.

3.3 Quantitative Data Collection Method

Quantitative research involves systematical data collection of numerical data to draw conclusions and inferences about a particular phenomenon. The key steps in conducting the quantitative research analysis regarding walkability are the research hypothesis, data collection, descriptive statistics, data analysis techniques, interpretation of results, reporting, and presentation. It has been combined with qualitative research techniques to comprehend the research problem better.

The Quantitative data collection for walkability assessment includes Level of Service (LOS) and Sidewalk Condition Index (SCI), which only require an extensive detailed field survey regarding the physical attributes. In this study, the pedestrian Level of Service (LOS) (Alemgena, Quezon, & Kumala, 2018) and the Sidewalk Condition Index (SCI) (M. M. Rahman & Sharmin, 2020) (Muhammad Mulyadi, Verani Rouly Sihombing, Hendrawan, Vitriana, & Nugroho, 2022) methodology was utilized to collect data on the walking conditions along a specific route by analyzing the design factors (e.g., path width, obstructions) and user factors (e.g., pedestrian volume) to examine the existing walkable structures associated with the pedestrian movement. Before the in-depth field investigation, a reconnaissance survey was led within the Motijheel Central Business District area to determine the current movement pattern and pinpoint the precise locations of the fieldwork. The current land use has been observed to identify the various pedestrian activities and places that emphasize movement within the study area. The Level of Service (LOS) method includes the ‘Gate Count Method’ for counting Pedestrian traffic volume and the ‘Effective Walkway Space Calculation.’, and Sidewalk Condition Index (SCI) method includes Systematic Direct Observation.

3.3.1 Level of Service (LOS) Data Collection Method

The LOS (Level of Service) for walkable space is defined (Gallin, 2001) (Itami, 2002) as " a broad assessment of the walking conditions along a route. LOS may be categorized into two types, e.g., Physical LOS and Environmental LOS. This research only considered the ‘Physical

LOS' based on physical quantitative analysis. Six different service levels (A to F) were used to categorize the physical Level of Service of walkability. These levels were based on speed, flow rates, the amount of space available per pedestrian, maneuverability without causing conflicts and varying walking speeds (V/C ratio), the ability to cross or walk against the flow of traffic, and the capacity to pass other pedestrians (Afrin & Yodo, 2020), explained in the following Table 3.1.

Table 3.1: Level of Service LOS, at Pedestrian Space (Rahman & Noman, 2018)

LEVEL OF SERVICE (LOS)			**CHARACTERISTICS**			
			SPACE (SQM/P)	**FLOW RATE (P/MIN/M)**	**SPEED (M/S)**	**V/C RATIO (VOLUME CAPACITY**
LOS A **Most Ideal Pedestrian Environment** Negative affecting factors regarding LOS are minimal	<85% satisfied	**5 points**	> 5.6	≤ 16	> 1.30	≤ 0.21
LOS B **Reasonable Pedestrian Condition As Acceptable Standard** A small number of factors impact pedestrian safety	<60% satisfied	**4 points**	3.7-5.6	16-23	1.27-1.30	0.21-0.31
LOS C **Basic Pedestrian Condition** a significant number of factors impact pedestrian safety and Comfort	<45% satisfied	**3 points**	2.2-3.7	23-33	1.22-1.27	0.31-0.44
LOS D **Poor Pedestrian Conditions** pedestrian LOS are wide-ranging or severe comfort is minimal	<30% satisfied	**2 points**	1.4-2.2	33-49	1.14-1.22	0.44-0.65
LOS E **Unsuitable Environment** Affecting factors are below acceptable standards	<15% satisfied	**1 point**	0.75-1.4	49-75	0.75-1.14	0.65-1.0

LOS F **Severe Unstable** walking speeds are severely restricted unavoidable contact with other pedestrians Cross and reverse-flow movements are virtually impossible	>15% satisfied	**0 points**	≤ 0.75	Variable	≤ 0.75	Variable

Gate Selection Process

This Case Study Research method utilized both Quantitative and Qualitative analysis. For the Quantitative analysis, a comprehensive field investigation is required. Following this, the study area Motijheel Central Business District was divided into total 91 segments of 100m in length (1 minute walkable distance between each segment) (M. Rahman & Al Noman, 2018) for in-depth exploration. Each segment is evaluated for Level of Service (LOS) via pedestrian count and determination of effective walkable space.

Gate Count Method

This research also collected pedestrian movement data using the 'Gate Count' method (Abedo, Salheen, & Elshater, 2019) (Knapskog, Hagen, Tennøy, & Rynning, 2019). A stationary observer uses this technique as an observational technique to analyze the movement rate of pedestrians in the research area, counting every pedestrian who passes a fictitious gate. Through the 'Gate Count' method (Abedo et al., 2019), Pedestrian movement count can be performed during peak and off-peak hours (morning 9.30 am, afternoon 2.30 pm, and evening 4.30 to 5.30 pm) of the day (at least three working days in moderate weather conditions), including a set of observations lasting five minutes. In the Motijheel CBD, as a commercial spatial arrangement, the peak hour has been identified according to office starting time which is morning 9.30 am and evening 4.30 to 5.30 pm. Statements were obtained at 91 gates that were chosen at 100-meter intervals and covered a variety of heavily, moderately, and sparingly used roadways by people. The findings were then analyzed through the Level of Service (LOS) statistical analysis method, and each gate's pedestrian movement rate was found on a 1-hour basis.

Effective Walkway Space Determination

The breadth of a walkway that pedestrians may utilize efficiently is known as the walkway's effective width (Nazir, Razi, Hossain, & Adhikary, 2014). Several obstructions narrow the walkable spaces (US Department of Transportation, 2006). The average values for the total walkway width and obstructions width were taken for a respective component. Effective walkway width was then determined using the following formula. In order to ensure the proper width, additional width is required if roadside items are on the sidewalk next to the curb. (Figure 3.2).

Formula:

WE=WT-WO…………………………………………. (2)
Where WE = Effective walkway width (m),
WO = Narrow distances from obstructions on the walkway (m),
WT = Total walkway width (m),

In the report 'Dhaka Structure Plan (DSP) 2015-20135', primary guidelines for walkability state that the clear pedestrian zone should be continuous, with a minimum of 1.8m (width) x 2.2m (Height) beyond all obstructions, adequate walkway space subtracted from building facing, window display, and green furnishing for groups of persons to pass.

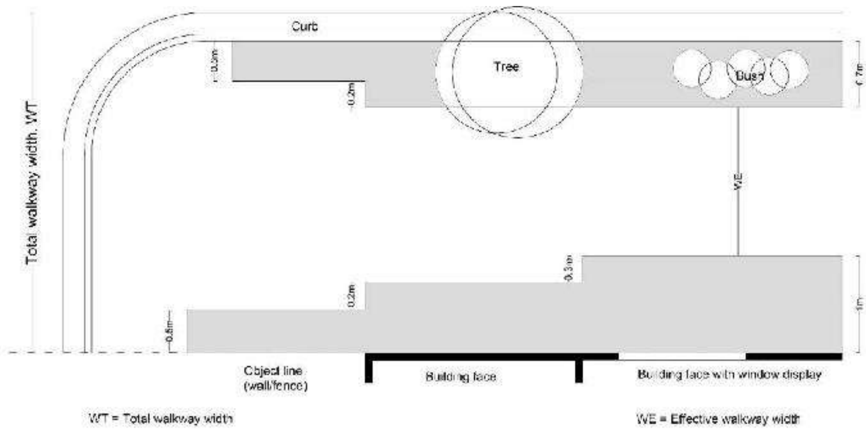


Figure 3.2: Effective Pedestrian Width Calculation Diagram (AASHTO, 2006)

3.3.2 Sidewalk Condition Index (SCI) Data Collection Method

The sidewalk condition index (SCI) (M. M. Rahman & Sharmin, 2020) (Muhammad Mulyadi et al., 2022) is based on visual inspection and observation. The Surveyor looks for the frequency and severity of specific distresses on the checklist, developed based on indicators for sustainable walkability. It measures two conditions:

- The Sidewalk surface damage severity.
- The smoothness of the sidewalk

First, a comprehensive condition survey of the study area has been conducted. During the survey work, efforts have to make to search out the base structure, surface quality, and distressed condition of the walkways within the study area's walkways. Next, a matrix has been developed (Appendix 2) to calculate the sidewalk condition index (SCI), which would conclude the range of 1, which means the fine condition, and 5 is the extremely severe condition for individual indicators of the walkways. On a 5-point scale (from very good to very bad), the walkable area's requirements are evaluated using paper-based on-street data. Then the calculated values will be accumulated with the ratings of the Public's opinion (Questionnaire Survey) and the Surveyor's visual inspection summarization (Field Survey) to extract RDV and FDV through the following formula. Next, the mean value (the arithmetic mean of the Calculated SCI, the Public's opinion, and the Surveyor's visual inspection) was calculated for each section of all segments, which is supposed to be the "Final SCI" of that particular section.

Summation of Public Opinion Rating (Weightage), $\sum Wi$

Raw Deduct Value, $RDV = \sum Wi*(Si+Di)$ [Si = Severity of Distress, Di = Density of Distress]

Factorized Deduct Value, $FDV = RDV/Wi/10$

Calculated Sidewalk condition index (SCI) =100 – FDV

This "Final SCI" provides a numerical rating for the pavement condition, where 0 represents the worst condition, and 100 represents the finest. The validated Sidewalk Condition Index (SCI) ranges are shown in Table 3.2.

Table 3.2: Standard SCI Range (Bari, Sunny, Nag, Tushar, & Haque, 2018)

SCI range	Rating
0-28	Failed
29-45	Poor
46-55	Fair
56-71	Good
72-85	Very good
86-100	Excellent

3.3.3 Advantages of Quantitative Data Collection Method

Quantitative research is valuable for studying and analyzing data systematically and statistically. It is based on numerical data and statistical analysis, which lends itself to objectivity and reliability. It also involves large sample sizes, precision and accuracy, statistical analysis, causal relationships, and efficiency, essential for understanding complex phenomena, making predictions, and informing policy and decision-making. However, it may need to capture the depth and richness of individual experiences.

3.4 Qualitative Data Collection Method

Qualitative research is a method of inquiry that focuses on understanding and interpreting people's experiences, perspectives, and behaviors in their natural settings. It aims to gain insights into the complexities and meanings of social phenomena by examining contexts and the social and cultural influences that shape them. Data is typically collected through various methods such as interviews, observations, focus groups, and analysis of documents and artifacts. Researchers immerse themselves in the study environment to obtain comprehensive data and develop a thorough grasp of the phenomenon being studied. The collected data is then analyzed using content analysis or grounded theory. It is particularly useful for exploring complex social and cultural phenomena, understanding people's perspectives, informing policy and program development, and generating new ideas or hypotheses for further investigation. In this research, the Qualitative Data Collection consists of a Questionnaire Survey Evaluation Procedure and a Pilot Study conducted in the study area.

3.4.1 Questionnaire Survey

A questionnaire survey is required when the information assortment is difficult from non-existing or non-perceivable (i.e., User demand and experience) walkable criteria which cannot be quantified from observation. This study used a questionnaire survey to learn more about the user group and the routes they choose based on their socioeconomic status and other predetermined factors (Appendix. 1). In order to evaluate pedestrian behavior, movement patterns, and existing problems in the study area, surveyors were stationed on both sides of the road and randomly selected pedestrians were asked a series of questions. This process has been processed in multiple steps, i.e., the definition of the target population, selection of sampling size, and data collection to assess the response rate. The sample size for the questionnaire survey was primarily piloted as a minimum number, and later it was increased to 190 respondents to get a better result. Between April 5 (Tuesday) and April 7 (Thursday), 2022, the survey was carried out three times daily (during the morning peak, off-peak in the lunch, and evening peak segments on three consecutive working days). Table 3.3 presents the Questionnaire Survey evaluation process for the desired outcome.

Table 3.3: Questionnaire Survey Evaluation Process for Desired Outcome

Accessibility (what kind of difficulties do they identify while walking in existing conditions)		
Question type	**Assessment process**	**Issues to be assessed**
Sidewalk safety issue	The rate on a linear scale from 1 to 5	Rate under the following condition: presence, continuity, tactile quality, maintenance, obstruction)
The conflict between traffic and pedestrian		Rate under the following condition: buffers between sidewalks and the roadway (e.g., landscaping, street furniture, on-street parking, bike lanes)
The reason behind the time consumption for reaching the destination	Specific answer	User's answers on specific conditions rate the significant issue to be marked
Identify obstacles that faced		User's answers on specific conditions rate the significant issue to be marked
Conveniences (crossing and connectivity) (how do they address the existing pedestrian conveniences)		
Pedestrian Conveniences	The rate on a linear scale from 1 to 5	Rate under the following condition: shelter, information, lighting, seating, trash receptacles, bike racks/ storage, marked crossings, and sidewalks leading to/from the bus stop)
Crossing & Connectivity		Presence, marking, crosswalk position, pedestrian island, pedestrian signal
Identify the important feature while using the pedestrian crossing	Specific answer	User's answers on specific conditions rate the significant issue to be marked
Walk appeal features (walkability motivational factor)		
Identify the important feature while walking	**Questionnaire survey** (specific answer)	User's answers on specific conditions rate the significant issue to be marked under the following situation: availability of pedestrian furniture, proper pedestrian lighting, curb extension, crossing signals at a certain distance, greenery at a specific interval shady/bush type, pedestrian division (following dsp), presence of crossing at the certain interval with proper marking, the existence of universal accessibility, e.g., curb ramp, running slope, connectivity, e.g., connecting public plaza, pedestrian holding area, corner connection)

Sampling for questionnaire analysis involves selecting a subset of individuals, known as the sample, from a larger population to participate in the study and respond to the questionnaire. The key steps involved in the sampling process include defining the target population, determining the sample size, choosing a sampling method, and determining the margin of error, confidence level, and anticipated response rate. Sampling balance the need for detailed analysis with the limitations of available resources respects the rights and privacy of participants, facilitates comparisons between different groups or conditions, and improves the quality and validity of the questionnaire analysis.

A Cluster sample size (Taherdoost, 2016) has been used in this study. When the entire population is broken up into clusters or groupings, this is called cluster sampling. Then, a random sample is selected from each of these clusters and included in the final sample (Wilson, 2010). The distinct categories of pedestrian users who followed either business or occupation were used to build the cluster for sample size. It should be noted that the questionnaire poll did not include pedestrians under the age of 15. Following Table 1: Sample size based on desired accuracy (Gill et al., 2010), a total sample size of 190 was estimated, instead the total population, according to BBS, is 210006 (BBS, 2014), with a confidence level of 95% and a margin of error of 5 (Taherdoost, 2016).

3.4.2 Pilot Study

A pilot study tests a questionnaire on a limited scale before its implementation in a larger-scale study or survey. It seeks to evaluate several crucial aspects, including questionnaire design, data acquisition procedures, response patterns, and response variability. It aids in identifying any issues or limitations before the main data collection phase. A pilot study for questionnaire analysis is an important stage in the research process, as it allows the questionnaire to be refined and the quality of data acquisition to be improved. It offers preliminary insights into the questionnaire's reliability and validity and time and resource management. It also aids in identifying any future problems that may influence data acquisition, such as lengthy or complicated items.

3.4.3 Mapping with Satellite Image

Mapping is a technique that requires comprehension and concentration that evolves into a form of note-taking that connects each fact to every other characteristic. It is a review that focuses on identifying existing relationships instead of outcomes (Fancello, Congiu, & Tsoukiàs, 2020) (Cooper, 2016). The process of Mapping with Satellite Images involved the following steps:

- Satellite images were obtained using a computer connected to the internet. A wireless Internet connection was established on the mobile phone, and then Google Earth was accessed while surveying.

- To designate the survey points, essential and recognizable landmarks of the area were sought, such as a main street, hotel, city center, nodes, and significant commercial structures.
- Following the activity or obstructions that encroached severely, each point was recorded.
- Each segment was also examined for the absence of essential and encouraging walkability variables. The content is then depicted graphically through mapping.

3.4.4 Photo Documentation

According to (Hogan, 2022) (Markwell, 2008) (Hernández et al., 2019), photograph documentation is a strategy in which "photos are made systematically to gather data for analyses." This study uses photo documentation to show the specific types of blockages and pedestrian traffic movements found in walkable areas according to the various street types and the physical infrastructure needed for walkability following survey mapping.

3.4.5 Advantages of Qualitative Data Collection Method

Qualitative research offers several advantages, making it a practical approach to understanding human experiences and social phenomena. Qualitative research allows researchers to explore topics in great detail and depth, providing descriptive data that helps uncover the complexity of the research subject. It is flexible and adaptable, allowing researchers to modify their approach as they gather new information. It emphasizes studying phenomena within their natural contexts. It values the voices and experiences of participants, allowing them to share their stories, perspectives, and insights focusing on the social, cultural, and environmental factors that influence individuals and their behaviors.

3.5 Conclusion

This study uses a Case Study Research approach to investigate the relationship between physical features influencing walkability status and movement dynamics within the built environment. When the research problem is relatively unexplored or needs explaination on established theories and frameworks, the Case Study Research method is useful. The Motijheel Central Business District (CBD) of Dhaka, Bangladesh, is used as a case study to examine walkability status. The case study research methodology incorporates both quantitative and qualitative methods. Quantitative research relies on statistical analysis, whereas qualitative research focuses on comprehending and interpreting people's experiences in their natural environments. The accumulation of Quantitative and Qualitative data (Consisting of a Questionnaire Survey Evaluation Procedure, Pilot Study, Mapping with Satellite Image, and Photo documentation) have been used to obtain the complexities and significance of social phenomena. Quantitative research entails analyzing numerical data to draw conclusions and inferences about the walkability of the CBD through the conditions of the Level of Service (LOS) and the Sidewalk Condition Index (SCI) methodologies. Field surveys were conducted to determine the present movement pattern on the precise locations during the fieldwork. To evaluate the walkability indicators, walkable conveniences, and other aspects of walkable space, an observation checklist has also been developed. This research provides an in-depth understanding of the context and participant perspectives, complementing its practical value.

CHAPTER 04
STUDY AREA ANALYSIS

4.1 Introduction

In the early Mughal period, the commercial core of Dhaka was confined to Chawk Bazar, Sadarghat, and the Banglabazar area. However, During the Pakistan period, the increased economic activities of the newly formed Dhaka necessitated the development of a commercial district. From that perspective, the swampy, marshy land in a desolate fringe area of Motijheel Dhaka came to be allocated for commercial purposes in 1954. In the 1960s, the administrative center was well-developed around Gulistan on the eastern side of the Ramna area. Thus, Motijheel and its adjacent regions grew as a vibrant commercial and administrative area and started serving as a CBD for the newly formed Dhaka. This historical change in the city's status gave Dhaka a new dimension, far beyond its experience, and significantly changed its spatial development pattern. The land use map 1975 suggests Dhaka had the modern core of the central business district in the Motijheel-Gulistan area. Later in the 1980s, CBD expanded northward toward the Kawran Bazaar and Sher-E-Bangla Nagar area, adding new pockets of public facilities and commercial purposes. However, the Motijheel area continued to be central to the majority of the big commercial structures. The activities of CBD have also become diffused.

Following the rapidly increasing demand and commercialization, the CBD continued towards Mahakhali, Gulshan, and Banani and took its concrete shape by 2005. Dhaka now has five CBDs- an old indigenous center, Motijheel, Kawran Bazar, Mohakhali, and Gulshan-Banani, according to the revised strategic transportation plan (JICA & DTCA, 2015), (Figure : 4.1)

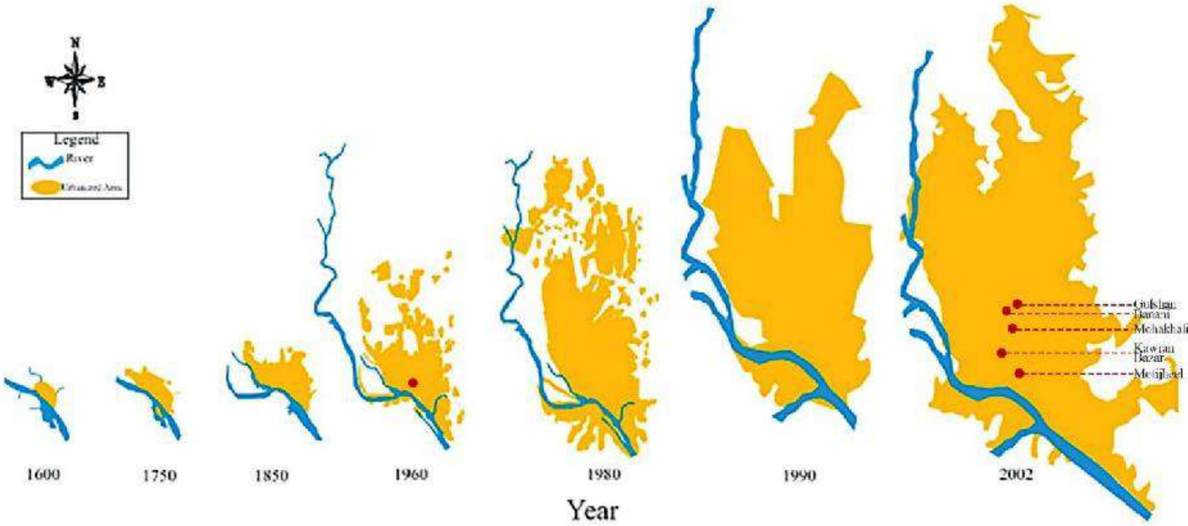


Figure 4.1: Evaluation of Dhaka City (Ahmed, Hasan, & Maniruzzaman, 2014)

The walkability pattern in the urban commercial context is like fluid on the macro scale within the diverse spatial arrangements. If the walkability concept is focused on a micro-scale, it can be seen as the root factor contributing to sustainable development goals (SDG) for future urban development. As a vibrant commercial and administrative zone, the Motijheel CBD area is highly looking to be the most accessible walkable city form. Nevertheless, the significance of this notion, walkability in the CBD context, has been deprived for years, reported by discontinuity, surface irregularities, pitiable construction materials, and multiple obstructions in pedestrian movement. This area is expected to attract a remarkable amount of inhabitants from surrounding areas of its diversified CBD land use pattern.
Moreover, the proposed MRT (Metro Rail Transit) Line-06 will proceed through (from Uttara-Mirpur-Agargaon-Farmgate-Shahbag-Motijheel) this commercial and administrative area while the Motijheel will be its end station (Figure 4.2). So it will be challenging to satisfy the existing condition of pedestrian accessibility in the CBD area. With the proper condition of the walkable framework, this urban fabric will be seriously effective in active passenger transfer to local destinations.

Several pages of research, reports, and policies in Bangladesh have been there for walkability issues, but only in a few paragraphs. To attain sustainable and integrated communities, the Dhaka Structure Plan (DSP, 2015) and the Revised Strategic Transport Plan (RSTP 2015) have addressed some strategies and objectives to establish improved and connected communication in the urban center. Moreover, Urban Transport Plan by DTCA has identified 14 key issues relating to the transport system for policy documentation to guide future megacity development. That includes creating a 'pedestrian priority' system to enhance pedestrian provisions. Among 69 policies under different transportation issues, approach no. 34 under point no. 02 addressed the pedestrian priority only (JICA & DTCA, 2015).

This chapter demonstrates the spatial understanding, lane configuration and the shortcomings in walkability compared to sustainable walkability assessment parameters in Motijheel CBD. First, the GIS Map of the Motijheel CBD has been analyzed to define the study area boundary, and existing street lane configuration. The observational field study has been required in this research to quantify the characteristics and shortcomings in walkable space adequacy by Level of Service (LOS) analysis and the existing detail condition of walkability following the checklist by the sidewalk Condition Index (SCI) Analysis within the Motijheel CBD area. Secondly, a questionnaire analysis has also been performed with 190 participants to identify the public experience regarding the current CBD walkable context and complement the quantitative data from field survey also.

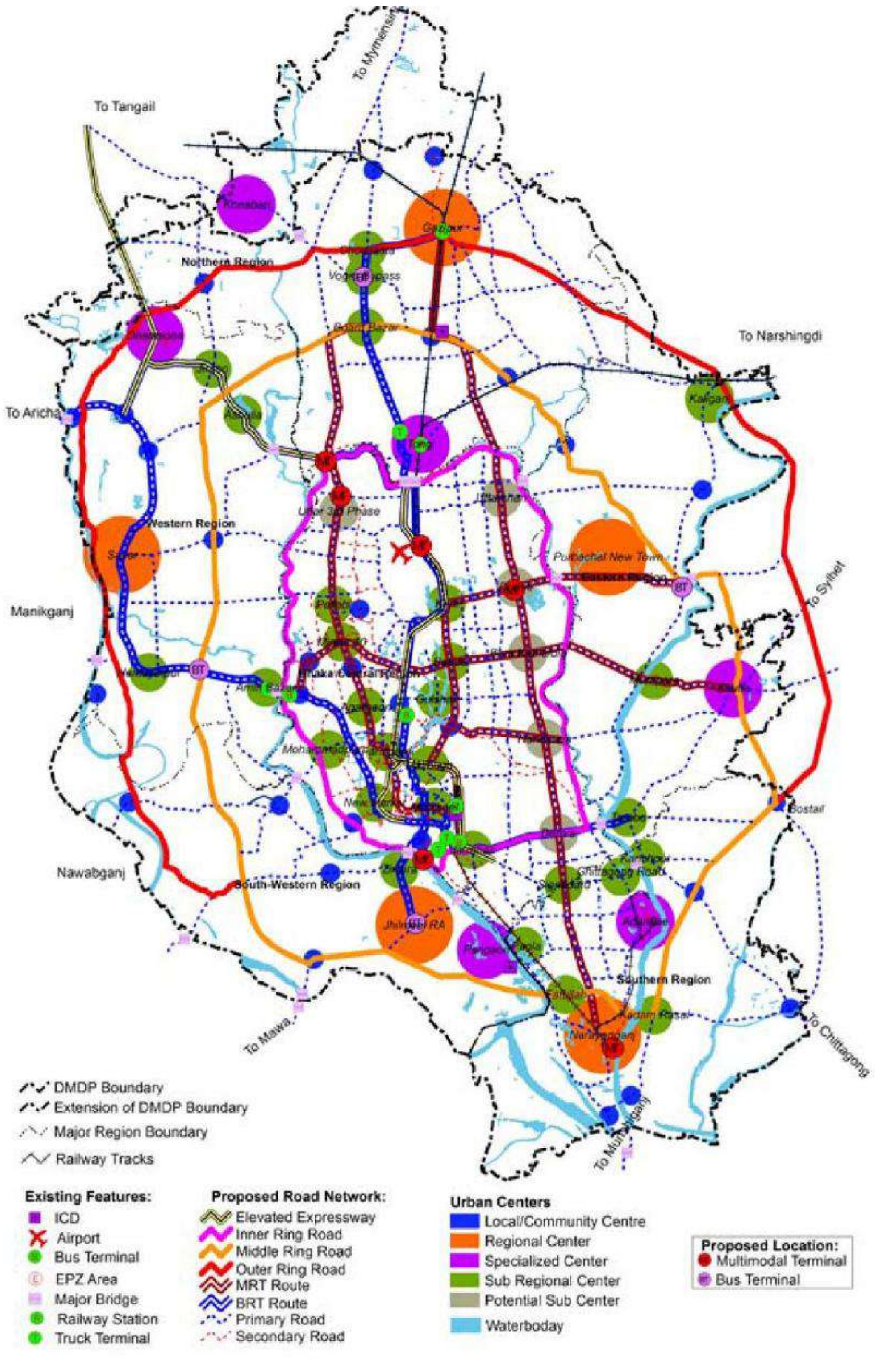


Figure 4.2: Proposed Integrated Transport Plan fpr RAJUK Area (Kartripakkha, Works, & Development, 2015)

In order to improve the current situation of walkability within a 400 m (5 min.) walking distance, the study seeks to understand the underlying relationship between pedestrian movement and the available walkable area.

4.2 Site Surroundings

The Motijheel CBD region is renowned for being a thriving commercial hub of Dhaka City. The Motijheel Thana includes Arambagh, Bangabhaban, Fakirapool, Dilkusha C.A., Bangladesh Bank colony, Motijheel 48 colony, T and T colony, GPO, Chamelibagh, Baitul Mokarram, and Gulistan. [Figure 4.3 (a)].

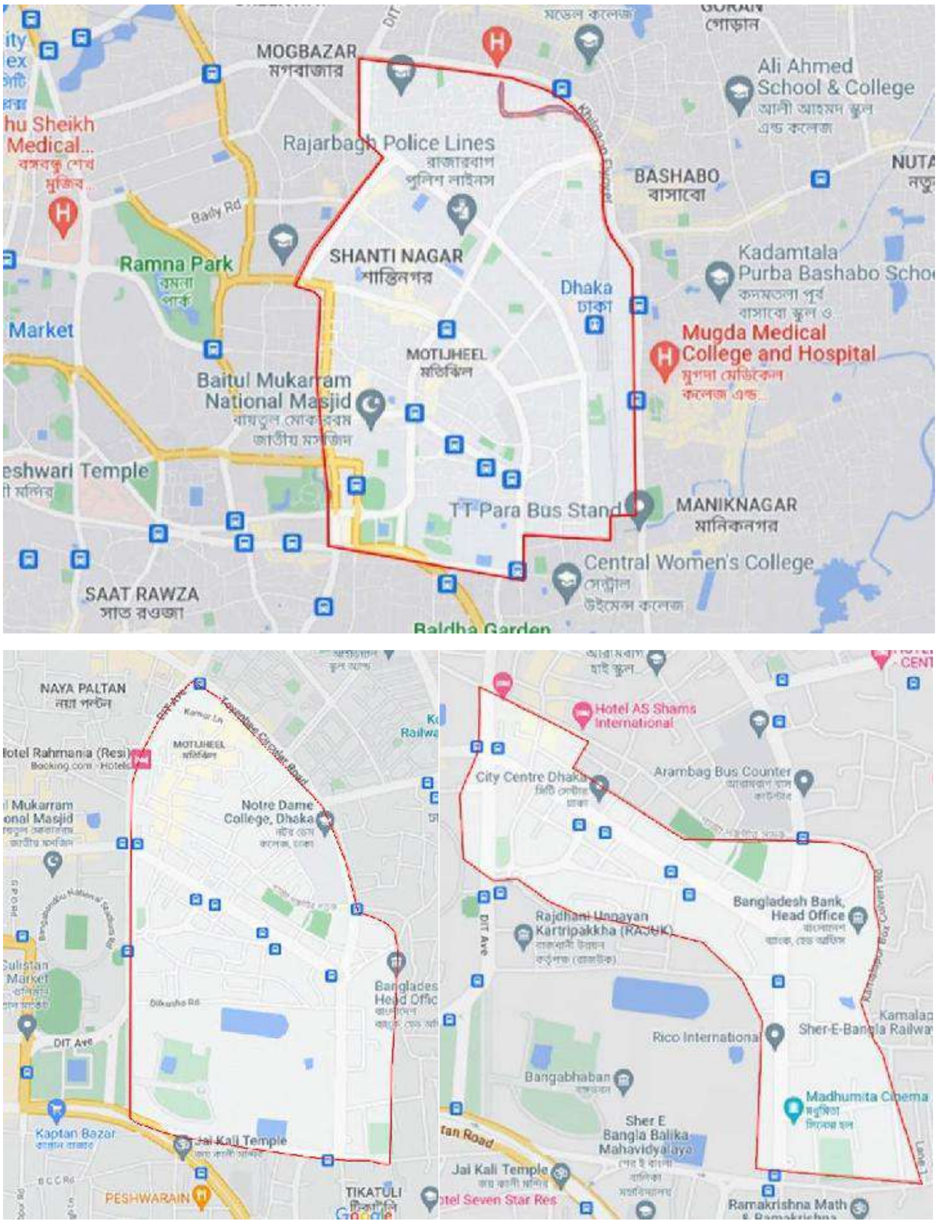


Figure 4.3: (a) Motijheel thana, (b) ward 32 within Motijheel thana, (c) boundary of the greater Motijheel CBD as the study area.

The CBD area within the Motijheel Thana boundary (ward no 32) Figure: 4.3(b), has been marked as the entire study area for this research [Figure 4.3(C)], with the iconic surroundings. One of the significant administrative divisions and commercial nodes of the south CBD area is the Motijheel Central Business District. This area's significant infrastructures covered approximately 46 sq. km, including Bangladesh Secretariat, National Mosque, the Bangabhaban, Bangladesh Bank, City Center, Sonali Bank Head Office, Janata Bank, Commercial Bank, Bangladesh Biman Head Office, Hotel Purbani, BFFC, RAJUK Bhaban, National Stadium Complex, Bima Corporation, Stock Exchange, Dhaka Power Distribution Company (DPDC). The study area of this research starts from DIT Avenue and Danik Bangla mor through Shapla Chattar (Motijheel circular road), Ittefaq mor to Dhaka Stock Exchange (on the South side of Shapla Chattar) surroundings [Figure 4.3(c)].

The Motijheel CBD area experiences severe traffic congestion during weekday business hours. To assess walkability in this context, this needs to know that walking can generally occur in the park, city square, promenade, and on the footpath for regular communication. However, in Dhaka city, the square and promenade concepts exist rarely. According to the fundamental need this research focuses only on the basic walkable phenomena generated on the footpath in daily communication before and after the motorized transit starts and ends. The following Figure [4.4 (a)] represents the catchment area with traffic influx direction of primary arterial Motijheel Road (up to 0.50 km from the entire surroundings) and the route analysis Figure [4.4 (b)] (including the bus stoppages, human haulers, bus and human hauler route), to understand the present transition pattern in CBD Motijheel area within 400m (5 min) walkable distance from transit nodes.

Aside from them, parking, food carts, cars, hawkers, and peddlers take up the majority of the road space and restrict pedestrian circulation. The DMDP recommends better management of the current practice of hawking activity on highways and sidewalks, notably in the Motijheel and Gulistan area. Otherwise, it creates a serious obstruction for pedestrian movement in the future. In the vision of improving walkable circumstances, the Dhaka structure plan (2016-35) has proposed a policy under the transportation section (Policy-Trans/1.5) that encourages the development of walkable space at high-volume pedestrian locations, including crossing facilities. Within the five CBD area in Dhaka, the Motijheel – Gulistan area has been noted for high volume pedestrian location that demands to be retrofitted in form of improved access and sustainable development.

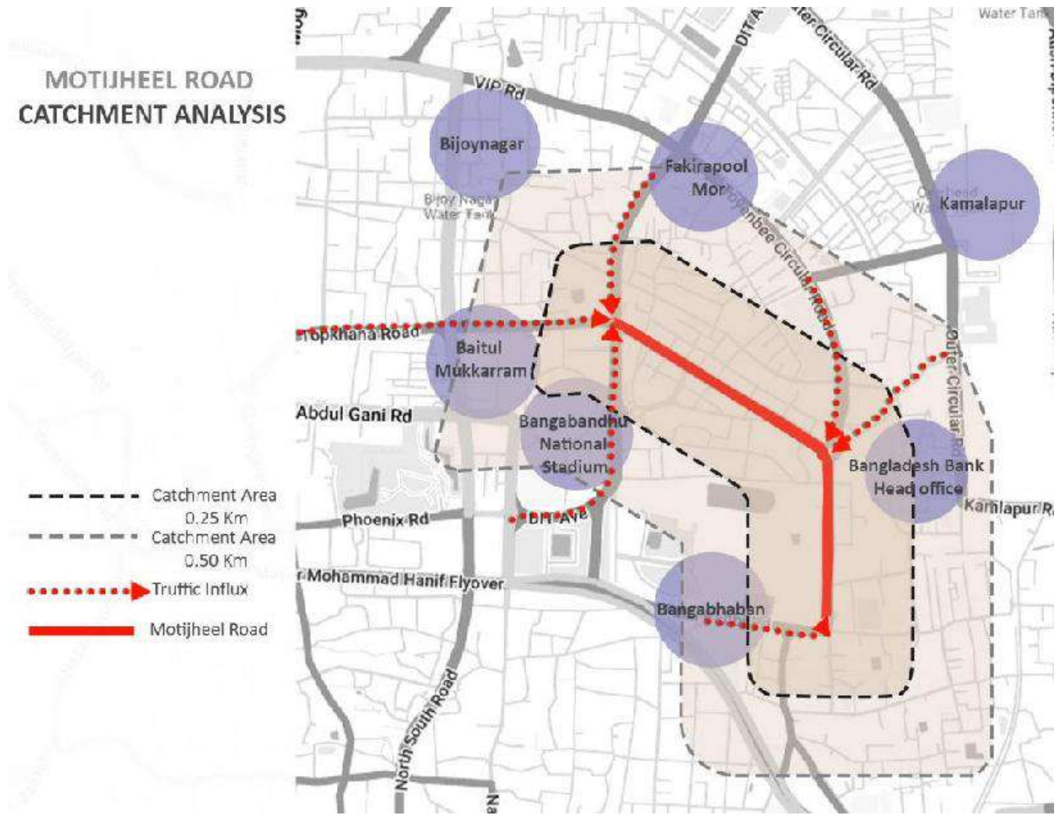


Figure 4.4: (a) Motijheel Road Catchment Analysis

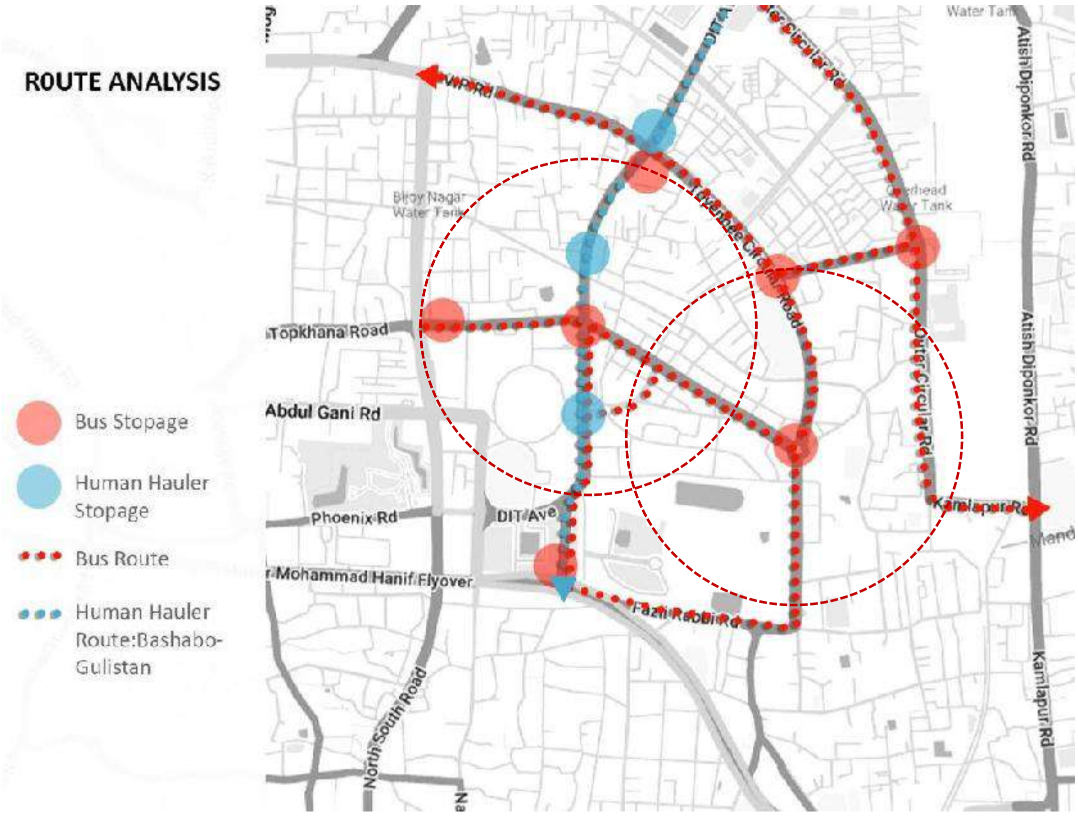


Figure 4.4: (b) Route Analysis

But the Motijheel CBD context has remained far away to follow any planning considerations regarding walkability. The area's projected metro station, which is already built and will significantly improve connectivity with the metropolitan network, would increase commuters' commercial activity and mobility. Therefore, a considerate attitude is necessary to establish a proper walkable context to ensure the efficient passenger transfer and interconnection within the local destinations.

4.3 Lane Configuration Study

Urban fabric comprises the entire road network, open spaces, and the building blocks. The accessibility within these urban arrangements depends on the clear permeability within these blocks. The more developed street permeability, the more functional city will develop. This road network can be divided into grid and organic practices within this permeable street development. Minimum plot lengths are more porous in the urban context to pass through, parallel to primary arterial roads. The Motijheel CBD area combines the grid pattern and organic characteristics both. This study area has identified three major nodes: Dainik Bangla Mor, Balaka Chattar, and Shapla Chattar. Alongside the primary road (Motijheel Road) connecting two major nodes (the Dainik Bangla Mor and Shapla Chattar), the dominant network type is in gird, which creates a web connecting to the adjacent areas. An organic pattern has also been found far away from the CBD boundary. The primary Motijheel Road (connecting Dainik Bangla Mor and Shapla Chattar) can be noted here as the most important route for easier passenger transfer to local destination. Instead of congesting the pathway along the main arterial route with pedestrians, the interior streets adjacent to the Motijheel road may be more advantageous. However, several dead-end sections limit through traffic within these nearby destinations. Despite this, some large blocks in the Dilkusha C.A., the Playground of BFFC, the Notre Dame College campus at Arambag, Office area of Bangladesh Bank make it difficult for pedestrians to navigate the route to their destinations.

According to the project's database on 'Revision and Updating of The Strategic Transportation Plan' (RSTP 2004) for Dhaka, final report has mentioned the street classifications according to functional hierarchy. Furthermore, DAP 2022-2035 has proposed six types of functional road configurations with specified pedestrian recommendations. The basic types of these street networks within the study area are presented in Table 4.1 under three major categories (Figure 4.5). These are the Primary Arterial Road (high-capacity urban road), can be subdivided into Dual Three Lane with NMV, Dual Two Lane with NMV, and Dual Two Lane. Secondary Road/Collector road (secondary distributor road with Non-Motorized Vehicle (NMV) from the direct arterial road to the local access road). And lastly, the Access Road/tertiary road (accessible to individual plots). According to DAP 2022, the existing pedestrian configuration has also been compared and presented in Figure 4.5 and Table 4.1. The comparison shows that the lane configurations need to be adequate from the standards in dimension, and walkable conditions should be applied as per standards. One of the particular characteristics of the urban transition in this CBD is a large number of Non-motorized Vehicles (NMVs) and walkway user. In most situations, many walkways need more walkable width and smooth surface, while providing the adequate footway is prime necessity. The following Figure 4.5 illustrates the functional hierarchy of all street segments and the bus stoppages at the Motijheel CBD area below.

Table 4.1: Road Classification According to Functional Hierarchy

Road Classification	Number Of Lanes	Standard Pedestrian Width (Ft)	CBD Road Name	Existing Width (Ft)	Existing Pedestrian Width (Ft)
Primary road	Dual three-lanes with nmv (100-130)	15	Toyenbee Circular Road	104	Approx. 8-10ft but encroached by other obstruction
			Motijheel road	102	
	Dual two lanes with nmv (80-100)	15	Motijheel road	90	Approx. 8-10ft but encroached by other obstruction
			Toyenbee cir. Road	93	
			Toyenbee road	96	
			Toyenbee road	84-96	
			Dit ave.	85-90	
	Dual two lanes (40-80)	15	Dilkusha road	50-52	Approx. 8-10ft but encroached by other obstruction
			Dit ave.	63-76	
			Purbani circle	73	
Secondary road or collector road	_	5_10	Kamalapur bazar road	39	Approx. 5ft but encroached by other obstruction
			Beside motijheel park	35	
			Dilkusha road	20-24	
			Gazi dostogir road	16	
			Dilkusha road	24-27	
Local access road/ tertiary road	_	If required	Dilkusha road	12	No pedestrian
			Back of hirajheel hotel	21	
			Back of Balaka building	13-20	
			Mcci is building the front road	16	
			Beside rajuk building	23	
			Agrani bank front road	24-32	
			Culvert road	21-30	
			Kamalapur box culvert road	23-28	

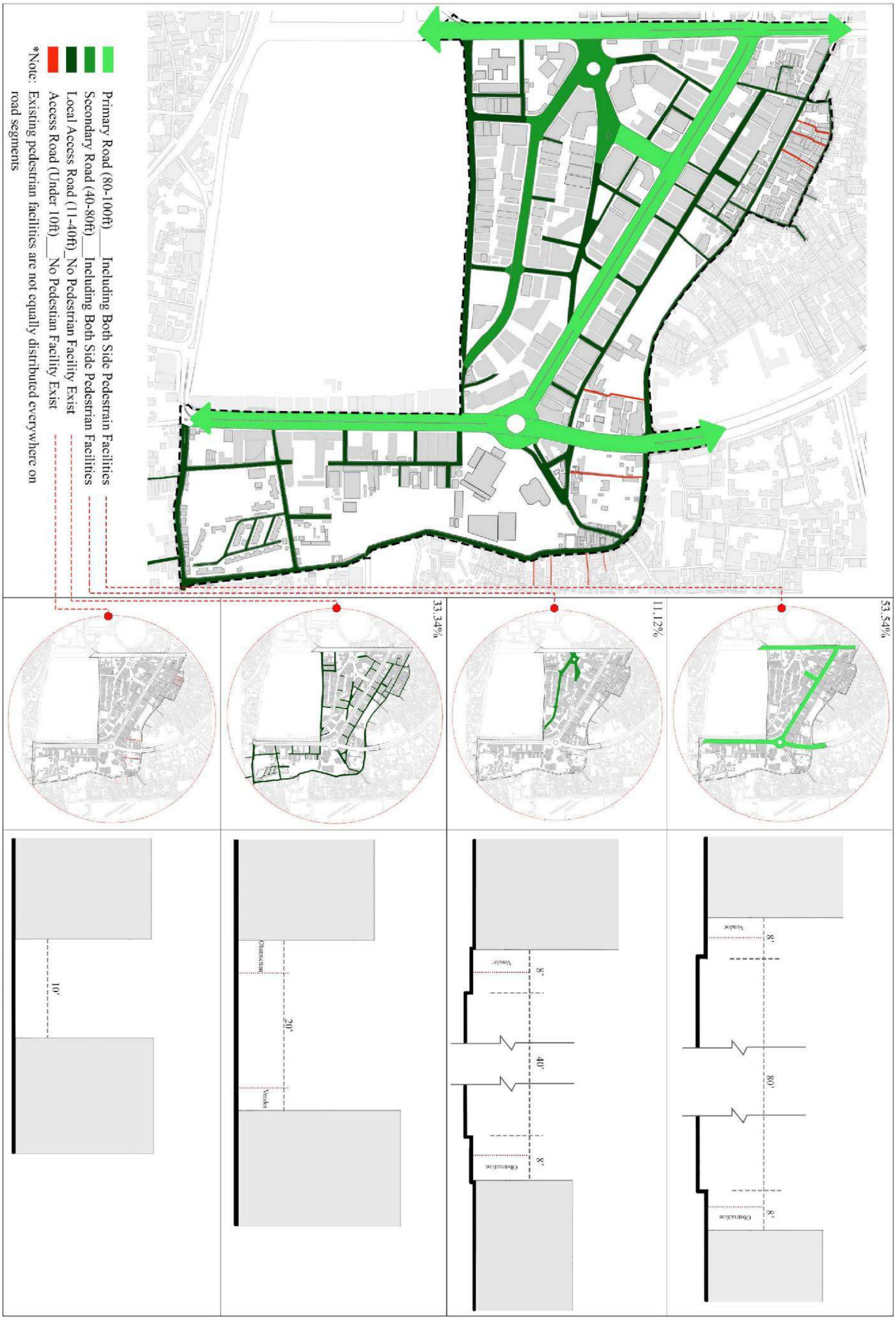


Figure 4.5: Existing Lane Configuration with Functional Hierarchy

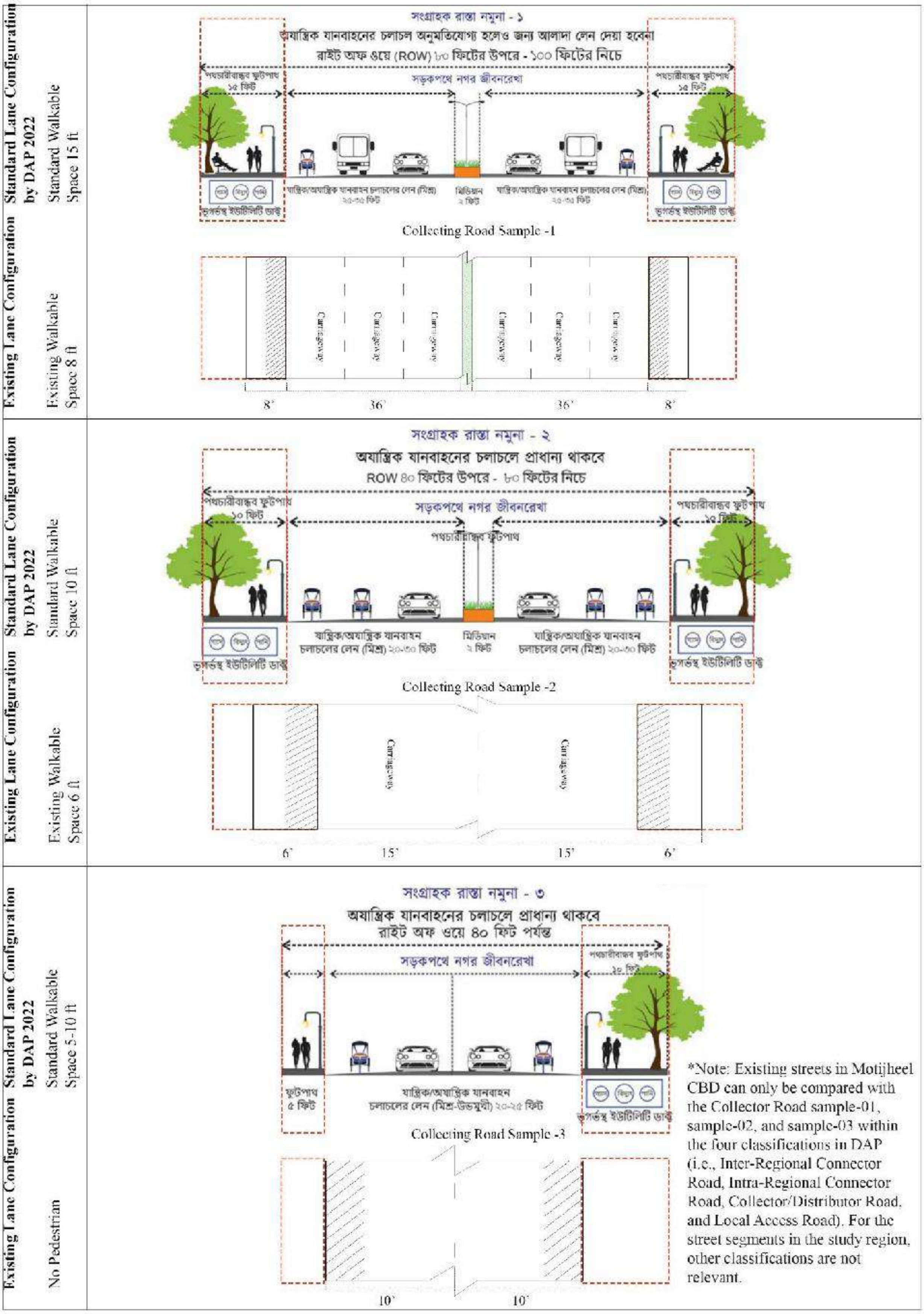


Figure 4.6: Comparing Lane Configuration with DAP 2022 Guideline

4.4 Evaluation Circumstances for Quantitative Analysis

In the previous section of this study, it was indicated that this case study research method utilized both quantitative and qualitative analysis. For quantitative analysis, a comprehensive field investigation is required. Following this, the Motijheel Central Business District study area was divided into 91 segments (Figure 4.7) of 100m in length (1 minute walkable distance between each segment).

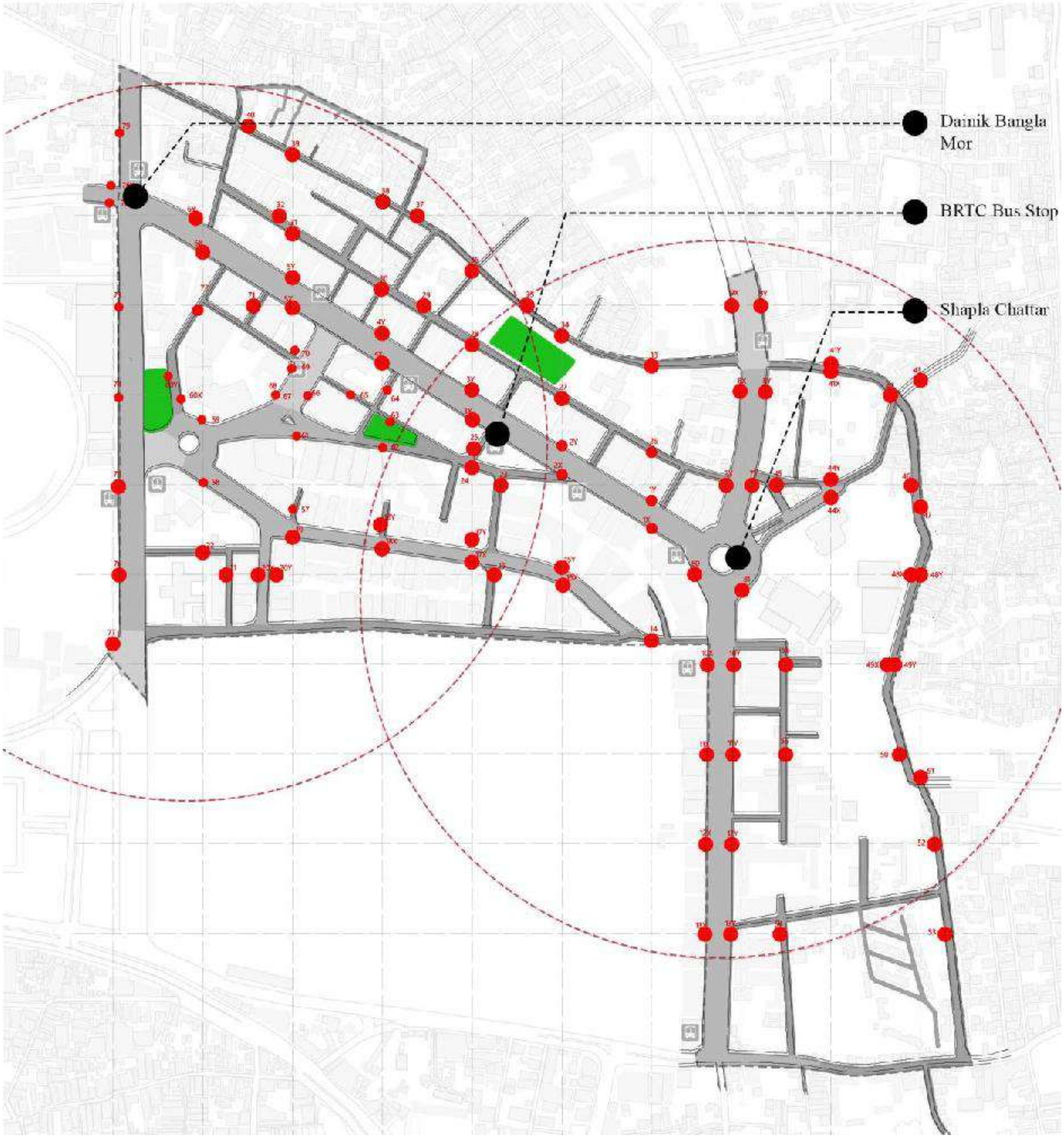


Figure 4.7: Gate Points within the Study Area

Each segment is evaluated for Level of Service (LOS) via pedestrian count and determination of effective walkable space, as well as Sidewalk Condition Index (SCI) Analysis based on its own set of obstruction criteria. To evaluate this concern, the lacking of physical attributes have been observed in detail as obstructions in pedestrian movement, which are assessed under the scale of level 1 (means very slight) to level 5 (means extremely severe). Found obstructions in walkable spaces are plotted in two terms separately: the severity (means how much width has been obstructed) and density (implies the frequency of the obstruction has been found). The evaluation criteria in severity and density of each deficit have been plotted under the following circumstances within 100m segments presented in Table 4.2.

Table 4.2: The Evaluation Value in Severity and Density of Each Criterion has been plotted under the Following Circumstances

Obstruction list	**Evaluation method**	**Rating category**					
		1	**2**	**3**	**4**	**5**	
1. Brick/tile missing 2. Loss of cc 3. Damage in base-layer 4. Deformation due to tree roots, water logging 5. Trash 6. Construction rubbish 7. Utility cut holes 8. Missing/broken cover of surface drain 9. Tree roots	**Observation through field survey**	1'x 1' (1sft)	2'x 2' (4sft)	3'x 3' (9sft)	4'x 4' (16sft)	Above 5'x 5' (25sft)	**Severity rating**
		1-2 times	2-3 times	3-4 times	5-6 times	Above seven times	**Density within 100m**
		Below 20%	20%	30%	40%	Above 50%	**(measured by the percentage of the obstructed area within 100m length)**
10. Hawkers 11. Vending belongings 12. Car parking		1' width	1.5' width	2' width	2.5' width	Above 3' width	**Severity (measured by the width cover of the total walkable width)**
		5-10	10-20	20-30	Above 30	Full-length cover	**Density within 100m (measured by numbers within 100m)**

4.5 Level of Service (LOS) Analysis

4.5.1 Pedestrian Flow Rate

Recommending comfortable walkability in urban areas is one of the most significant issues in the sustainable urban planning agenda within a wide range of effective transportation systems. The fundamental correlation between the frequency of pedestrian activity and the walkable space serves as one of the main indicators of walkability. This study took into account the mobility patterns within the Motijheel CBD area within a 400 m walkable radius from each node point (5 min walking distance) to determine this association. Based on field surveys conducted in the research in 2022, a detailed set (Appendix 7) has been created to comprehend the pedestrian flow rate at each chosen gate point.

The Gate count approach has been employed to determine the frequency of pedestrian movement in the research area. Three times per day, a stationary observer counts every person crossing a fictitious gate. To conduct this Movement Frequency Assessment, the study area has been divided into 100m lengths (1-minute pedestrian distance) that intersect the thoroughfare network at 91 reasonable Gate points. Five minutes were spent on each set of observations, which were then converted to movement rates per hour. In the late section, this movement pattern is compared with the individual walkable space requirement and Level of Service (LOS) properties (see 3.4.1) to find the existing fundamental deficiencies. From the field survey on every notional Gates, there is a significant amount of pedestrian activity in the study area from early in the morning to late at night, with the peak times being in the morning (9.30 am to 10.30 am) and the afternoon (4.30 pm to 5.30 pm). The time frame for fieldwork from 05th May 2022 to 6th July 2022 has been undertaken to conduct the pedestrian count survey within the CBD area. Observations were taken with maximum coverage of incoming and outgoing routes towards nodes and connecting junctions within its walkable ring. It has covered a variety of streets that are frequently used by pedestrians in varying degrees of intensity (Table 4.3 and Figure 4.8).

Heavy pedestrian flow rates (greater than 45 people per min per meter) have been identified on Gate points: 2x (along Motijheel Road), 10y (In front of Hirajheel Hotel), 14 (in front of Peoples Insurance Building opposite Metlife Head office), 24 (back of Petrol Pump and BRTC Bus stand), 34 (back of BFF), 40 (on Gazi Dastagir Road connecting Dainik Bangla Mor, 44, 81 (near Bangladesh Bank), 62 (front of Sundarban Courier Service), 77 (Bus Stoppage at DIT Avenue near Stadium). Medium flow rates (greater than 30 persons per min per meter) at Gate Points: 1y, 3x, 6x, 6y, 8y, 8x, 11x, 20x, 26, 29, 31, 43, 44y, 60x, 61, 75, 76, and 73. Some local access roads adjacent to the residential part, the Toynbee Road near Notre-dame Colledge and opposite intercity bus stands area, front of DPDC RAJUK, Paltan Maydan (on DIT Avenue), has low pedestrian volume (less than 20 people per min per meter). These are 5x, 5y, 9x, 9y, 12x, 15x, 34, 33, 45, 56, 63, 65, 64, 70, 71, 79y, and 78x.

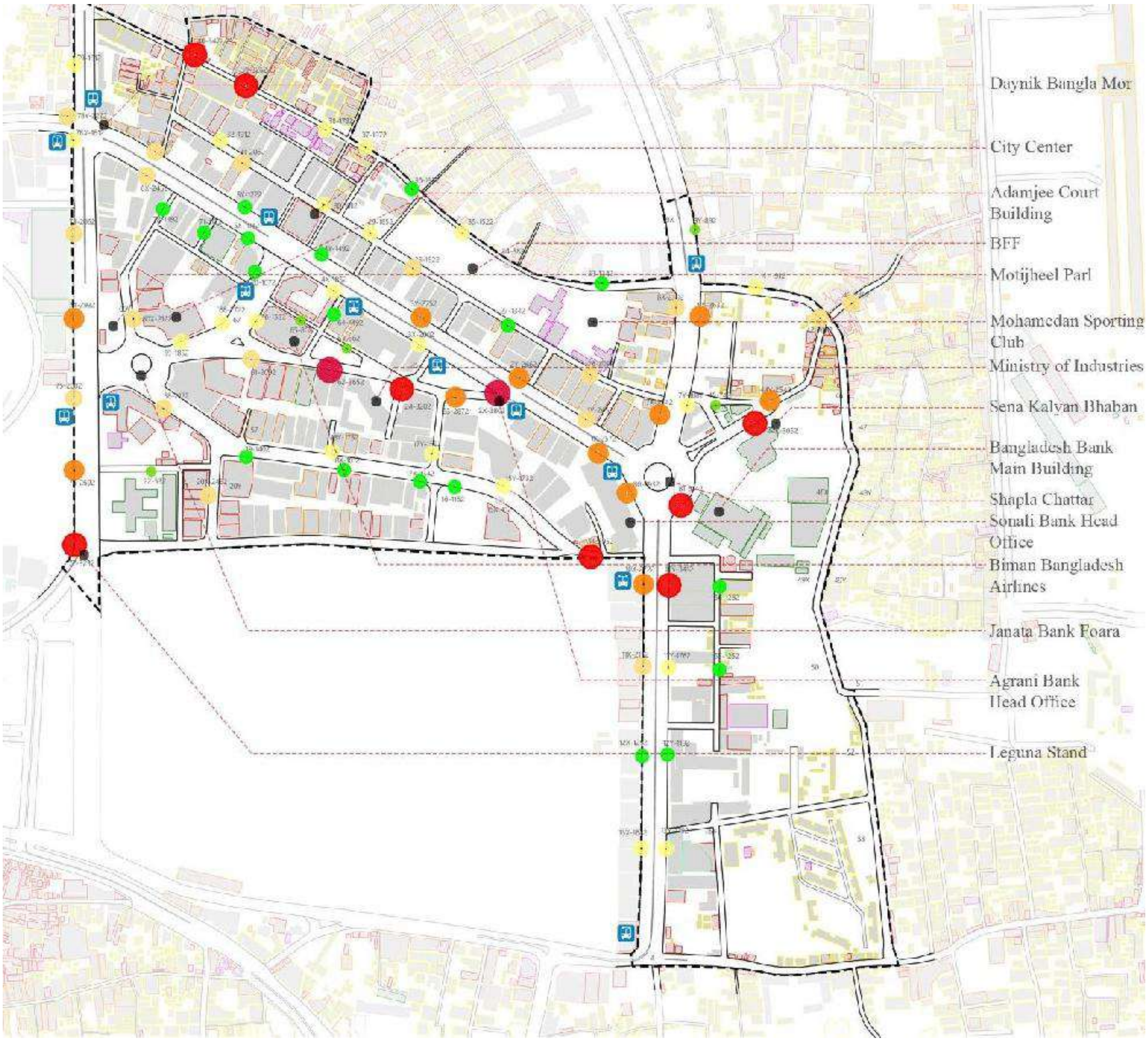
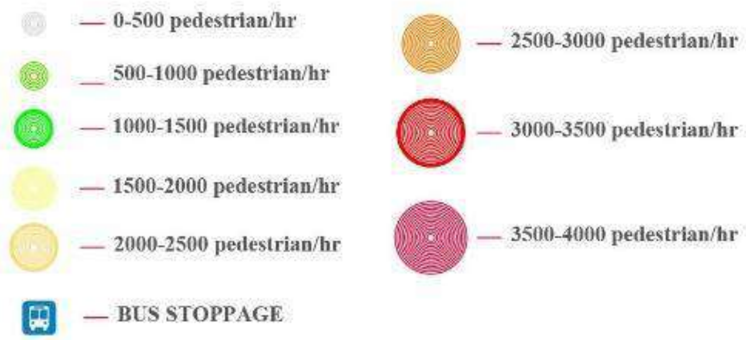


Figure 4.8: Around-five-minute walking distance pedestrian volume in the chosen gates (small circle denotes low movement rate, while large circle denotes high movement rate).



*Note: Above in Figure 4.8 illustration, High pedestrian volume (3000 – 4000 pers. /hr.) count has been detected as 30%, Medium pedestrian Volume (1500 – 3000 pers. /hr.) is 42%, and Low pedestrian volume (500 – 1500 pers. /hr.) is 28% within the entire CBD context.

Table 4.3: Pedestrian Volumes at Different Street Segments

4.5.2 Existing Effective Pedestrian Space

Adequate, effective walkable space is specifically related to the pedestrian movement pattern. A person requires a frictionless walkable space on the both-way directional pavement. Effective walkable space means a clear space dedicated to walking without any obstruction.

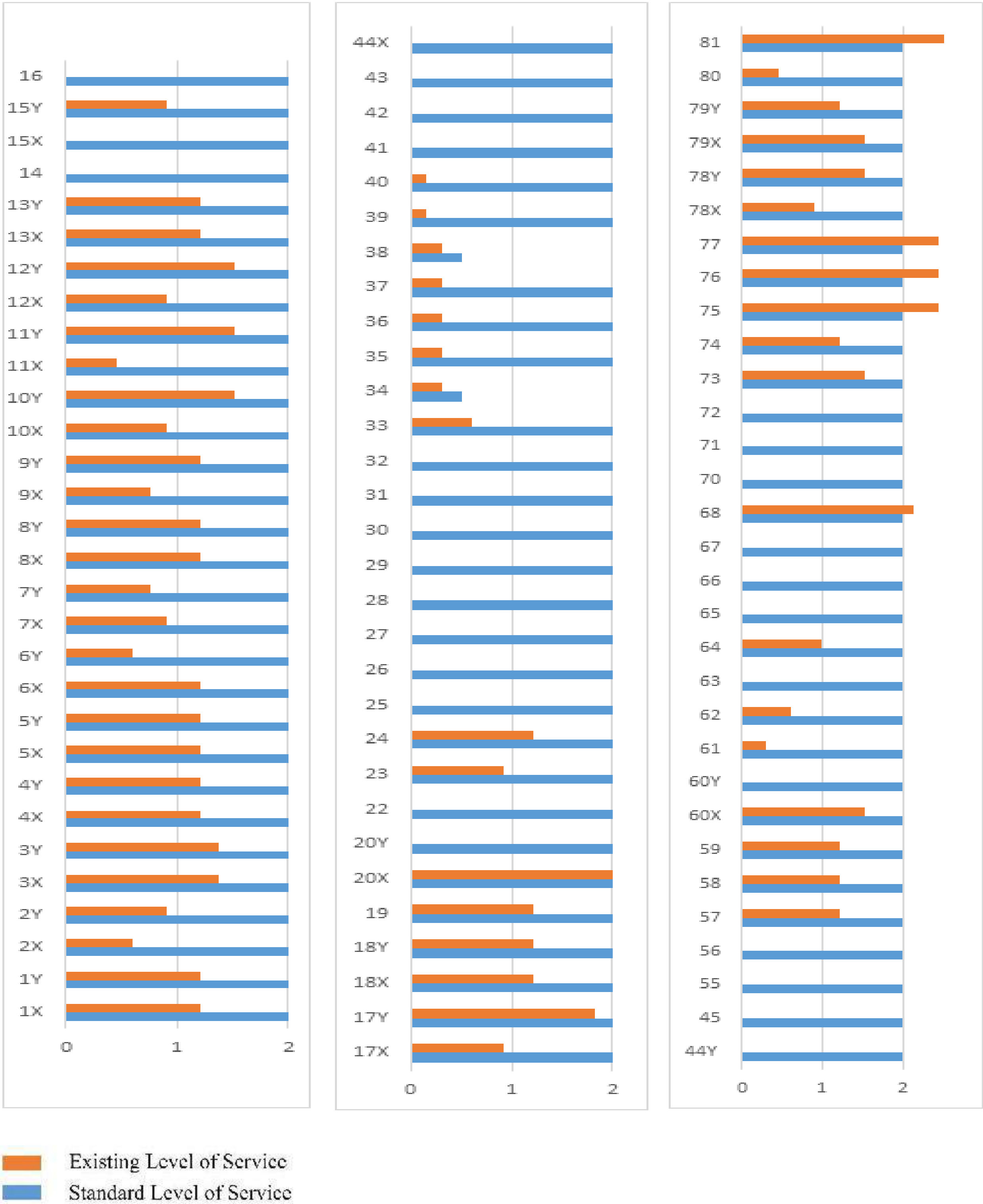


Figure 4.9: Graphical Presentation of Level of Service Analysis

The overall status has been plotted in (Figure 4.9), which presents the relationship between available pedestrian spaces and adequate space for the walk only. According to the Level of Service (LOS) standard analysis, the available existing walkable space has also been equated with manual counting (Appendix 12) to reveal the inadequacy. This analysis exposes several encroachment facts on the available walkable space, reducing the clear width and generating high friction in the pedestrian movement. 87% walkable segments are identified as failed (LOS F) to serve theoretically. The available effective walkable space must be proportionate to the currently generating pedestrian flow rate. LOS F means the walking speeds are severely obstructed, unavoidable contact with other pedestrians, cross and reverse-flow movements are virtually impossible, and flow is sporadic and unstable. Some Segments (2x, 10y, 62) are identified as LOS D and LOS E (12%), mentioned as an inappropriate walkable environment. Several secondary connecting streets behind the commercial plots along primary roads have no pavement infrastructure practically, where possible walkable spaces are obstructed by bike or rickshaw parking and food vendors such gate points are 20y, 22, 25, 34, and 38. From the observation, these entire spaces can be potential walkable spaces according to the pedestrian flow rate. Only 1% of this entire walkable network has been identified in category LOS C as basic walkable environment only.

4.6 Sidewalk Condition Index Analysis

The sidewalk condition index (SCI) is a visual inspection and observation that presents the total overview of the entire study area's walkable circumstances regarding the frequency and severity of specific distresses (Appendix 10). A matrix (Appendix 2) has been developed to plot the range values (1 is for fine conditions and five is for extremely severe conditions) from the Surveyor's visual inspection for different barriers on each selected sidewalk segment.

The observation study in this research potrays, that the location of bus stops along the primary arterial roads adjacent to the Shapla chatter (i.e., Motijheel Road, Dainik Bangla node area, and near the Petrol pump, DIT Avenue, Toyenbee Road) connects the Central Business District (CBD) with the entire city network. These unreasonably disorganized stoppages invite an unlimited number of pedestrians to walk up during peak hours (morning and afternoon) without having enough walkable space to pass through. The dense pedestrian movement near the node area around the bus stoppage and there are many different kinds of cafés, and food booths in the Dilkusha commercial area, the BRTC bus stop, and other busy areas. During their lunch periods, many corporate executives also stroll along the secondary collector road. In addition, people also visit roadside hawker markets, which oddly creates congestion in the walkable spaces in peak hours near about 4 to 5 pm.

Figure 4.10: The Future Metro Station Transit Area

Figure 4.11:Pedestrian Congestion at 2.30 pm on Collector Road

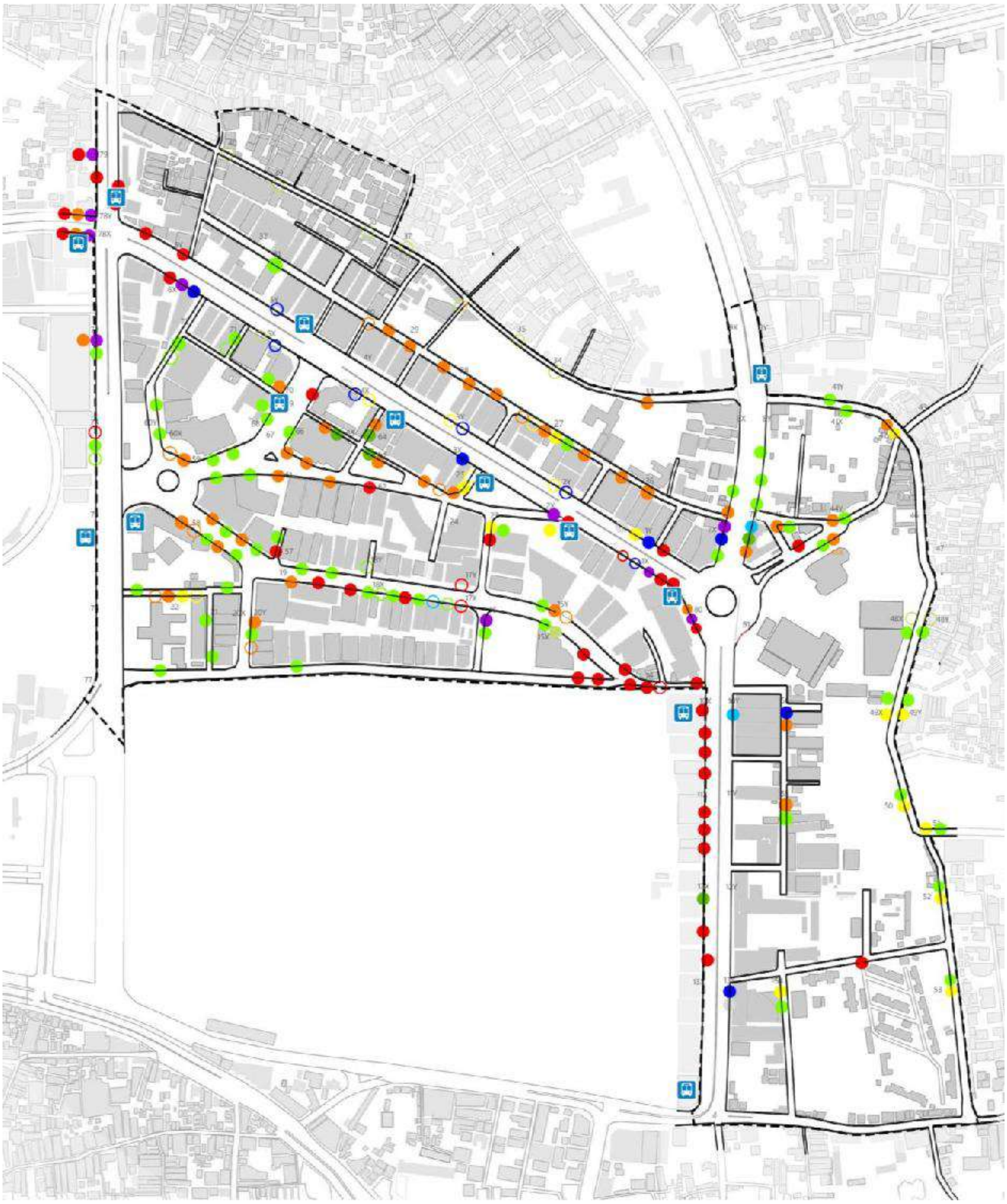
Figure 4.10 portrays the future metro station area where the movement will start with insufficient space, and Figure 4.11 shows the collector road congestion at 2.30 pm. The reason for congestion or space inadequacy has been evaluated in detail by SCI analysis. Apart from the congestion, the available walkable parts are not properly used because of the enormous infrastructural deficits that threaten the walkable environment of the Motijheel CBD area, such as surface irregularities, water accumulation problems, discontinuity, pitiable pavement construction material, loss of concrete at drainage covering, filthy garbage stand overflows on walkable space, absence of crossing demarcation, bus stoppage, and informal van rickshaw parking and so on in this research, the assessment on these existing physical attributes are the core fact to notify the faults in walkability within the CBD context.

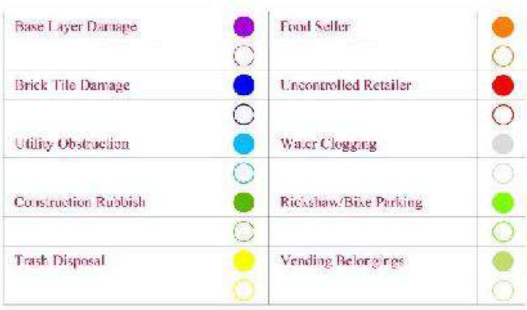
4.6.1 Primary Obstructions

Ninety-one points within the study area have been categorized under ten obstructions in field observation. Table 4.4 and Figure 4.12 presents an evaluation under individual obstruction criteria in percentage within 400m walkable distance in the study area. Each obstruction is presented in severity (How severe the obstruction is) and density (How frequently the obstruction exists). According to these total percentage presentations, the Food Retailer Traders (25% severe and 8% dense, Table 4.4) and Hawker Encroachment (14% extreme and 5% dense, Table 4.4) have been considered major serious obstructions in the CBD context. Consequently, pedestrians are often forced to walk in the street instead of the footpaths, which increases the risk of pedestrian injuries and has the adverse effect of reducing the walkable space and thereby increasing congestion. Apart from the encroachment by a hawker, vending belongings also have a serious percentage, i.e., 13% severe and 11% dense that massively obstruct most walkable spaces (Figure 4.12). In counting these all, the primary obstruction on these walkable segments is 52% for informal retail business within this Motijheel CBD context.

Table 4.4: Evaluation under Individual Obstruction Criteria Presented in Percentage

Ref no.	**Severity (S) Density (D)**	**Legend**	**Major obstruction**	**Severely encroached space in width**	**Extremely dense encroachment along the length**	**Percentage**	**Remarks**
1y, 2x, 6x, 6y, 7x, 16, 73, 78x, 78y, 80, 79	S	●	**01** Base layer damage	✓		12%	No pedestrian at no -16
1x, 2y, 16	D	○			✓	3%	No pedestrian at no -16
1y, 3x, 6x, 7x, 13y, 56	S	●	**02** Brick tile damage	✓		6%	
1x, 2y, 3y, 4x, 5x, 5y	D	○			✓	6%	
7y, 10y	S	●	**03** Utility obstruction	✓		2%	
17x	D	○			✓	1%	
7y, 12x, 63, 64, 65	S	●	**04** Construction rubbish	✓		5%	No pedestrian at no -63,64,65
	D	○			✓		
1y, 2x, 22, 23, 25, 27, 42, 49x. 49y, 50, 51, 52, 53, 54	S	●	**05** Trash disposal	✓		14%	No pedestrian at no -22,23,25
2y, 3y, 4x, 22, 25, 27	D	○			✓	6%	No pedestrian at no -22,25
7x, 7y, 15y, 20y, 22, 25, 26, 27, 33, 42, 44x, 44y, 45, 55, 56, 58, 59, 63, 64, 65, 69, 70, 73, 78x, 78y, 80	S	●	**06** Food seller	✓		25%	No pedestrian at no -22,25,26,63,64,65
15y, 20y, 22, 25, 27, 30, 58, 59	D	○			✓	8%	No pedestrian at no -22,25,30
1y, 2x, 6x, 6y, 10x, 14, 23, 57, 62, 74, 78x, 78y, 80, 79	S	●	**07** Hawking Activity	✓		14%	No pedestrian at no -23
1x, 14, 17x, 17y, 74	D	○			✓	5%	
1y, 13y	S	●	**08** Water clogging	✓		2%	
1x, 4x	D	○			✓	2%	
15x, 15y, 16, 18x, 20y, 21, 23, 27, 31, 41, 44x, 44y, 45, 48x, 48y, 49x. 49y, 50, 51, 52, 53, 54, 55, 57, 69, 70, 71, 72, 73, 74	S	●	**09** Rickshaw/bike parking	✓		29%	No pedestrian at no -16, 21,23,31,72
5y, 16, 17x, 18x, 18y, 20y, 21, 27, 29, 31, 41, 48x, 48y, 71, 72, 74	D	○			✓	15%	No pedestrian at no -16,27,29,31,72
15x, 33, 43, 48x, 48y, 49x. 49y, 50, 51, 52, 53, 54, 79	S	●	**10** Shop belonging	✓		13%	
5x, 34, 35, 36, 37, 38, 39, 40, 43, 48x, 48y	D	○			✓	11%	No pedestrian at no -34, 35, 36, 37, 38, 39, 40





*Note: identified most important obstructions are 52% for informal retail business including food retail business, hawking activity and vending belongings. The second most significant obstructions are 29% for informal bike parking and lastly 18% for surface deformations within the entire CBD context.

Figure 4.12: Obstructions from Sidewalk Condition Index Analysis

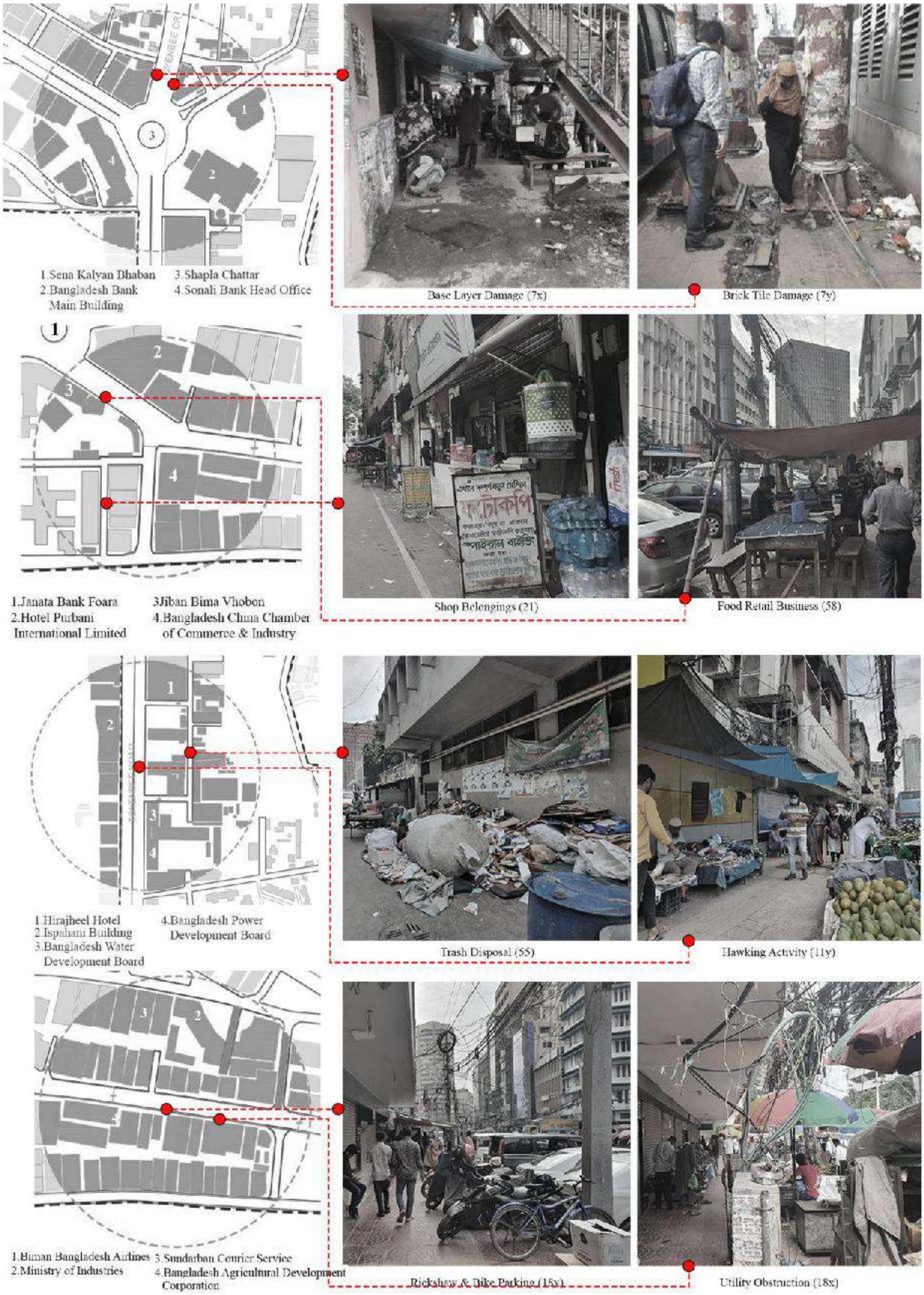
4.6.2 Secondary Obstructions

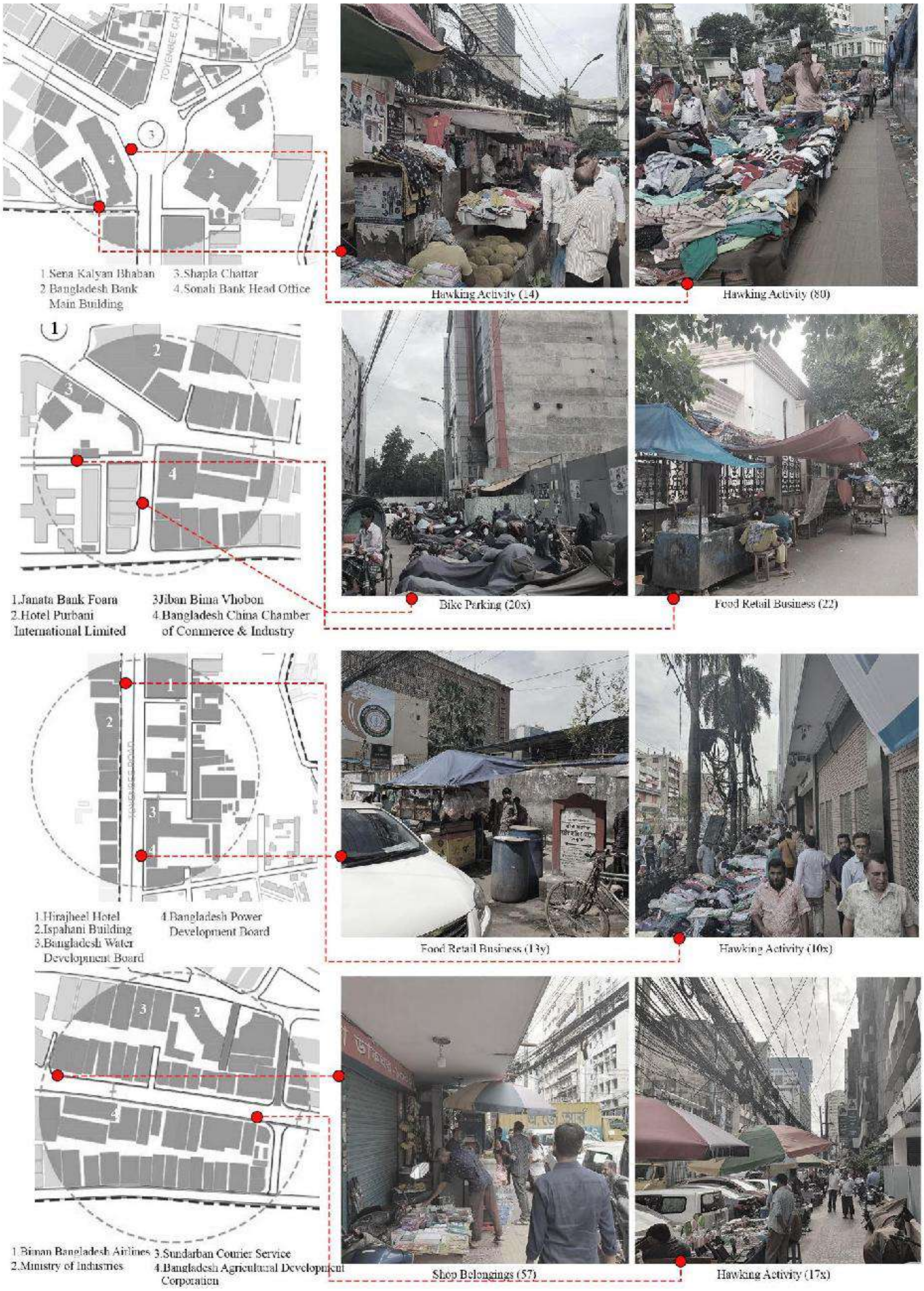
The second most serious obstruction has been notified is rickshaw or bike parking (29% severe and 15% dense) on walkable spaces because they have no separate zone to stand. Subsequently, it affects the pedestrian flow rate and overall width throughout the pavement, which is unexpected and problematic for pedestrians. Existing pedestrian users are already a pressure on the existing walkable space. This CBD's efficiency in walkability is worsening daily in north-south and east-west directions both, which is severely discontinuous. At the same time, with the discontinuity issue, the scope of organized crossing facilities is completely underprivileged within the overall walkable network. Ordinarily, no signage exists for a pedestrian crossing at several points (Figure 4.13).

Figure 4.13: Crossing at Shapla-chatter node and Crossing at Dainik-Bangla Node

The garbage management system (14% severely blocked and 8% dense) is the third most significant issue obstructing walking activity. A large garbage station enters the walkable space at gates 6y to 40 (connecting Dainik Bangla Mor to Gazi Dastagir road). In addition, the existing drainage line needs to be cleaned regularly, and abrupt toilet activity creates hygiene problems in the walkable space here. Base layer damage, Brick Tile Missing, has also been notified as a thoughtful issue (12% severe, 6% severe) that causes water logging at walkable areas in the rainy season (5% severe). In the study area, the broken pavement has been found near Dainik Banglar Mor. The condition of the pavement near Gulistan Circle is vulnerable. Some bricks and stones on the pavements often disturb pedestrians while walking. Moreover, facilities for differently abled person is totally ignored in CBD context. Eventually, it was proven that these irregularities like trashes, utility hole on the walkable space cause pedestrians difficulties. Related photographs also illustrate the severe obstacles encountered in the walkable space in Table: 4.5 (Field survey 2022).

Table 4.5: **Major Obstruction Typology Presented from Different Street Segments**





4.7 Questionnaire Analysis

Questionnaire survey is required when the information assortment is difficult from non-existing or non-perceivable (i.e., User demand and experience) walkable criteria which cannot be quantified from observation. In addition to providing details on the user group, origin-destination, walkable distance, and mode of transportation, this section will highlight the key findings of the questionnaire survey conducted within the study area and provide feedback from the general public on the area's current walkability based on a set of predetermined criteria (Appendix 1). This process has been processed in multiple steps, i.e., the definition of the target population, selection of sampling size, and data collection to assess the response rate. For more accurate result, the minimum sample size for the questionnaire survey was increased to 190 respondents after a pilot study. For the questionnaire survey, there were surveyors at several gates in the research area within five minutes of walking distance. They questioned the randomly chosen people.

The questions in the questionnaire survey have been designed in this research under three segments according to the variables for sustainable walkability to determine the walking behavioral pattern. One segment is 'Accessibility,' responding to the walking environment, sense of pedestrian density, time to hold destination point, and understanding surface conditions and obstructions [supporting Question 06]. Another one is the 'Connectivity' responding to the pedestrian facilities, uses, crossing, and the existing connectivity of walkable space [supporting Question 05 (d, e), and 07)], and the final segment on 'Walk Appeal Features' responding to the motivational features for the walkable environment [supporting Question 05 (a, b, c), and 08)].

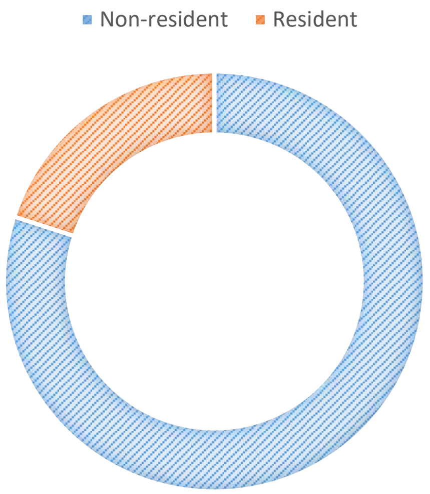


Figure 4.14: Pedestrian type in the study area (resident vs. Non-resident pedestrian) (Questionnaire survey, June 2022)

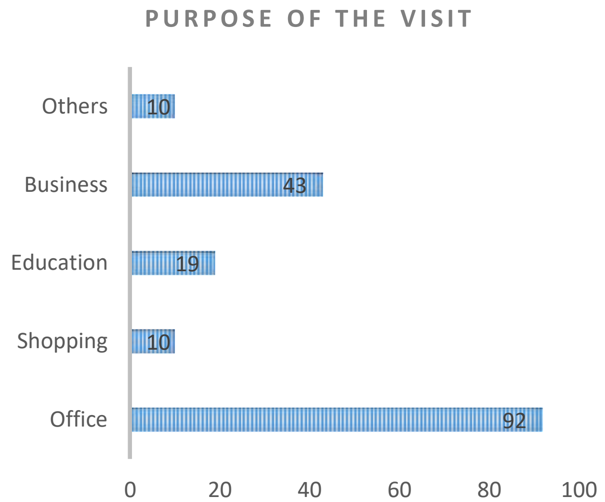


Figure 4.15: Purpose of the visit to the CBD area (Questionnaire survey, June 2022)

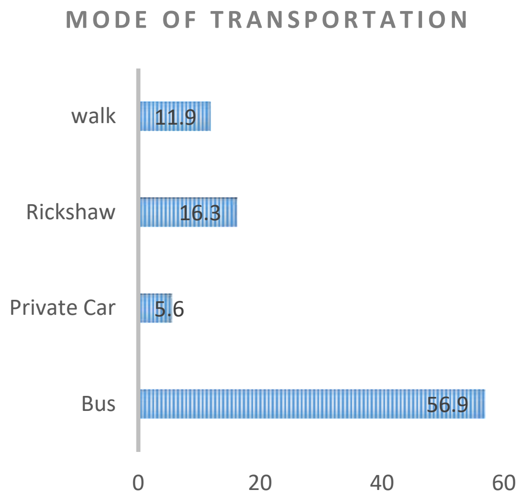


Figure 4.16: Mode of transport used by the pedestrians as part of the movement route (Questionnaire survey, June 2022)

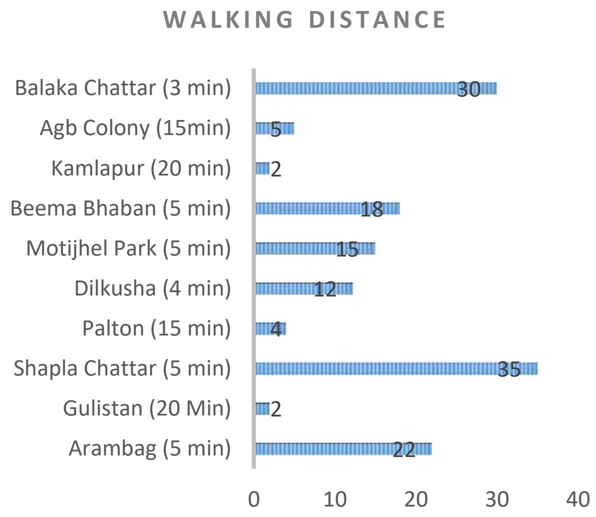


Figure 4.17: Walking distance to reach the desired destination (Questionnaire survey, June 2022)

A general set of questions (Q_01, 02, 03, 04) portrays the type of residents and the reason behind walking. It defines the walking distance to reach the nearby destination, and route choice, to understand the user choice and the walkability context. However, this study did not include pedestrians younger than 15 years, beggars, and school-age students will get the proper result.

80 percent (152 out of 190 interviewees) of the pedestrians in the research area are non-residents who come from different parts of the city. In contrast, only 20% of pedestrians are local inhabitants walking in the walkways within the Motijheel area (Figure- 4.14).

Among these respondents (Figure-4.15), 83.1% have been marked for official activity, 22% have observed for business, 12% for education, and 6.3% for other activities according to the purpose of visiting the place. The outcome demonstrates a strong commercial character acting as a significant predator to create movement in the studied area. Additionally, it will draw more commuters in the future, which must be taken into account at the outset of sustainable planning.

For transportation along this commuter route, 56.9% of pedestrians use buses, 16.3% use rickshaws, 3.8% use bicycles, 5.6% use CNG auto-rickshaws, and 11.9% rely only on walking (Figure 4.16). The outcome demonstrates that the majority of pedestrians in the current system use public transportation as part of their journey to get where they're going. The vision of using the metro station at Shapla Chatter area will be the densest pedestrian generation point to reach the local destinations.

Figure 4.17 presents that 82.7% of the total respondents walk within 3-5min walking distance, 13.7% within 10 -15min walking distance, and 4.13% within 20min walking distance. The result shows that the "pedestrian shed" of the study area is within a 5-10min walk, since a significant portion of pedestrians travel minimum 5 to maximum 10 minutes on foot to get destination point. The outcome strongly suggests that, in order to improve accessibility conditions around the public transit precinct, the shortest route of the street network should be enhanced to pass through within a 5–10 minute walking distance.

According to the questionnaire survey (Figure 4.18), 73.4% of pedestrians used to walk to get to their destination, within 41.1% of them doing so to avoid traffic, 29.7% to get to a bus stop close, and 11.4% to save money on transit. According to the findings, people are more likely to walk short distances and escape traffic delays.

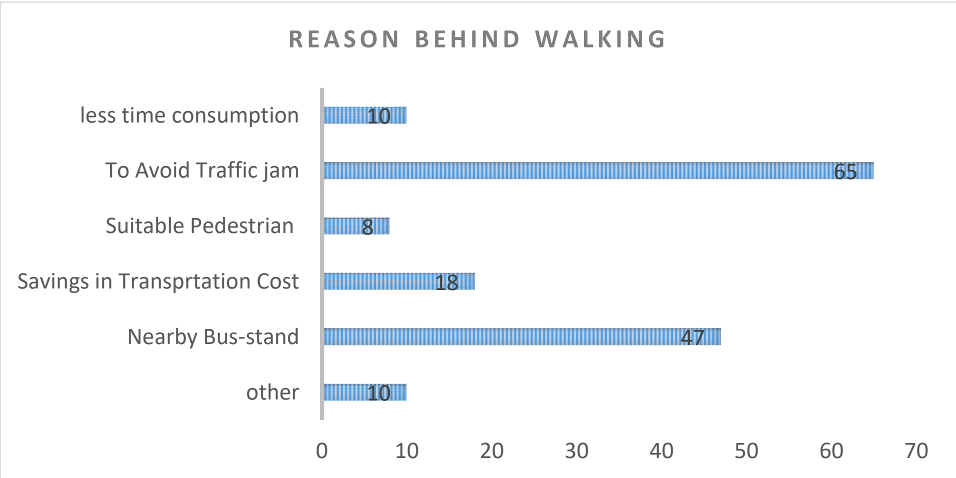


Figure 4.18: Reason behind Pedestrian Walking (Questionnaire survey, June 2022)

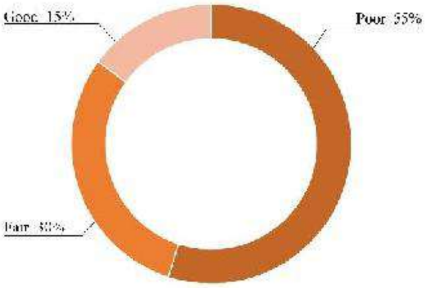
4.7.1 Accessibility

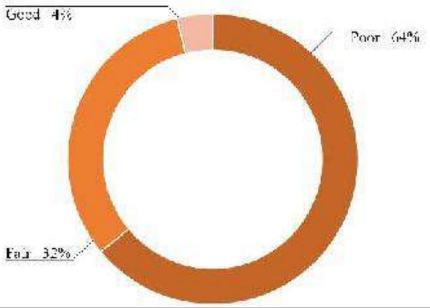
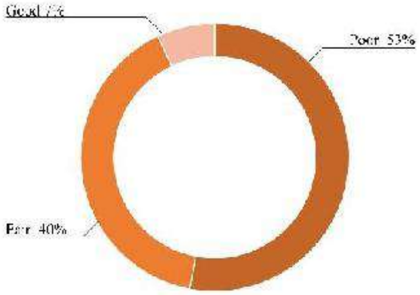
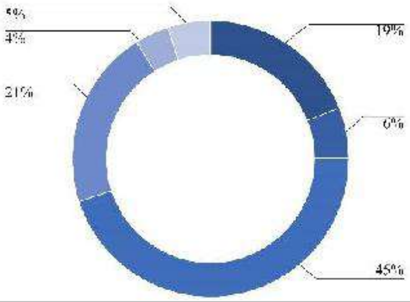
First, the question about sidewalk safety and space adequacy arises to define the user's understanding of the walkable environment. From question number 05_(a), 104 out of 190 (55%) rated it as a poor condition on the safety security issues, majorly because of discontinuity, poor maintenance, and obstructed space condition. Furthermore, 30% and 16% rated this walkable context consecutively as fair and good from an orthodox perspective. Question number 05_ (b) defines the percentage of user density vs. adequate walkable space, where 64% rated it as poor (121 respondents out of 190). Furthermore, 33% commented as fair because of habituating within this substantial conflicted condition.

Secondly, the question about time consumption arises to identify the route choice and the easy passage to reach the last stop. Question 05_ (e) detects the time consumption evaluation for reaching the destination while using the pedestrian space, where 53% (100 out of 190 respondents) rated this journey as miserable, majorly of the obstructed and severely conflicted conditions to reach their destination. On some points, these evaluation ratings are 40% and 7%, where secondary roads are the shortest walkable route, with the total street width seeming adequate for walking.

In the third phase of this section, Question number 06 arises to identify the significant reason or obstructions that hinder easy communication through the walkable context. Among six types of obstacles plotted in the questionnaire, users identified the top 3 barriers that are hawkers, food vendors 47% (88 respondents out of 190), on-spot bike and rickshaw parking 22% (42respondents out of 190), and lastly the unnecessary garbage 20% (31 respondents out of 190). Retailer businesses and food vendors generate massive amounts of trash, i.e., vending belongings and used packages, over the walkable space, significantly obstructing pedestrians. Construction rubbish at a certain distance, utility cut holes, and surface deformation due to tree roots are consecutively 4%, 5%, and 8%. The 8% Surface deformation generates due to multiple reasons, i.e., brick tile missing, loss of concrete, and damage in the base layer. These explanations are plotted in percentages, identified from the questionnaire survey 2022 in Table 4.6.

Table 4.6: Evaluation of Questionnaire Survey Analysis (Q _ 05a, b, e and 06)

DIAGRAM PER QUESTION	CRITERIA		RESPONSE NUMBER OUT OF 190 SAMPLES	RESPOND PERCENTAGE
QUESTION NO. 05_A SAFETY SECURITY AT THE PEDESTRIAN LEVEL		POOR		
		FAIR		
		GOOD		
	**POOR**		104	55%
	FAIR		57	30%
	GOOD		30	16%
	BETTER		0	0%
	EXCELLENT		0	0%
QUESTION NO. 05_B CONFLICT BETWEEN TRAFFIC AND PEDESTRIAN		POOR		
		FAIR		
		GOOD		
	POOR		121	64%
	FAIR		62	33%

	**GOOD**	8	4%
	BETTER	0	0%
	EXCELLENT	0	0%
QUESTION NO. 05_E **TIME CONSUMPTION WHILE USING PEDESTRIAN SPACE** 1.6	POOR FAIR GOOD		
	**POOR**	100	53%
	FAIR	76	40%
	GOOD	14	7%
	BETTER	0	0
	EXCELLENT	0	0
QUESTION NO. 06 **IDENTIFY OBSTACLES** 1.6	**1** **4** **2** **5** **3** **6**		
	**1. UNNECESSARY GARBAGE**	31	19%
	2. CONSTRUCTION RUBBISH	12	6%
	3. VENDOR	88	45%
	4. ON SPOT PARKING	42	21%
	5. SURFACE DEFORMATION	9	4%
	6. UTILITY CUT HOLES	10	5%

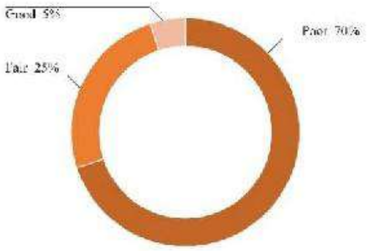
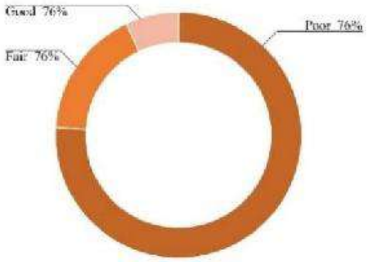
4.7.2 Walkable Conveniences

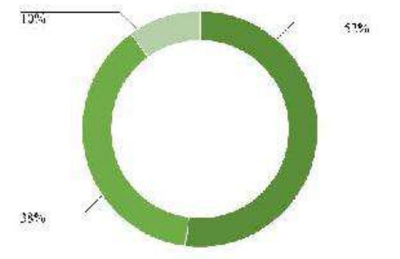
Question 05_ (c) identifies the pedestrian conveniences and green furnishing features. 70% of respondents rated these walkable spaces as poor (131 respondents out of 190) as there is no pedestrian island, curb extension, shelter, information, lighting, seating, trash receptacles, bike racks, marked crossings, sidewalks leading to/from the bus stop. Furthermore, 25% commented as fair because the spaces adjacent to Motijheel Park at Balaka Chattar have been renovated recently. Some existing green furnishing along Paltan Maydan pavement on DIT Avenue has a large canopy giving shade to pedestrian users. Nevertheless, pedestrian furniture no longer exists in the total CBD context.

Question number 05_ (d) emphasizes the pavement crossings, where 76% of respondents rated the crossing condition poor as there is no marking on the street at the nodal point. Moreover, in the connecting section to the secondary collector road, the surface condition is extremely vulnerable and discontinuous that interrupting the easy pass way. Furthermore, only 18% responded that it was fair only for one foot-over bridge near Shapla Chattor or because of their habituated perspective.

Question 07, ' Identifies the important feature while using the pedestrian crossing,' has been formulated as a given option question. The public will choose their best demand within three options. Finally, 52% (100 out of 190 respondents) notified the necessity of marking the location of the appropriate crossing. The following Table 4.7 represents the public response regarding the existing walkable conveniences in Motijheel CBD, Dhaka.

Table 4.7: Evaluation of Questionnaire Survey Analysis (Q _ 05 C, D and 07)

DIAGRAM PER QUESTION	CRITERIA	RESPONSE NUMBER OUT OF 190 SAMPLES	RESPOND PERCENTAGE
PEDESTRIAN AMENITIES & GREEN FURNISHING	**POOR** **FAIR** **GOOD**		
	**POOR**	131	70%
	FAIR	50	25%
	GOOD	9	5%
	BETTER	0	0%
	EXCELLENT	0	0%
QUESTION NO. 05_D PEDESTRIAN CROSSING & CONNECTIVITY	POOR FAIR GOOD		
	**POOR**	145	76%
	FAIR	35	18%
	GOOD	15	8%
	BETTER	0	0%
		0	0%
QUESTION NO. 07 IDENTIFY THE IMPORTANT FEATURE WHILE USING PEDESTRIAN CROSSING	**1** **2** **3**		
	1. MARKING THE LOCATION OF THE APPROPRIATE CROSSING	100	52%
	2. EXACT SIGNAL AT THE PLACE OF THE ROAD CROSSING	73	38%

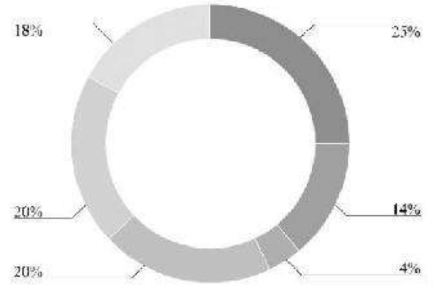
	**3. PLACEMENT OF TRAFFIC POLICE AT THE PLACE OF ROAD CROSSING**	17	9%

4.7.3 Walk Appeal Features

Walk appeal features are the part that motivates a walk or the standards for a walkable space should follow. These features include Pedestrian Furniture, lighting, Curb Extension, Greenery at a specific interval, Pedestrian Division, Presence of Crossing with Proper Marking, Universal Accessibility, a Curb Ramp, Connecting public plaza, and a pedestrian holding area.

Question number 08 identifies the suggestions from the users for important features regarding a walkable environment. Under six categories, the top-rated four categories are Un-obstructed Road [30% (57 respondents out of 190)], Attractive Green Shaded Pavement [20% (38 respondents out of 190], a Uniform Walkable Surface without breakage [20% (39 respondents out of 190)], and Connected Pedestrian Network [18% (33 respondents out of 190)]. Universal accessibility and pavement luminance category do not attract the users much due to ignorance within this context. The following Table 4.8 signifies the necessity of top rated features for the walkable environment in the Motijheel CBD context.

Table 4.8: Evaluation of Questionnaire Survey Analysis (Q_ 08)

DIAGRAM PER QUESTION	CRITERIA	RESPONSE NUMBER OUT OF 190 SAMPLES	RESPOND PERCENTAGE
QUESTION NO. 08 IDENTIFY THE IMPORTANT FEATURE WHILE WALKING	**1 4 2 5 3 6**		
	**1. UNOBSTRUCTED ROAD**	47	25%
	2. ILLUMINATED AND SAFE ROAD	25	14%
	3. PUBLICLY ACCESSIBLE(FOR THE ELDERLY AND CHILDREN)	8	4%
	4. ATTRACTIVE AND GREEN-SHADED PEDESTRIAN	38	20%
	5. FLAT SIDEWALK SURFACE WITHOUT BREAKAGE	39	20%

	6. CONTINUOUS SIDEWALK CONNECTION	33	18%

4.8 Validation Outcome

The questionnaire analysis has also been complemented the collective data from SCI analysis for the final and valid outcome. To accumulate the calculated Side walk Condition Index (SCI), the Surveyor's visual inspection was averaged, and the public's opinions were decoded from the questionnaire survey analysis, following the most responded option is rated as 5, and the least responded option is rated as 1. Then the values of the calculated Side walk Condition Index (SCI) were summarized (Appendix 13)

Next, the mean value of SCI (the arithmetic mean of Calculated SCI, the Public's opinion-based SCI, and the Surveyor's visual inspection-based SCI) was calculated for each section of all locations. This mean value is supposed to be the "Final SCI" of that particular section. This "Final SCI" provides a numeric rating for walkable road network segments, extending from 0 to 100, with 0 representing the worst possible condition. With computed SCI and Final SCI, a linear regression graph has been created to demonstrate the accuracy of the results for each gate. In all 91 segments, 92.4% of walkable areas are in poor condition, while 7.6% are comparatively in fair condition (summarized from Appendix 13), presented in Table 4.9. The following regression graph (Figure 4.19) shows the R-value of 0.9962, showing that the results obtained for selected segments are fairly flawless.

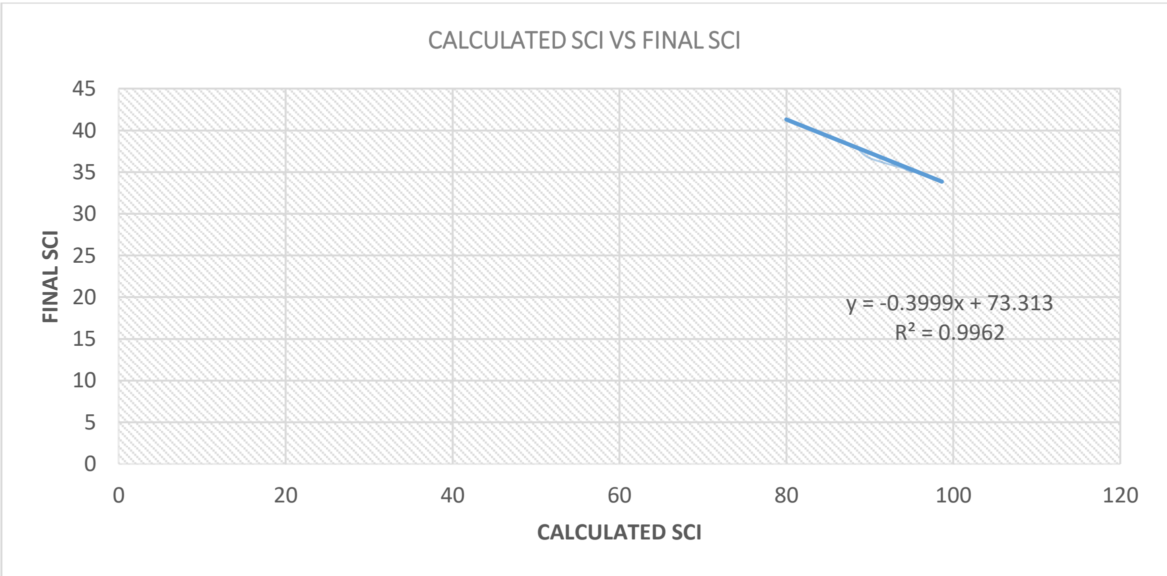


Figure 4.19: Linear Regression Graph (calculated SCI vs. final SCI) (field survey, April 2022)

Table 4.9: Sidewalk Condition Index Analysis (See Appendix 9)

SCI range	Rating	Number of Walkable Areas (Motijheel CBD)	Resultant of SCI (Motijheel CBD)
0-28	Failed	0	
28-45	Poor	84	92.4%
46-55	Fair	7	7.6%
56-71	Good	0	
72-85	Very good	0	
86-100	Excellent	0	

4.9 Conclusion

From the above stated exploration details, it is proved that the walkable context in Motijheel CBD is not breathing out yet in this megacity for sustainability. This research emphasizes the fundamental walkable phenomena at the pedestrian level for daily communication before and after the motorized transition starts and ends. The entire description has portrayed in this chapter strongly regarding the existing physical infrastructure shortcomings according to the functional street hierarchy of the walkable space by Level of Service (LOS) and Sidewalk Condition Index (SCI) analysis through the quantitative method following objective 01. The information collection from non-existent and non-perceivable walkable criteria (user desire and experience) for establishing sustainable walkability has also been done through a questionnaire survey to complement the collective quantitative data of SCI analysis for the final and valid outcome. The overall walkable scenario has been portrayed in this chapter and justified by several photographs of each segment. The entire evaluation process to quantify and qualify the field study has been detailed chronologically to obtain the final results. The quantitative analysis of Level of Service (LOS) has been plotted first, where 87% of existing walkable segments are found to be highly congested and incompatible compared to standard user volume. Then the qualitative survey results are incorporated with the observational rating for SCI analysis, which results in 92.4% of existing walkable conditions are severely unacceptable. Specific strategic initiatives should undertake from these identified perspectives to diminish the overall adverse impact on the walkability of this CBD’s walkable environment which will be discussed in the next chapters.

CHAPTER 05
DISCUSSIONS ON FINDINGS

5.1 Introduction

In the interest of creating a sustainable city that is welcoming, vibrant, human-scaled, safe and secure, less polluting, and desirable to businesses or individuals, walkability is essential. For good pedestrian accessibility within Motijheel CBD, efficient passenger transfer and regulating mass movement during peak hours have become indispensable. Due to extensive economic expansion and various land uses, the number of walkable passengers in CBD is relatively large. A new set of traffic volumes have been expected to be added simultaneously due to the metro station's location on a major arterial connection. These traffic volumes must be dispersed by walking to the desired location. A literature framework suggests multiple criteria, including urban form, physical infrastructure, legibility, journey quality, and policies and programs that act on the overall walkability phenomenon. In order to evaluate walkability in this CDB context of Dhaka City, this research has largely focused on the physical features, i.e., the quality of Pedestrian Infrastructure as well as the walkable trip experiences. It requires an analytical approach to assess the accessibility, walkable conveniences, and walk appeal features in the study area of Motijheel using Quantitative and Qualitative analysis of the current walkable structure. The study examines the area's road configuration system, land use pattern, pedestrian flow rate, and possible walkable infrastructures. The study assesses the shortcomings of walkable infrastructure that negatively impact the pedestrian circulation inside this CBD area. In order to comprehend the existing inadequacies and the experience of a walkable setting, the preceding chapter 04 attempted to examine pedestrian mobility and physical features within the local urban grid in the case of Motijheel CBD. This chapter summarizes and discusses the major results found from chapter 04 on walkability's drawbacks, current walkable conditions, and public experiences on walkable accessibility, conveniences, and walk appeal qualities.

5.2 Findings on Walkability Status in CBD

In order to improve future urban sustainable development, this research intends to pinpoint the issues with the walkable environment in Motijheel CBD and make some practical suggestions over the following findings.

5.2.1 Limitations between the Regulatory Framework and the Reality in Practice

This research summarizes the local policy measures for documentation regarding walkability in Chapter 2, section 2.10. The local guidelines mentioned in section 2.10.2 in the 'Revised Strategic Transport Plan (RSTP 2015)' by DTCA present only the street lane configurations and classifications. No detailed specifications regarding sustainable walkability were mentioned there. The DTCA has also published a draft of the 'Pedestrian Safety Policy' without any respect to any context or road classification, stated in section 2.10.2. The Dhaka Structure Plan (DSP 2016-2035) is not exceptional from others. However, it only specifies the general dimensions of the clear pedestrian area without following the land-use-specific pedestrian flow rate pattern. Lastly, the Detail Area Plan (DAP 2022-2035) contains specific guidelines according to the street typology (described in section 2.10.3), but still not appropriate enough.

Limitations in Road Classification

The Detail Area Plan (DAP 2022-2035) describes the street classifications with appropriate urban infrastructure in four typologies (Figure 2.8): inter-regional or intra-regional connecting road, Collector road with three samples, and local access road. However, this study states that most of the roads in Motijheel CBD, like others, are ineligible for the intra-regional (above 170ft) or inter-regional road (100 – 130ft) specifications. According to DAP, the primary roads in Motijheel CBD comprise 53.54%, comparable to 'Collector Road Sample 01' specifications for walkability. Another 11.12% of secondary roads are comparable to 'Collector Road Sample 02', and 33.34% of access roads (11 to 40 feet) in the Motijheel CBD, according to the DAP, can be comparable to 'Collector Road Sample 03's specifications.

Unfortunately, the exact specification for walkable segments mentioned in DAP cannot be applicable in the practical context due to frequent street width variety. In practical situations, street widths are not confined to these three categories only. In addition, it is difficult to reduce the lane width for pedestrian expansion. Ultimately the collector roads in this study area consist of roads less than 12 meters (40 feet) in width, which is incompatible with any walkability standard. Except for these primary and collector roads, local access roads with a width of 10 - 20ft comprehends no strategies for walkability. In contrast, the massive portions of street segments have been identified as under 20ft in width (Appendix 7, 8, and 9), a major limitation of local strategies for walkability.

The DAP did not define the roads with a width of 10ft or less than that, while the RSTP mentioned that roads with a 10ft width must be prioritized with pedestrians. Following this strategy, this research identified existing roads and new possible interventions to be full-time walkable without even NMT transition.

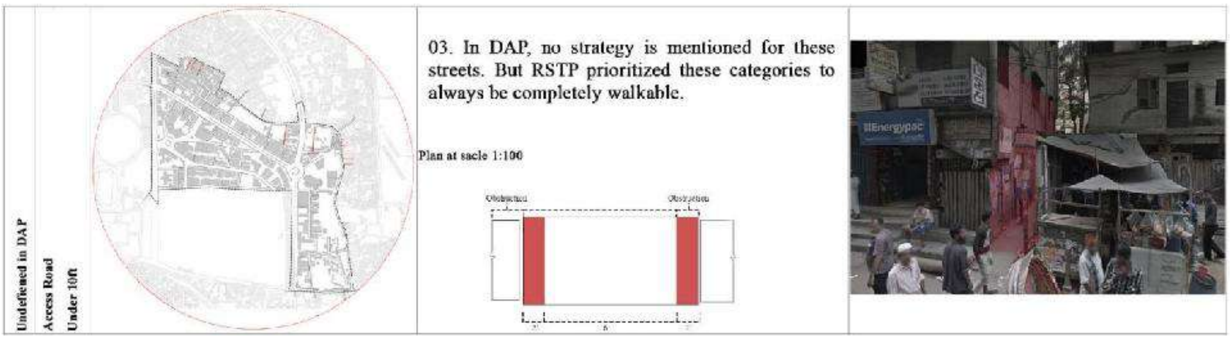
Limitations in Extension Guidelines

DAP has already stated in the section of 'Transportation and Connectivity Infrastructure' (DAP, Vol 1, Page 163) that vehicular transit roads should be constructed with a minimum width of 40ft, which is now unreasonable for retrofitting the existing condition. Another proposition in pedestrian extension guidelines (DAP, Vol 1, Page 167) entails that street extension of 5 feet for walkability can be allowed without public opinion. In practical situations, these statements have proven challenging to apply towards roads or plots that conflicted with this extension guideline statement.

Shared Pedestrian Concept

It will be challenging to completely pedestrianize most of the road segments due to the accessibility issue of the built forms. This study intends to implement the shared pedestrian concept outlined in DAP (Page 175), discussed in Section 2.10.3. However, the shared pedestrian concept in DAP needs to be more precise to guide the development of the practical context in depth.

Ultimately, the urban lifeline guidelines in DAP demands to be revised for Dhaka's central business district and any other local contexts. For sustainable development, this study initiates new interventions for this context-specific walkability based on pedestrian traffic demand in the following chapter. Table 5.1 illustrates the street classification and functional configuration, emphasizing that 33.34 % of access roads require development guidelines for sustainable walkability.



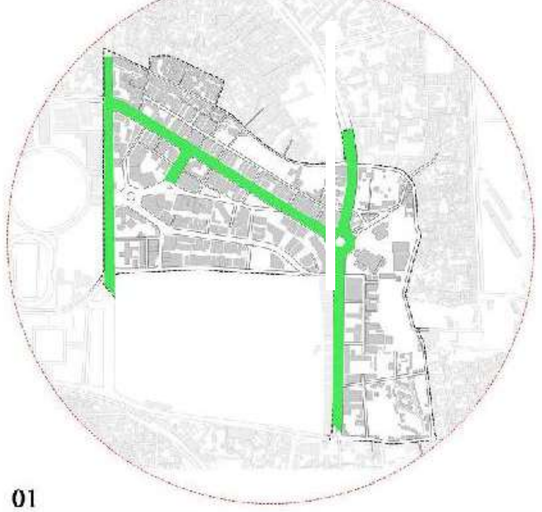
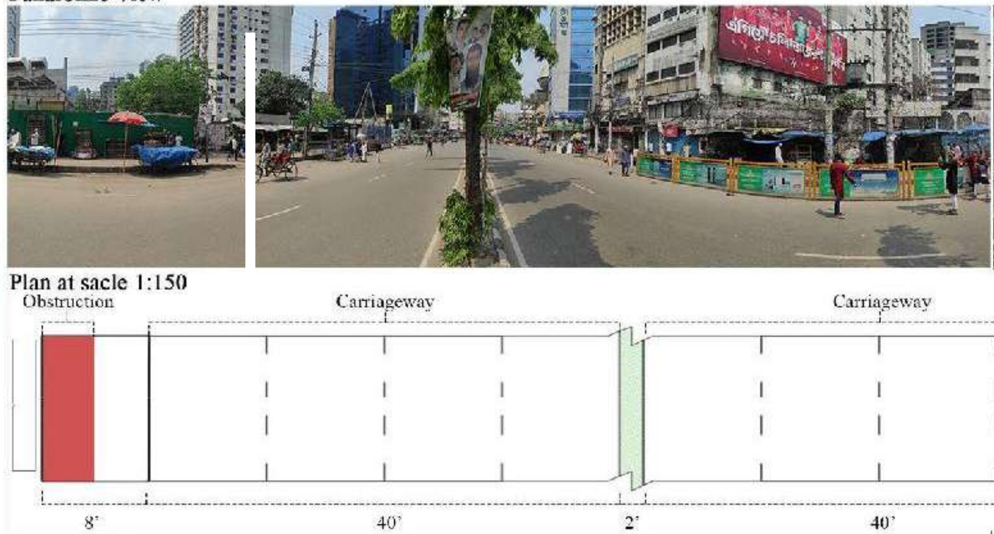
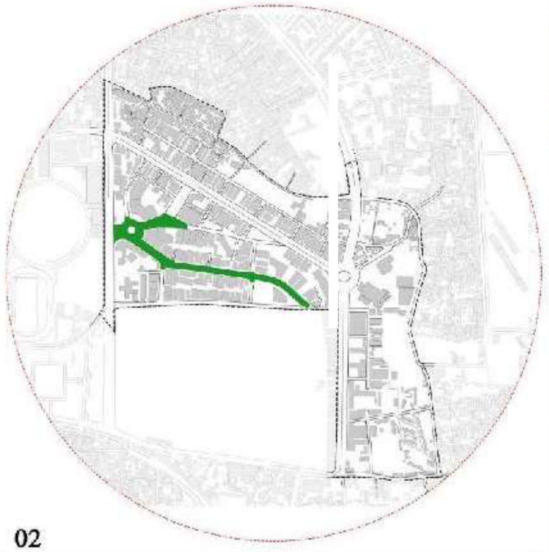
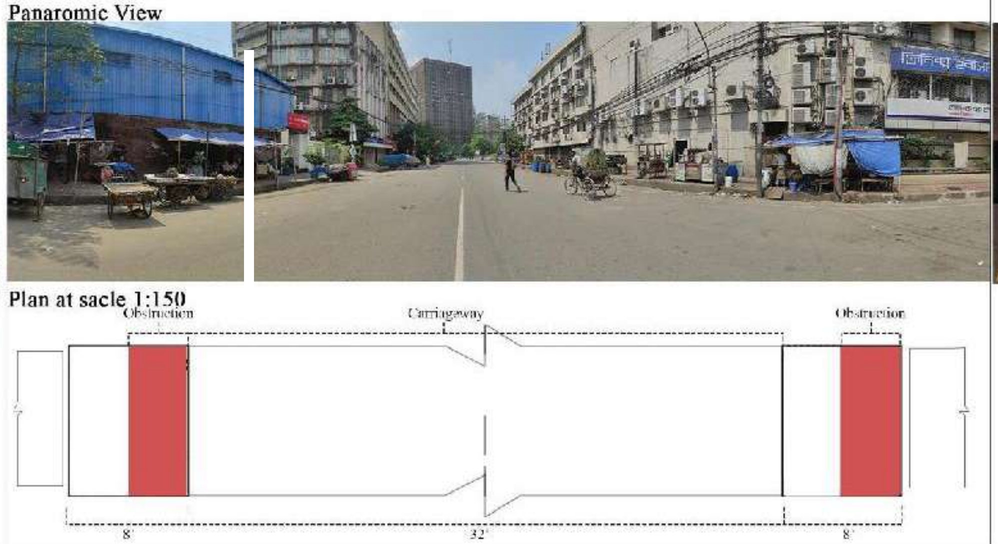
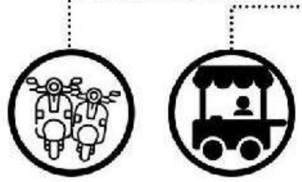
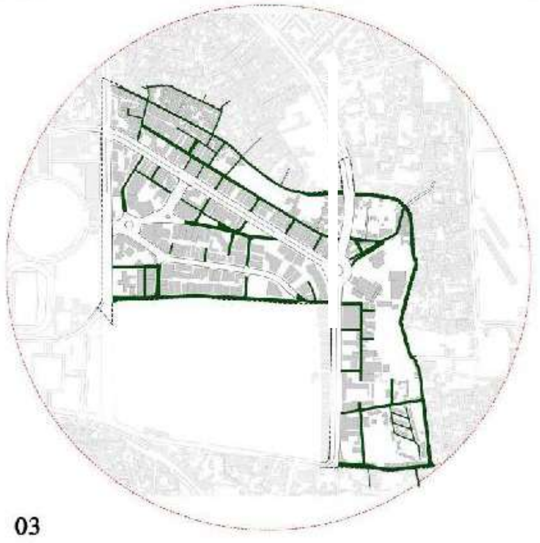
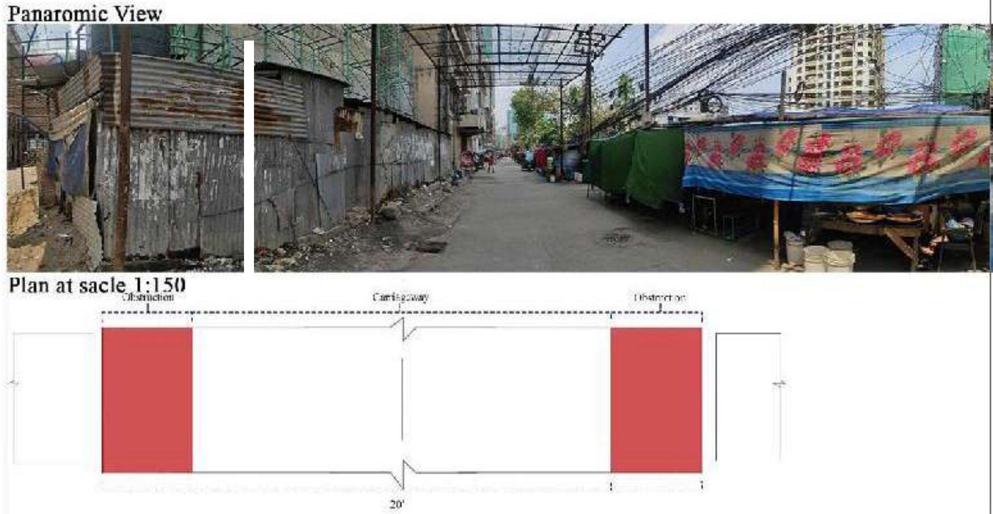
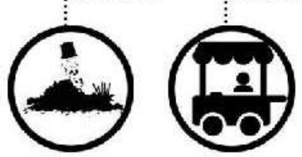
Existing Road type with Percentage	Road Width	Map	Illustration	Images with Types of Obstruction
Primary Road (53.54%)	81-100 ft	01 		  01. In DAP 2022, the strategy for walkability on the primary roads is defined as 15 feet for pedestrians on both sides. However, retrofitting has become quite difficult to expand the walkway toward the property line (outlined in the DAP extension guidelines) with compensation due to ownership issues. Expansion plans necessitate further investigation into this matter.
Secondary Road (11.12%)	41-80 ft	02 		  02. The walkability strategy for Secondary roads is stated in DAP 2022 as 10 feet for pedestrians on both sides. Due to ownership concerns, it is especially challenging to adapt the DAP extension standards' recommended pathway enlargement toward the property line with compensation. Plans for expansion require additional research on this subject.
Local Access Road (33.34%)	11-40 ft	03 		  03. This category of roads has no DAP or RSTP-encrypted local strategies. According to a recommendation in DAP 2022, this research has brought these streets under the concept of shared walkability. However, the proper instructions for sharing the walkable space with the transit lane are wholly absent in DAP.

Table 5.1: Existing Circumstance and Specification Deficiency in DAP 2022 According to Street Typology

5.2.2 Identify the Existing Characteristics and Shortcomings of Walkability

As mentioned in the previous chapter, this research concentrates on the physical attributes of walkability rather than the Urban Design Qualities and Individual Reactions (discussed in section 1.5). Following this, the data collection process regarding the assessment of this walkable environment has been conducted through Quantitative analysis, including Level of Service (LOS) analysis (section 4.5) and Sidewalk Condition Index (SCI) analysis (section 4.6) for in-depth observation.

(a) Lack of Availability

Following objective 01, Quantitative Analysis: This research aims to identify the Motijheel CBD's existing walkable characteristics and shortcomings to understand their impact on urban sustainability considering the local and global perspectives. The Quantitative LOS analysis emphasizes quantifying the existing walkable spaces regarding the number of users and the effective walkable width at selected gate points over the primary, secondary, secondary collector, and local access road segments. Maximum, 87% of existing walkable spaces here proved severely congested (compared to Level of Service (LOS) Standards, represented as LOS F for local movement. It means the walking speeds are severely constrained; reverse flow is essentially not possible, and interaction with other pedestrians is inevitable.

Table 5.2: Existing Pedestrian Infrastructure According to Level of Service (LOS)

Total Assessed Segments	Existing Condition	Percent age	Remarks
91	A	0%	The ideal pedestrian environment
	B	0%	Reasonable pedestrian condition as an acceptable standard
	C	1%	Basic pedestrian condition
	D & E	12%	Unsuitable environment -Affecting factors are below acceptable standards
	F	87%	Severe Unstable - Contact with other pedestrians is unavoidable. - Movements that cross or reverse the flow are practically impossible. - Sporadic and erratic flow



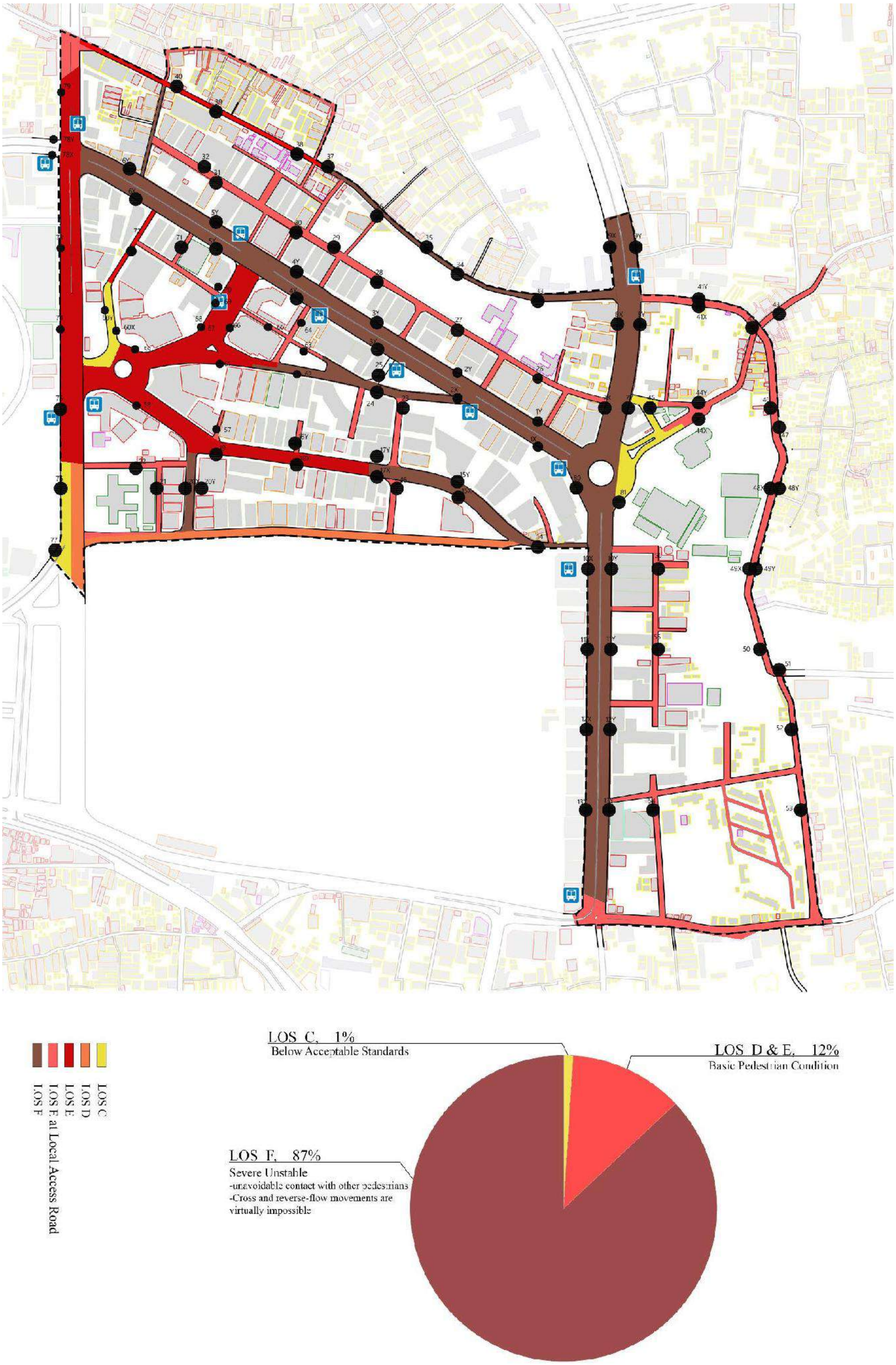



Figure 5.1: Existing Pedestrian Infrastructure according to Level of Service (LOS) (Chapter 04, Figure 4.9)

Another 12% are categorized below acceptable standards in LOS D and E. Furthermore, 1% is only classified in LOS C as basic pedestrian conditions. The phenomena of these outcomes, seen in Figure 4.9, are summarized in Figures 5.1 and Table 5.2.

(b) Lack of Accessibility

Then, the Sidewalk Condition Index (SCI) analysis in the Quantitative part (Section 4.6, Chapter 04) identifies why these spaces are so obstructed and also quantifies the issues in percentage related to physical obstructions by observational rating on the checklist.

Unorganized Retail Business

The first and foremost issue as an obstruction identified the unorganized retail business, including food retailers, vendors, and vending belongings (Table 5.3). These unorganized retail businesses severely obstruct 52% of the walkable segments in Motijheel CBD. The observation entails that these businesses also attract public demand, leading to excessive pedestrian traffic within this walkable space. The vending belongings like food cooking & serving counters and car repairing materials are massively responsible for the obstruction in walkability within this CBD area. Identified sections are over the Motijheel primary road and the secondary collector Kamlapur Box Culvert road (1y, 2x, 22, 23, 25, 27, 42, 49x. 49y, 50, 51, 52, 53, 54).

Informal Bike Parking

The second issue identified for obstructing the walkable space is informal bike parking. 29% (Table 5.3) of walkable segments in the CBD boundary are obstructed for this issue. These segments are on the secondary roads (57, 58, 18y, 17y). Some local access roads (like the Access road to Mohammedan Sporting Club, Connecting road beside the City Center, and the pedestrian space adjacent to Biman Bhaban near Bok Chattar) connect to the primary road where a defined walkable area does not exist.

Surface Deformation

Lastly, the significant loss in the physical condition of walkable segments is the base layer damage and missing brick tile (18%) (Table 5.3). It means that 18% of walkable sections are significantly damaged in base layer conditions and the misplaced aspect of the tiles. Massive base layer damage has occurred in many segments (1y, 2x, 6x, 6y, 7x, 16, 73, 78x, 78y, 80, 79) over the primary Motijheel road and the DIT Avenue. These are the major arterial roads where public transit starts and ends.

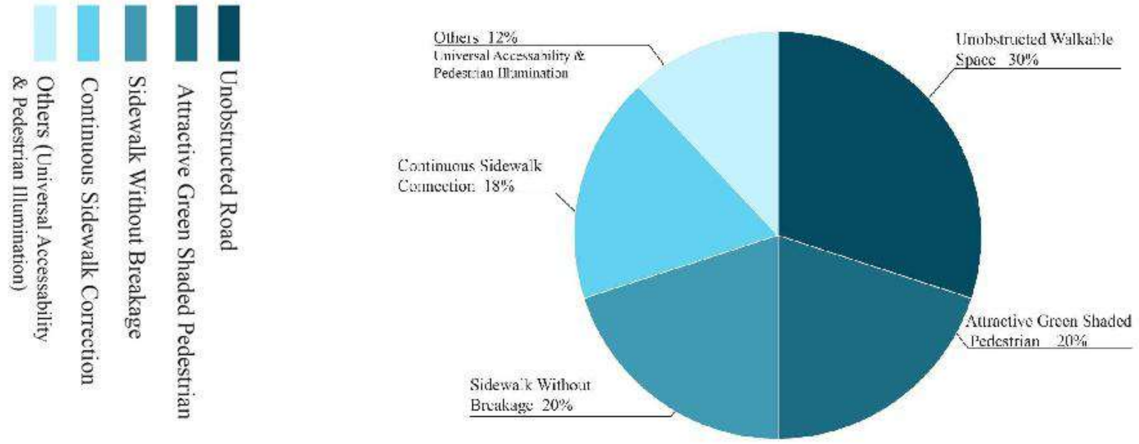
Table 5.3: Blockades from Sidewalk Condition Index Analysis (Refer to Table 4.4)

Major obstruction		**Percentage**	**Images**
Category	**Sub-category**		
Hawking Activity	Clothing Vendor, Cart Food Retail Shop Belongings	52%	 
Bike parking		29%	 
Surface Irregularity	Base Layer Damage Brick Tile Damage Missing Drain Coverage	18%	 
Others	Utility Obstruction Water Clogging Construction Rubish Trash Disposal	17%	 

5.2.3 Public Experiences Concerning the Existing Physical Parameters

Following objective 02, Qualitative analysis: this research investigates the public experiences concerning the physical parameters affecting walkability in the study area. Regarding this, conducted Qualitative Questionnaire survey entails that non-resident users, mostly coming for office and business purposes, use public transport and prefer to walk within 5min walking distance to avoid an unnecessary traffic jams (explained in section 4.7, Chapter 04).

For decoding the public experience, the questionnaire analysis has been categorized into three parts, i.e., Accessibility, Convenience, and Walk appeal features. Accessibility, according to public review, is pathetic because of excess conflict within passenger transfer provoked by massive obstructions. The next concern is the convenience of walkable segments, and the user experiences in connectivity have been rated 76% poor. Observation also entails that no marked pedestrian crossing exists in the CBD area, which creates discomfort for most users to travel by walking. The data from Table 4.8 of Chapter 4 regarding public encounters are shown in Figure 5.2. Finally, 30% of the user demand prioritizes the unobstructed walkable space while assessing walk appeal features. Furthermore, 20% of users voted for Green shaded walkable space and 18% for continuous sidewalk connection.



Source: Field Survey, April 2022

a. Highly obstructed road

b. Discontinuous sidewalk

c. Absence of green shading

Figure 5.2: Questionnaire Analysis Outcome (Details in Table 4.8)

5.3 Conclusion

In order to improve future urban sustainable development, this research intends to pinpoint the issues with the walkability environment in Motijheel CBD and make some practical suggestions. Lane configuration, walkway conditions, public transport system, safety, accessibility, and land use patterns all contribute to an area's walkability. Retrofitting these aspects in an urban area is a large part of sustainable design. From the discussion of findings in section 5.2, it is obvious that guidelines in the theoretical framework for walkability must be revised and relatable to specific contexts. Moreover, the availability of walkable space is neglected in Motijheel CBD, and the existing provisions are massively obstructed and disconnected by the encroachment process. Lack of available walkable space and accessibility due to unorganized retail business, informal parking, and surface deformation has been identified as the existing characteristics and shortcomings of walkability in Motijheel CBD. The physical obstructions of walkable space result in congestion or blockage in urban movement, specifically reflected in the Questionnaire analysis. The fact signifies that the existing walkable conditions do not promote sustainable walkability in CBD due to non-accessibility and availability. Users' urge for unobstructed (30%), shaded (20%), and connected walkways (18%) confirm the lack of connectivity, non-availability of a walkable network, and unwanted obstruction in the surface layer, damage, and absence of crossing facility create dissatisfaction, demotivating walkability within the entire CBD area.

CHAPTER 06
RECOMMENDATION AND CONCLUSION

6.1 Introduction

The study takes a case study research approach through statistical analytic methods to quantify the shortcomings and the public experiences of this commercial urban fabric with a special focus on walkability. After exploring the substantial exploration, this study suggests certain recommendations for the Motijheel CBD area for sustainable walkability. A variety of lane configurations with walkways, public transportation systems, accessibility, and land use patterns influence the walkability of a city area. A significant portion of sustainable design considers how to retrofit each element in an urban setting. It is clear from the discussion in the previous chapter that the physical attributes of walkability, i.e., Accessibility, Convenience, and Walk appeal features—can contribute to the overall sustainable walkability development.

Nevertheless, the encroaching practice and the inadequate walkability infrastructure severely hinder and cause congestion in urban travel, which is particularly evident from the Quantitative (LOS and SCI) analysis. Users' desires for unobstructed, shaded, and connected walkways also attest that undesirable surface impediments, lack of crossing facilities, and the discontinuous walkable network discourage walking throughout the CBD area. Considering the Quantitative and Qualitative analysis in the preceding chapter that privileges this research to propose certain walkable space recommendations and reorganized movement strategies in the following sub-sections.

6.2 Walkability Status Regarding Sustainable Development

The literature review has already discussed the understanding of sustainable development (see section 2.5). Moreover, the factors affecting sustainable development in section 2.6 explains the 5A’s: Availability, Accessibility, Attractiveness, Affordability, and Awareness. Integrating all these five A's in urban design processes of sustainability will result in a higher acceptance, allowing its technical feasibility and successful implementation. This study examines the walkability in relation to the Availability and Accessibility with regard to solely the physical qualities. From the discussion above in section 5.2.1, the **Availability** of the walkable segments in

Motijheel CBD is negligible. This issue must be mitigated to be sustainable by expanding walkable width according to the pedestrian flow rate and developing an integrated network.

From section 5.2.2, the **Accessibility** through walkable segments in the existing CBD context is not sound. Many walkable spaces are congested and impassable, which impedes users' access to their destination. For a clear, accessible walkable network, identified blockades need to be removed, and a huge segment of pedestrian activity, like hawking and pedestrian traffic, needs to be redirected in a restructured way.

Apart from the above statements, the attractiveness of walkability has also been observed in Motijheel CBD. This part can be noticed as a neglected issue evident from section 5.2.3, which is discovered by qualitative analysis while the public experience explorations have been done. The walkable context here needs to improve in tactile quality and green-shaded excellence, and these subjects require considerable redesign development to provide an attractive, walkable environment. The road configurations, present walkability status, and associated photo documentation are shown in Table 5.1 to show how the current obstructions make it difficult for walkability to be sustained.

6.3 Summary of the Findings

Findings have been generated primarily from the literature review regarding the Local walkability agenda for a sustainable urban development perspective and the Global practice models. The quantitative and qualitative assessment methods with results following the objectives have also been summarized in discussion Chapter 05. Discussions from the preceding chapter are summarized in this section in the following three sub-sections.

6.3.1 Walkability Standards (Local & Global) and Gap in Context

Walkability standards may vary between local and global contexts, and the gap in walkability can differ depending on the specific context as well. Understanding the sustainable goals with local policies and global agenda is vital to assess the influencing factors regarding walkability for sustainable development. The literature review of this research has combined several essential issues of walkability for sustainable development from local standards that has summarized in the following Table 6.1 below.

Table 6.1: Walkability Standards Comparison and Gap in Context (Local & Global)

	Section	Policy	Reference	Gap in Context	Comparison
Local Guideline	2.10.1	Urban Transport Policy (2004), DTCA	(The Urban Transport Policy, 2004)	Initiated only the pedestrian priority concept.	Not yet initiated any of the planning policy in the current context of the walkability in Motijheel CBD. For sustainability this research mentioned 5A's in Section 2.6, from where only 2A i.e., Availability and Accessibility has been explored. After inspection it has been proved that no sustainable factors nor exist or followed in present walkable condition in the Motijheel CBD.
	2.10.2 (a)	RSTP (Revised Strategic Transport Policy) 2015	(JICA & DTCA, 2015)	The local access road less than 10ft wide must be fully pedestrian certified by RSTP. No other walkability specifications were found in this report authorized by DTCA.	
	2.10.2 (b)	Pedestrian Safety Draft (2021), DTCA	((DTCA), 2021)	Published insufficient and non-contextual but general guidelines for walkability.	
	2.10.3	DAP (Detail Area Plan 2022	(Rajdhani Unnayan Kartripakkha, 2010)	Concludes with several pedestrian measurement standards specific to road configuration but not compatible enough to develop walkability in specific conditions.	
		DSP (Dhaka Structure Plan) 2016-2035	(*Dhaka Structure Plan 2016-2035*, 2016)	Mentioned only the pedestrian zoning and general measurement standards, without following site specific pedestrian flow rate.	
	2.12	Case Study (Dhanmondi)	(Associates, 2021)	Project considerations regarding design strategy has been developed, such as Lane configuration, Designated car access to secondary road, NMT priority lane, Road merging treatment, Sidewalk placement and pedestrian access, Plantation management, Shifted sidewalk considering trees, Median shift, Footpath ramp, Raised pedestrian crossing, Equal Curb-Level with proposed crossing, Rickshaw repairing management kiosk in alternate road, Tea-stall provisions with designated footpath, Utility management, Plot access, Bus stoppage, and Parking provisions.	
Global Practices	2.13	Sao Paulo, Brazil	(Venter, Mahendra, & Hidalgo, 2019)	Expand the overall walkable space	
		Denmark, Copenhegen	(*Pedestrian Only Streets: Case Study | Stroget, Copenhagen - Global Designing Cities Initiative*, n.d.)	Familiarize Full time pedestrianization	
		Amsterdam, Netherlands, Nagoya, Hongkong	(Maas & van Eekelen, 2004)**,** (Iryo-Asano & Alhajyaseen, 2014)**,** (Saleh, Grigorova, & Elattar, 2020)	Initiated steps for Shared Pedestrian Space	
		Cidade, Brazil		Introduce Traffic calming interim	
		Mumbai, India	(MMRC, 2017)	Introduce pedestrian plaza at intersection	
		Jakarta, Indonesia	(ITDP, 2017)	Initiated Visually active frontage with walkable space	
		Budapest, Hungary	(Ahmad, Ahmad, & Aliyu, 2021)	Create attractive green shaded sidewalk	

The local access road less than 10ft wide must be fully pedestrian certified by The RSTP. No other walkability specifications were found in this report authorized by DTCA.

A draft of the ‘Pedestrian Safety Policy’ by DTCA published insufficient and non-contextual but general guidelines for walkability. Another report on ‘Pedestrian Safety’ that DTCA and ARI (Accident Research Institute, BUET) co-developed identifies the two key concerns regarding the walkable phenomenon. The first is to provide raised walkways at intersection points to reduce vehicle speed for safety. The Second is to shorten crossing distances; the curb extension function should be implemented at crossing places. Both of these choices are advantageous for improving a reliable walkable network.

The DSP’ 2016 mentioned only the pedestrian zoning and generic structure, not site-specific standards. In contrast, the DAP 2022-2035 concludes with several pedestrian measurement standards specific to road configuration but not compatible enough to develop walkability in specific conditions. Ultimately these strategies for walkability need to be investigated site-specific infrastructure required for sustainable development. Furthermore, the global practice models illustrate some challenges, such as hawker management, shared pedestrian space, temporary traffic calming measures, pedestrian plazas, and shaded walkways. These aspects effectively achieve long-term sustainability and an effective walking environment regarding the pedestrian volume and effective width.

6.3.2 Contextual Results over Shortfalls

The primary research objective is to identify the existing characteristics and shortcomings of the pedestrian environment related to walkability and understand their impact on urban sustainability, considering the local and global perspectives. These research results are quantified in two analytical sections, i.e., level of service (LOS) and Sidewalk Condition Index (SCI). According to the 'Level of Services (LOS)' quantitative analysis, the effective width of the walking space in the CBD area is 87% inadequate to accommodate the current pedestrian traffic. Furthermore, the ‘Sidewalk Condition Index (SCI)’ analysis reveals 92.4% poor conditioned walkable areas for specific physical obstructions. The outcomes of these quantitative analyses are summarized in the following subsections.

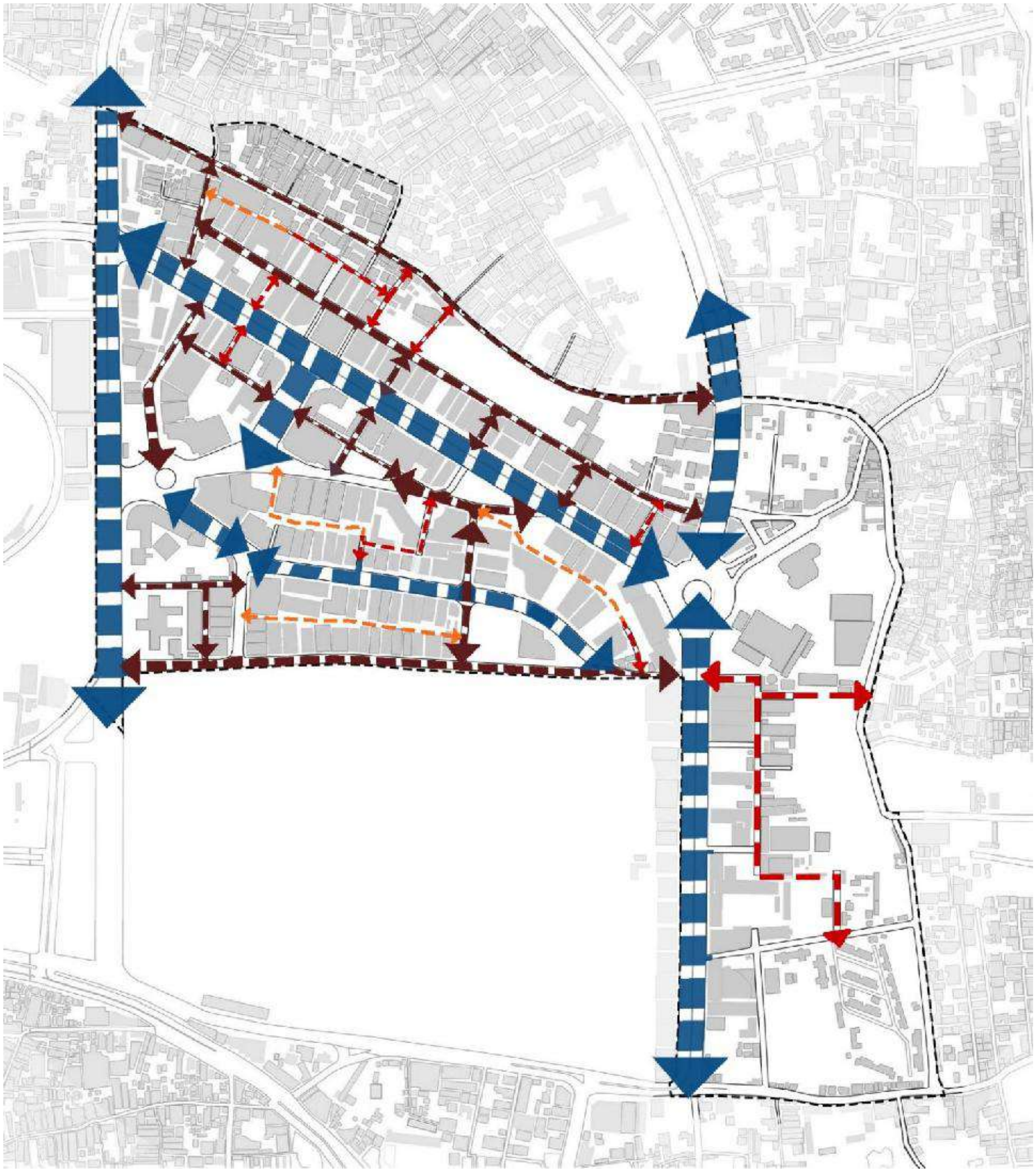
Demand for Increased Walkable Space

Level of Service (LOS) quantifies the clear walkable width according to the generated pedestrian traffic. Despite having footpaths along with primary roads, the walkable widths need to be improved for the users in Motijheel CBD to avoid conflict and congestion between pedestrians immediately. The quantitative diagnosis in the previous chapter by LOS (chapter 4, section 4.5) represents the greater inadequacy of walkable space compared to the pedestrian traffic volume and the available walkable infrastructure. LOS Analysis suggests that 2m or 6.56ft (per present volume) should be a minimum clear walkable area for the Motijheel CBD context (Appendix 12). However, where it is difficult to arrange 2m walkable space on secondary or collector roads, the DAP 2022 guidelines can be followed: a minimum 5ft clear sidewalk on both sides. Another option of a one-sided wide walkable space can be beneficial to accommodate vending activities in an organized way with walkability on a large scale. Future Metro passengers will also require adequate walkable space for transition. Predicting this huge pedestrian traffic load, sidewalk infrastructure must expand at different transition levels.

Unorganized Retail Business Activity

From Sidewalk Index Analysis, the retail business activity such as low-cost food retailers, fruit sellers, clothing, and other daily necessities along the primary roads (both sides of Motijheel Road connecting Danik Bangla Mor to Shapla Chattar) generate inadequacy problems in walkable space severely. Pedestrians are the primary target for selling goods, especially around 3 pm to 5 pm. Massive pedestrian passing occurred at this time due to this street vending activity, evidently found from the pedestrian flow rate count at the selected gate points during the field survey. The data discussion from section 5.2.2 in Table 5.3 also represents that 52% (Food seller 25%, Hawking Activity 14%, and Vending Belongings 13%) of walkable segments are non-accessible or partially accessible for this vending activity, mentioned as a vital obstruction in a clear walkable area.

Due to Metro Station for MRT Line-6, the passenger pressure will have to disburse in the future during peak hours through these walkable spaces. Considering this phenomenon, these vending activities on the primary road must be relocated to make the major walkable space gathering free. Some activities may be relocated to the back street of each property with the shared walkable zone on secondary road segments. This will pull a huge segment of pedestrian traffic to these areas.



Conflict Free Walkable Space (Applicable for 53.54% Primary Road)

Redirected Pedestrian Flow by Shared Walkable for Better Connectivity (Applicable for 33.34% Local Access Road)

Existing Fulltime Walkable Network

New Interventions for Fulltime Walkable Network

Figure 6.1: Proposed Pedestrian Movement Pattern

Figure 6.1 illustrates the obstruction-free of 53.54% primary road's walkable sections to ease congestion, potentially shared sections with re-locatable hawking activities in 33.34% access road segments, and new interventions of entirely pedestrian portions through inspecting all kinds of roads to create a network that is easier to navigate on foot.

6.3.3 Experiential Shortfalls

Most of the data on pedestrian experiences comes from the questionnaire analysis focused on physical matrix because these cannot be statistically counted in field surveys. The qualitative analysis from the questionnaire survey (Section 4.7.2) presents (76% rated as poor) the underprivileged condition of pedestrian connectivity concerning walkability. Observations in the literature review also address the limited provision of mid-block crossings with photographs of crossing situations (See Figure 4.13). The pedestrians are used to crossing nodes in a rush without any signal or demarcation on the road through the median divider. This phenomenon depicts the unsustainable, harmful situation for physical matrix of walkability. Pedestrians should take the most direct and least strenuous routes. As an intervention, some crossings may be declared and designed as pedestrian priority segments on major roads to ensure both-side connectivity. As well as inadequate attractiveness (Green Shading and Furnishing) is another demanding issue that rapidly deteriorates the CBD's walkable environment. However, this research did not detail the scope of green furnishing generation space but mentioned it as a prime necessity for a sustainable, walkable environment.

6.4 Recommendations

This research only considers the physical characteristics of walkability. Before promoting the expansion of the pedestrian width according to the volume of pedestrian traffic on major road segments, this research first assesses the availability or sufficiency of the present walkable space through the Level of Service (LOS), where 87% of walkable areas are discovered as highly congested (Chapter 5, Figure 5.1). The Sidewalk Condition Index analysis needed a thorough field study to identify the primary issues preventing walkability in Motijheel CBD. This analysis identified the three main barriers in walking space (chapter 05, Table 5.3). The results of the questionnaire survey analysis, which is in line with objective 2, show how the public felt about the unobstructed and shaded walkways, which are completely absent from the Motijheel CBD walking environs. Based on these findings, recommendations have been suggested regarding increasing walkable space to develop comfortable walkability features in the following sub-points.

a) Expansion of Walkable Space

The primary requirement for avoiding pedestrian conflict and congestion is to increase the effective width of the pedestrian area.

- The optimum clear walking area for the primary road in Motijheel CBD should be clear at a minimum 2m for achieving LOS A (Most ideal walkable condition, space per person - 5.6 sqm), on detected segments identified as LOS 'F' (Severely unstable) according to the level of service (LOS) analysis (Appendix 12). Concerning the current pedestrian volume per hour, other subsidiary roads should reach at least LOS 'B' (Reasonable walking condition) to improve walkable conditions.
- The clear walkway should be separated from the mixed-use frontage zones to prevent conflicts between shoppers and pedestrians as per DAP 2022.
- **Full-time walkable links** can only be created with roads of 10 feet in width or less (Figure 6.2), according to the law established by the RSTP. All dead ends must be suggested as full-time pedestrian schemes connecting to local access roads. In the context of the CBD, it will be advantageous for being a strong walkable network.

b) Shared Walkable Space

Roads with a width of less than 20 ft. are difficult to be separable from the walkways. In this case, 'Shared Pedestrian Space' can be considered to manage the massive movement.

- Shared pedestrian space can be provided on secondary/collector or local access roads where the walkways and NMT transition will be at grade level.
- **Traffic calming measures** like Speed bumps, Pedestrian Bollards, or Speed Limits can be implemented to ensure pedestrian safety in this area.
- **Partial pedestrianization** can be introduced during peak hours for pedestrian traffic safety, while vehicular movement will be restricted. During rush hour, automobile movement may be restricted on this hours. It will be advantageous to divert heavy pedestrian traffic to the shared pedestrian stretches of the secondary road. Table 6.2 and Figure 6.2 provide and demonstrate the Shared walkable categories with the other interventions.

c) Hawking and Parking Management

To cater to the massive number of pedestrians during peak hours, the walking area along the main route connecting bus stops should be vending-free.

- It is possible to relocate informal vending operations to shared places while maintaining a clear walking area. These could be advantageous to both the vendor and the user. The seller attracts a substantial volume of foot traffic, which may cause the foot traffic to be diverted from the pavements along major roadways. Considering DAP, vending activity can be limited during a specified time window to make a congestion-free walkable area.
- **Parking** will be allowable only on road space adjacent to pedestrians following the greater lane width, not in the way of any pedestrian access (See Figure 6.2, Shared Section Type-4).

d) Pedestrian Plaza or Promenade

Connectivity in the walkable network can be improved by connecting intersections with pedestrian plazas or promenades (mentioned in Figure 6.1).

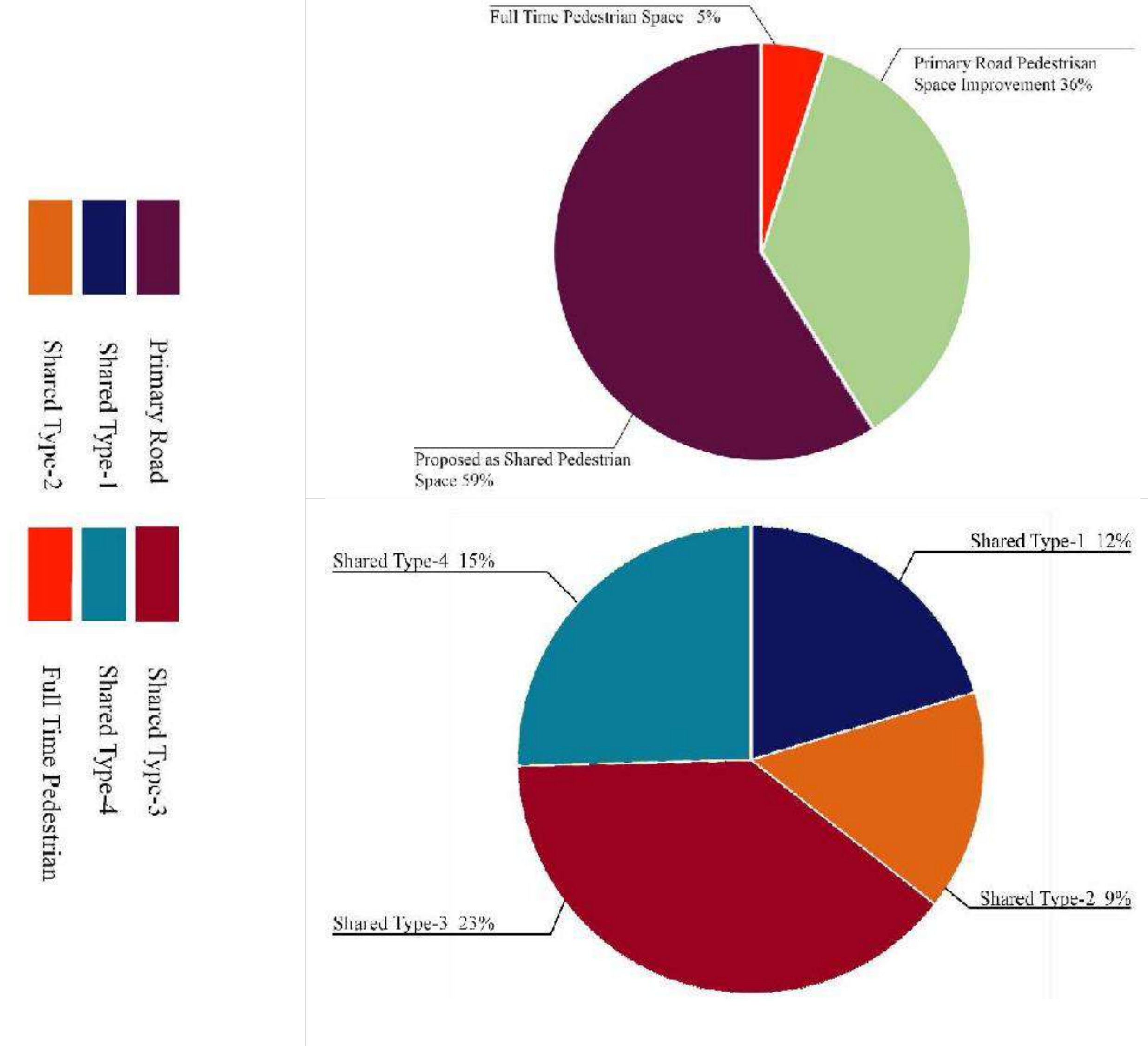
e) Uniform Walkable Surface

Changes to the uneven pedestrian surface (such as base layer deterioration, missing brick tiles, and drain coverage) require quick amendments to protect the clear and continuous walkable space. Periodic regular maintenance must be implemented in this area with the most appropriate methods and materials, or the walkable system may collapse once more, even with new initiatives implementation. The following important procedures must be followed to maintain a consistent walking surface: routine cleaning, damage repair, leveling, maintenance, appropriate drainage, non-slip treatment, and accessibility concerns. Regular cleaning removes dirt, debris, and loose materials, and fixing damage stops it from getting worse and from making the surface uneven. If the surface is noticeably uneven, leveling may be necessary. While non-slip treatment improves traction and lowers the risk of slipping, proper drainage minimizes water collection. Considerations for accessibility include using the right ramps, rails, and tactile indicators. Depending on the type of surface, specific maintenance requirements may change, so seek advice from professionals or adhere to manufacturer recommendations.

Figure 6.2: Applicable Street Segments for Specific Recommendations

Table 6.2: Applicable Street Segments for Specific Recommendations

Type Name	Applicable Road Width (ft)	Breakdown	Number of Gate Point	Percentage %
Shared-1	11-20	Footpath-Carriageway-Footpath	14,34,35,36,37,38,39,40,57, 65,63,71,72	**12**
Shared-2	20-24	Vendor-Footpath-Carriageway	16,26,27,28,43,52,54,64,69, 70	**9**
Shared-3	24-32	Vendor-Footpath-Carriageway-Footpath	23,24,28,29,30,31,32,33,41x, 41y,42,44x,44y,45,46,47,48x,48 y,49x,49y,50,51,53,61,62	**23**
Shared-4	32-35	Vendor-Footpath-Road Bike Parking -Carriageway	15x,15y,17x,17y,18x,18y, 19,20x,20y,44x,44y,57,58, 60x,60x,60y	**15**
Primary Road Pedestrian Space	80-100	Frontage Zone-Footpath-Green Furnishing Zone -Carriageway	1x,1y,2x,2y,3x,3y,4x,4y,5x,5y,6 x,6y,7x,7y,8x,8y,9x,9y,10x,10y, 11x,11y,12x,12y,13x,13y,66,68, 73,74,75,76,77,78x, 78y,79	**36**
Full Pedestrian		21,22,54,55,56		**5**



6.5 Concluding Remarks

One of the most important aspects for improving walkability is the physical environment, and the qualities of urban design and the sense of interest are also tied to the growth of walkability. In order to raise everyone's quality of life, it improves connectivity with the public transit system and promotes pedestrian activity. In order to aid sustainable urban development and alleviate similar problems in other local contexts, this research helps to assess the walkable physical environment within the living commercial CBD context. This research seeks to identify the challenges and suggest strategic means to improve walking condition within the living commercial CBD context to aid sustainable urban design and alleviate related problems in other local contexts. The research findings have been presented using quantitative and qualitative analysis in the case study research approach. According to a quantitative analysis termed Level of Services (LOS), the effective walkable width in the context of the CBD is 87% congested. Additionally, the Sidewalk Condition Index (SCI) analysis reveals the severity and recurrence of specific physical obstructions within current walkable areas. The disorganized retail industry (40%) and informal parking (29%) with uneven surfaces (18%) are the major obstructions endangering the current walkability. The qualitative survey results are then combined with the observational evaluation for the SCI analysis, resulting in 92.4% underprivileged walking circumstances in CBD. A shaded, comfortable, and walking foundation is notably lacking in the Motijheel CBD setting, according to the examination of the public experience. Based on these findings, this research suggests the idea of shared pedestrian spaces for 33.34% of streets in the CBD context, with vending activities for prioritizing walkability ensuing local regulations. Furthermore, hawking free wide walkways for 53.34% of primary roads has been suggested to avoid congestion and enhance the walkability of this CBD area. In-depth research into the Imageability, coherence, and sense of comfort of walkability can be done in the future.

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APPENDICES

APPENDIX 1: Questionnaire Analysis

বুয়েটে গবেষণা কাজের জন্য জরিপ

(এই সাক্ষাতকার জরিপটি সম্পূর্ণরূপে একাদেমিক কাজের জন্য এবং স্বেচ্ছাশ্রমে তৈরি, যার প্রতিটি তথ্যই গোপন থাকবে। এই জরিপ এর উদ্দেশ্য হল, উল্লেখযোগ্য বাণিজ্যিক কেন্দ্র হিসাবে ঢাকা, মতিঝিল এলাকার পথচারীদের চলাচলের স্থান কতটা উপযোগি তার উপর তথ্য সংগ্রহ করা এবং সাম্প্রতিক বিদ্যমান পরিস্থিতির অবস্থা তদন্ত করে প্রধান ত্রুটিগুলো নির্ণয় করা।)

নামঃ		বয়সঃ	
লিঙ্গঃ	পুরুষ/মহিলা	পেশাঃ	
প্রকৃতিঃ	আবাসিক/অনাবাসিক	তারিখঃ	__/__/২০২২

১। আপনি কি গন্তব্য স্থানে পৌছাতে নিয়মিত র কোন যানবাহন ব্যবহার করে থাকেন?

ক। রিকশা	গ। সাইকেল	ঙ। বাস
খ। কার/ সিএন জি	ঘ। পায়ে হাটা	চ। অন্যান্য leguna

২। আপনি পায়ে হেটে কোথা থেকে আসছেন?

____

৩। এই এলাকায় আসার উদ্দেশ্য কি?

ক। অফিস	গ। শিক্ষা	ঙ। অন্যান্য
খ। কেনাকাটা	ঘ। বাবস্যা	

৪। এই মুহূর্তে হাটার বিশেষ উদ্দেশ্য কি?

ক। কাছের বাস স্ট্যান্ড /	গ। রাস্তাটি ফুটপাথ হাটার উপযোগী	ঙ। কম সময়ে গন্তব্যে পৌঁছানোর কারণ
খ। যাতায়াত খরচ বাঁচানো / অর্থনৈতিক কারণ	ঘ। ট্রাফিক জ্যাম এড়ানো	চ। রাস্তাটি নিরাপদ

৫। ফুটপাথ ব্যাবহারের ক্ষেত্রে আপনি কি কি অসুবিধার সম্মুখীন হন? (প্রতিটি ক্ষেত্রে আপনার মন্তব্যের মাত্রা হার নির্ণয় করুন)

ক। **নিরাপত্তার অভাব** ○ ত্রুটিপূর্ণ ○ চলনসই ○ ভাল ○ উত্তম ○ চমৎকার	খ। **বেশি মানুষের ভিড়** ○ ত্রুটিপূর্ণ ○ চলনসই ○ ভাল ○ উত্তম ○ চমৎকার	গ। **মোটেই আকর্ষণীও নয়** ○ ত্রুটিপূর্ণ ○ চলনসই ○ ভাল ○ উত্তম ○ চমৎকার
ঘ। **রাস্তা পারাপার করতে অসুবিধা** ○ ত্রুটিপূর্ণ ○ চলনসই ○ ভাল ○ উত্তম ○ চমৎকার	ঙ। **গন্তব্যে পৌছাতে বিলম্ব হওয়া** ○ ত্রুটিপূর্ণ ○ চলনসই ○ ভাল ○ উত্তম ○ চমৎকার	

৬। ফুটপাথ ব্যাবহারের ক্ষেত্রে নিম্নোক্ত প্রতিবন্ধকতা গুলোতে আপনার মন্তব্যের মাত্রা হার নির্ণয় করুন

ক। অপ্রয়োজনীয় আবর্জনা ○ ত্রুটিপূর্ণ ○ চলনসই ○ ভাল ○ উত্তম ○ চমৎকার	খ। নির্মাণাধীন প্রকল্পের উপাদান ○ ত্রুটিপূর্ণ ○ চলনসই ○ ভাল ○ উত্তম ○ চমৎকার	গ। ভ্রাম্যমাণ বিক্রেতা ○ ত্রুটিপূর্ণ ○ চলনসই ○ ভাল ○ উত্তম ○ চমৎকার
ঘ। যত্রতত্র যানবাহন বিরতি স্থান ○ ত্রুটিপূর্ণ ○ চলনসই ○ ভাল ○ উত্তম ○ চমৎকার	ঙ। অসমতল পৃষ্ঠতলের ঘন ঘন ভাঙ্গন ○ ত্রুটিপূর্ণ ○ চলনসই ○ ভাল ○ উত্তম ○ চমৎকার	চ। সেবা সংযোগ স্থাপনা (যেমন, বৈদ্যুতিক খুতি, ফুত-অভার ব্রিজ) ○ ত্রুটিপূর্ণ ○ চলনসই ○ ভাল ○ উত্তম ○ চমৎকার

৭। আপনি রাস্তা পারাপার এর ক্ষেত্রে কোনটি গুরুত্বপূর্ণ মনে করেন?

ক। যথাযথ পারাপার এর স্থান চিহ্নিতকরন	খ। রাস্তা পারাপার এর স্থানে যথার্থ সংকেত স্থাপন	গ। রাস্তা পারাপারের স্থানে ট্রাফিক পুলিশ মোতায়ওন।

৮। হাটার ক্ষেত্রে কোন বিষয়টি আপনার জন্য গুরুত্বপূর্ণ?

ক। প্রতিবন্ধকহীন রাস্তা	গ। সার্বজনীন প্রবেশযোগ্য হওয়া (বয়স্ক এবং শিশুদের ক্ষেত্রে)	ঙ। সমতল ভাঙন বিহীন ফুটপাথ পৃষ্ঠতল
খ। আলোকিত এবং নিরাপদ রাস্তা	ঘ। আকর্ষণীও সবুজাভ ছায়াতল বিশিষ্ট ফুটপাথ	চ। বিরতিহীন একটানা ফুটপাথ সংযোগ

SL NO.

(ধন্যবাদ)

APPENDIX 1: Questionnaire Analysis

Survey for Research work at BUET

(This interview survey is purely for academic purposes and is a voluntary process, all of which will be kept confidential. The purpose of this survey is to collect information on the suitability of pedestrian space in Motijheel area of Dhaka as a significant commercial center and to identify the major deficiencies by investigating the status of the recent existing situation.)

Name:		Age:	
Sex:	Male/Female	Occupation:	
Type:	Resident /Non-resident	Date:	__/__/2022

1. Which Vehicle do you regularly use to reach your destination?

a. Rickshaw	c. Cycle	e. Bus
b. Car/ CNG	d. By Walking	f. Other leguna

2. Where do you come from on foot?

____

3. What is the purpose of coming to this area?

a. Office	c. Education	e. Other
b. Shopping	d. Business	

4. What is the special purpose of walking at this moment?

a. Nearby bus-stand	c. Footpath is suitable for walking	e. To reach the destination in less time
b. Save travel costs / economic reasons	d. To avoid Traffic Jam	f. Safety of the road

5. What difficulties do you face when using the sidewalk? (Rate your comments in each case)

a. **Lack of safety** ○ Defective ○ Usable ○ Good ○ Very Good ○ Excellent	b. **Crowd of the people** ○ Defective ○ Usable ○ Good ○ Very Good ○ Excellent	c. **Not attractive at all** ○ Defective ○ Usable ○ Good ○ Very Good ○ Excellent
d. **Difficulty in road crossing** ○ Defective ○ Usable ○ Good ○ Very Good ○ Excellent	e. **Delay in reaching the destination** ○ Defective ○ Usable ○ Good ○ Very Good ○ Excellent	

6. Rate your comments on the following barriers to sidewalk use

a. Unnecessary garbage ○ Defective ○ Usable ○ Good ○ Very Good ○ Excellent	b. Components of the project under construction ○ Defective ○ Usable ○ Good ○ Very Good ○ Excellent	c. Street vendors ○ Defective ○ Usable ○ Good ○ Very Good ○ Excellent
d. Vehicle parking here and there ○ Defective ○ Usable ○ Good ○ Very Good ○ Excellent	e. Frequent breakdown of uneven surfaces ○ Defective ○ Usable ○ Good ○ Very Good ○ Excellent	f. Installation of service connections (e.g., power lines, foot-over bridges) ○ Defective ○ Usable ○ Good ○ Very Good ○ Excellent

7. What do you think is important in terms of crossing the road?

a. Marking the place of proper crossing	b. Installation of proper signals at road crossings	c. Deploying traffic police at road crossings.

8. What is important to you when it comes to walking?

a. Barrier-free Road.	c. Being universally accessible (for adults and children)	e. A flat non-broken sidewalk surface
b. Properly lit and safe streets	d. Attractive and green shaded footpaths	f. Intermittent continuous pavement connection

SL NO.

(**Thank You)**

Appendix 2: Sidewalk Condition Index (SCI) Matrix for Field Survey

	Distress	Severity of Distress (Si)						Density of Distress (Di)					Raw Deduct Value
	Location: The location to be surveyed Section: Name of the section	Weight (Wi)	Very slight	Slight	Moderate	Severe	Very severe	Few	Intermittent	Frequent	Extreme	Through out	Wi * (Si+Di)
1	Base layer damage	3											
2	Brick tile damage	2											
3	Utility obstruction	1											
4	Construction rubbish	2											
5	Trash disposal	4											
6	Food seller	5											
7	Hawking activity	5											
8	Water clogging	2											
9	Rickshaw parking	4											
10	Shop belonging	5											

Summation of Public Opinion Rating (Weightage),

∑ Wi Raw Deduct Value, RDV = ∑ Wi*(Si+Di) [Si = Severity of Distress, Di = Density of Distress] Factorized Deduct Value, FDV = RDV/Wi/10

Calculated Sidewalk condition index (SCI) =100 – FDV

This "Final SCI" provides a numerical rating for the pavement condition, where 0 represents the worst condition, and 100 represents the finest.

Source: (Rahman, Tanzila, Shawon, & Sharmin, 2020)

***Note:** Weightage for each distress criteria have been derived from questioner analysis importance.

APPENDIX 3: Thana Map of Motijheel Site

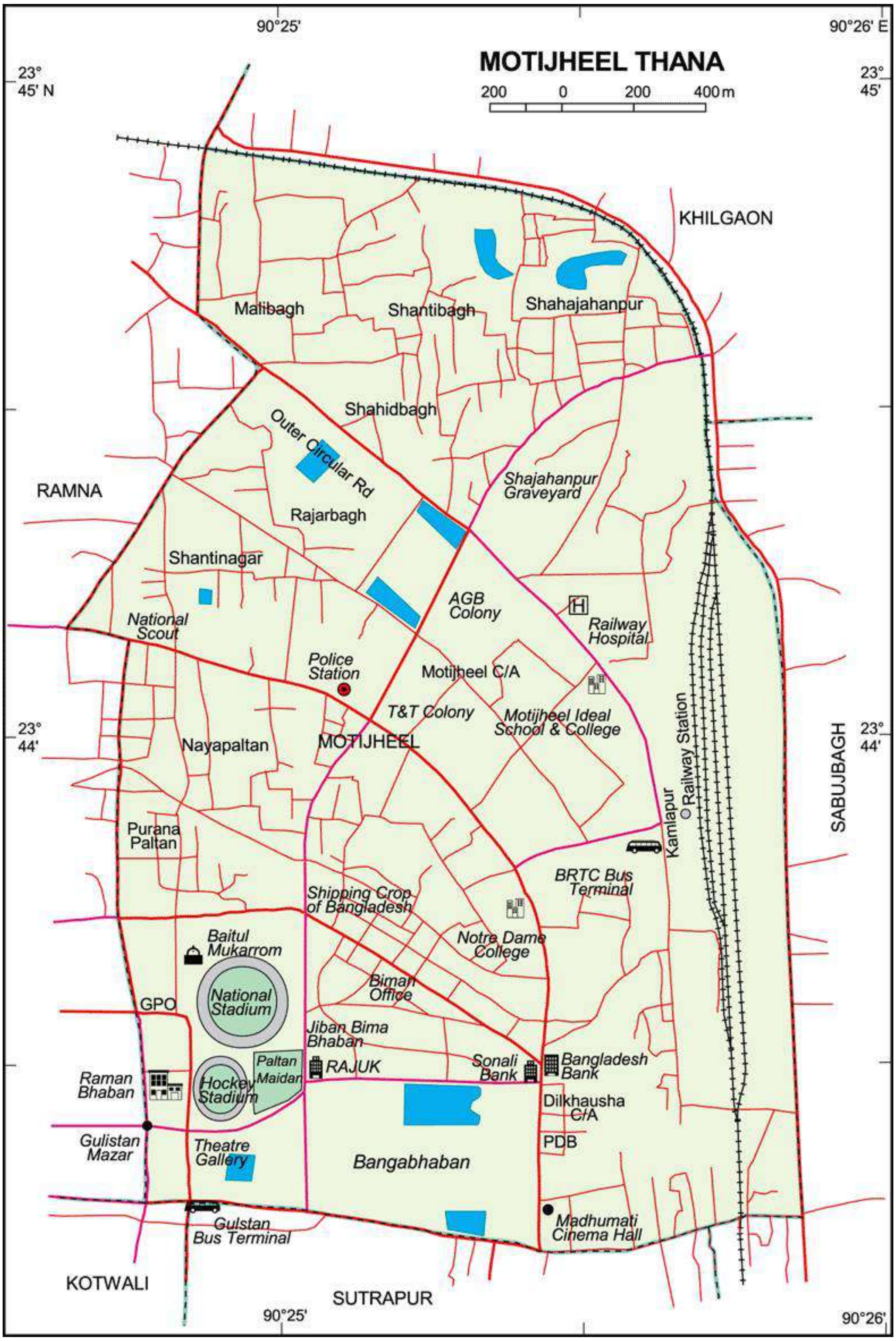
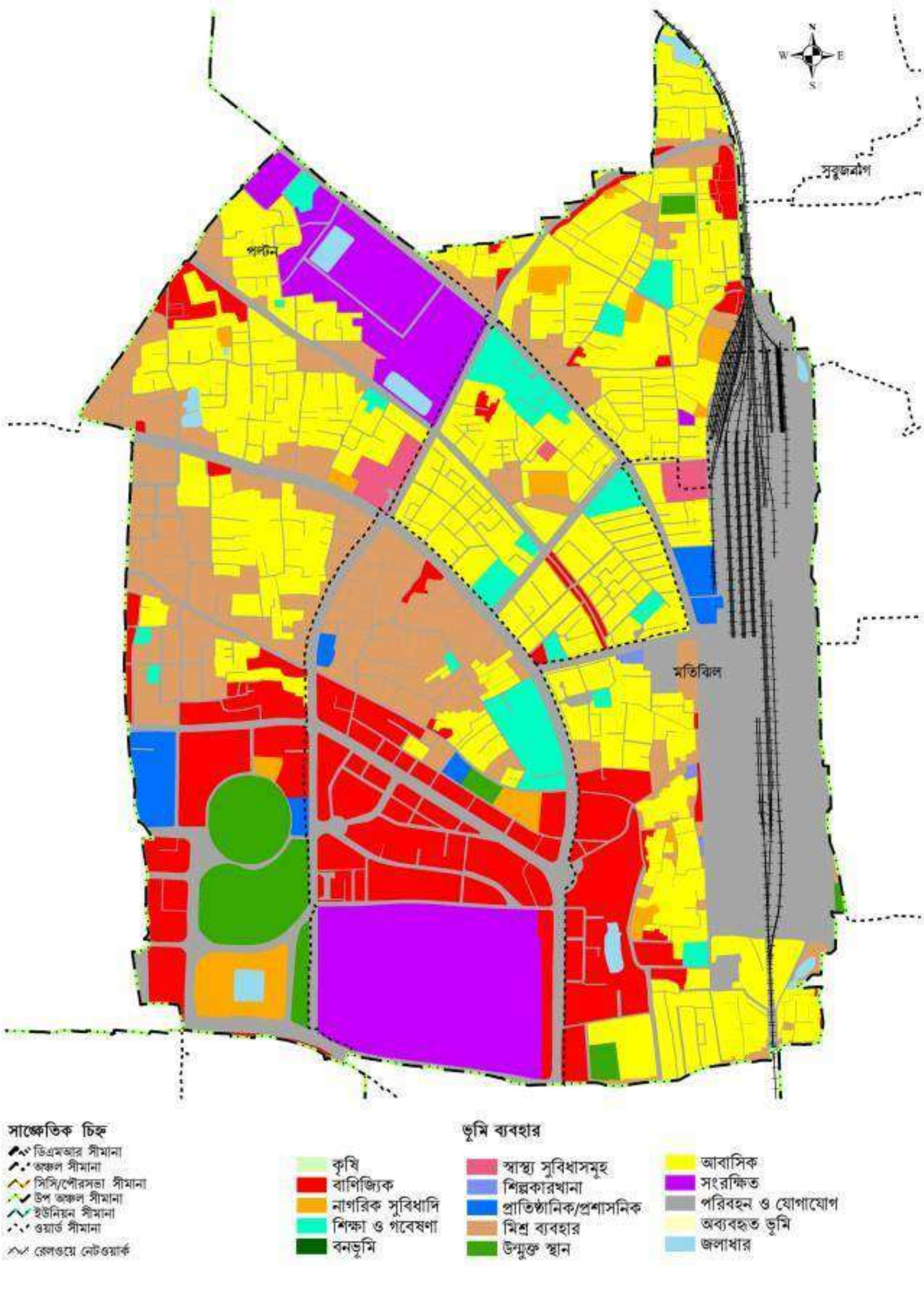


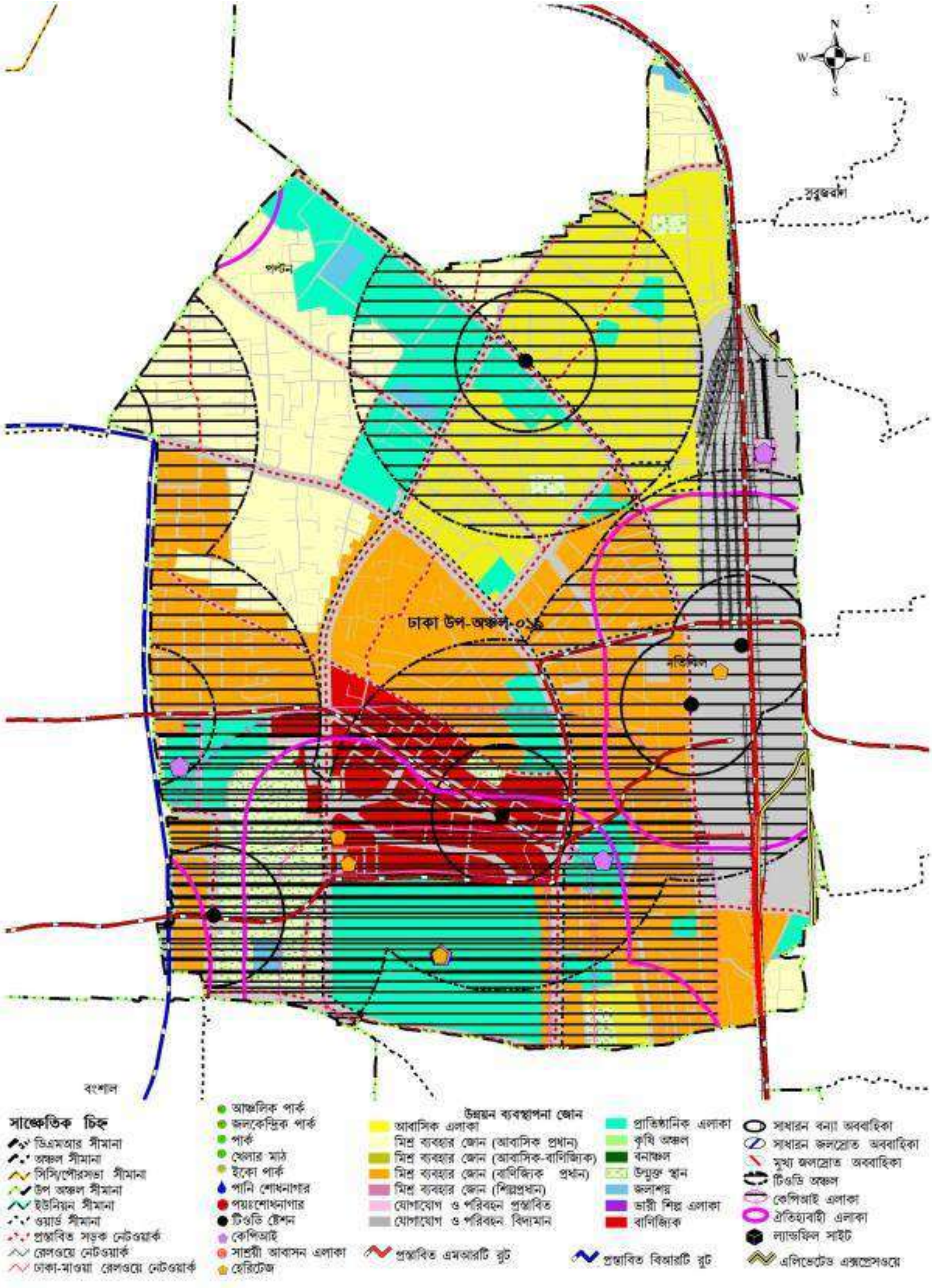
Figure: Showing Map of Motijheel Thana (Circle indicates the study area) [Source http://maps-of-bangladesh.blogspot.com]

APPENDIX 4: Land Use of Dhaka Sub- Region- 19



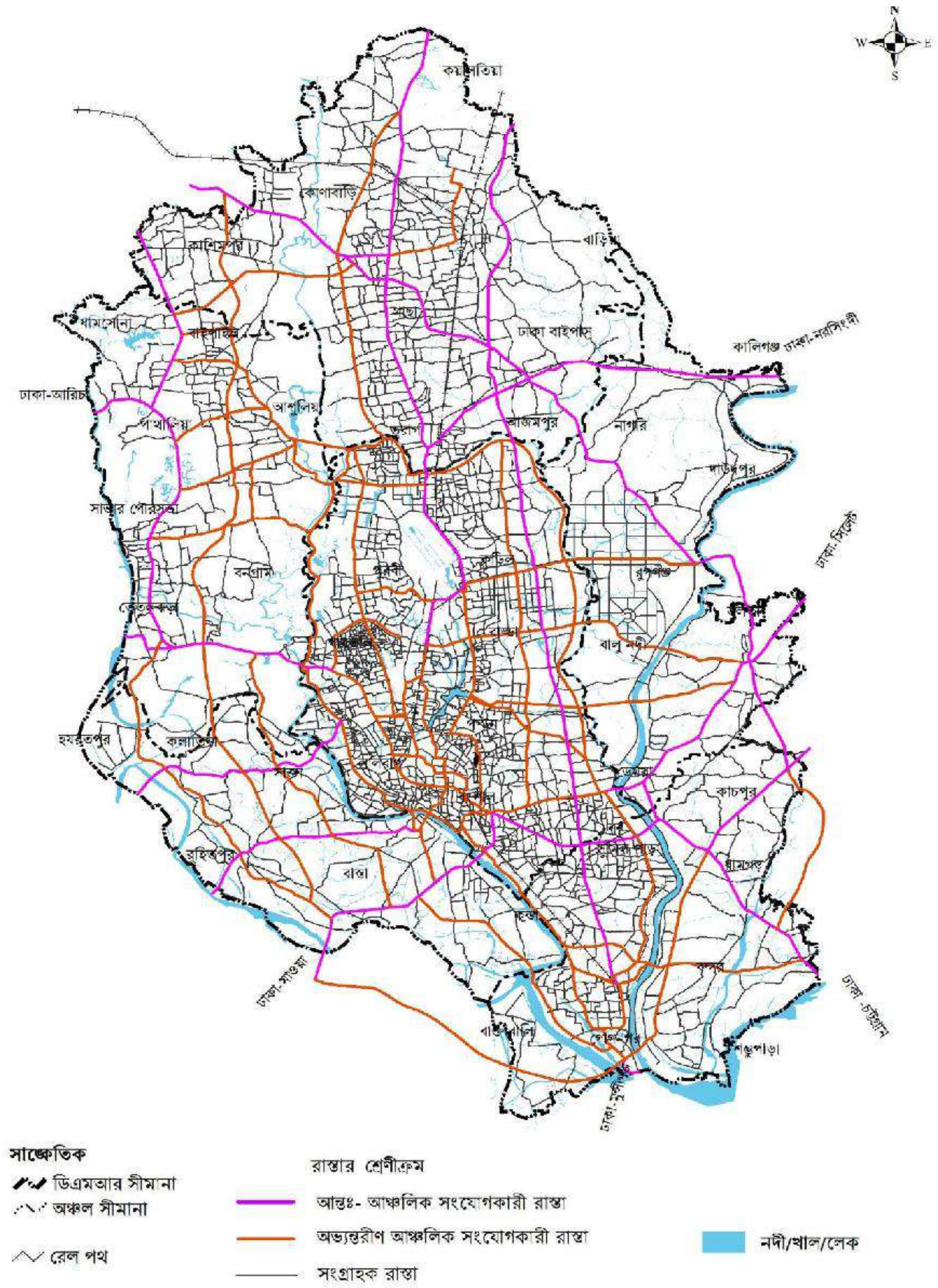
Source: (Detail Area Plan, 2022)

APPENDIX 5: Dhaka Sub-Region 19 Integrated Development Plan



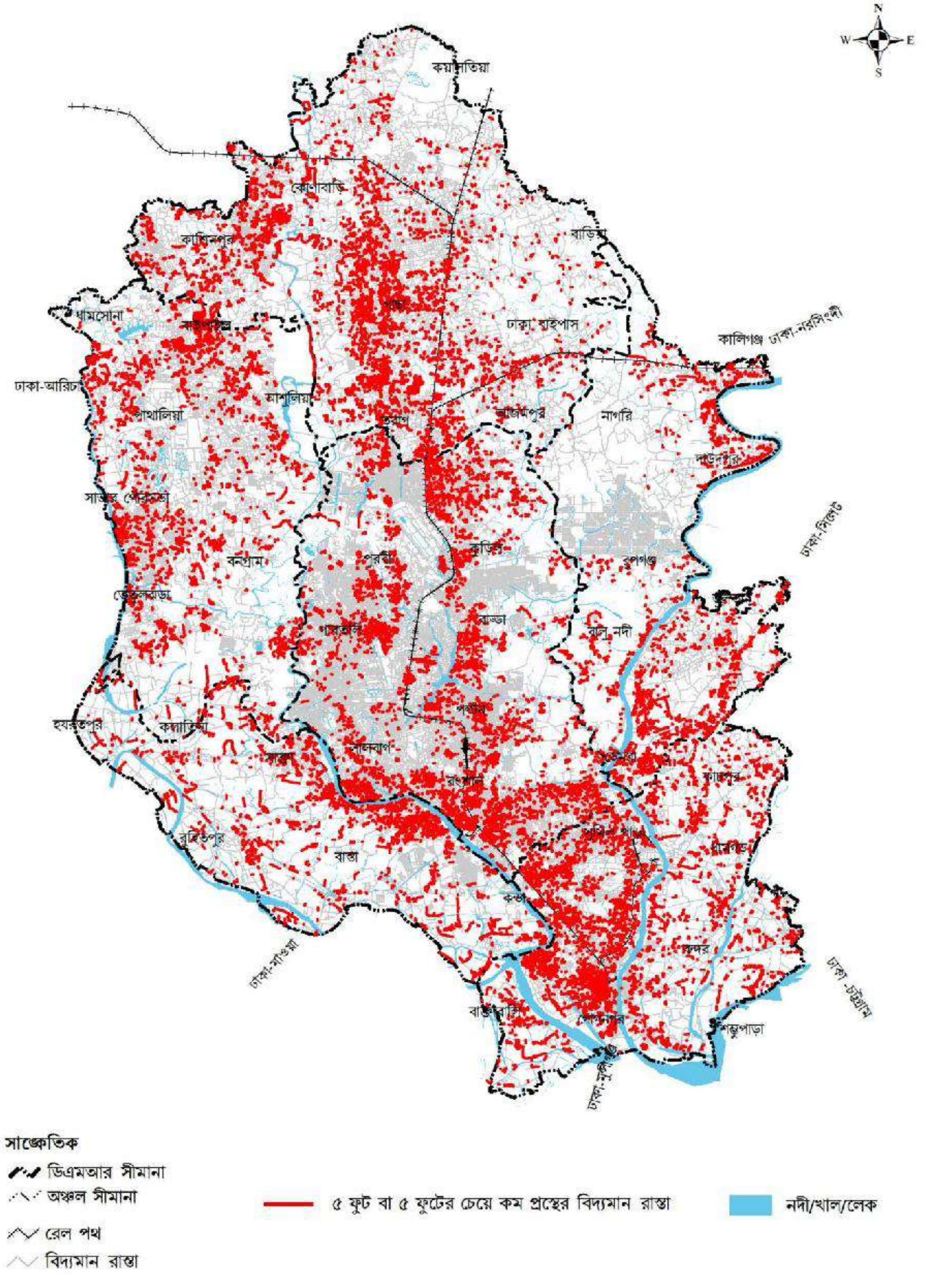
Source: (Detail Area Plan, 2022)

APPENDIX 6: Road Classification According to DAP (2022 – 2035)

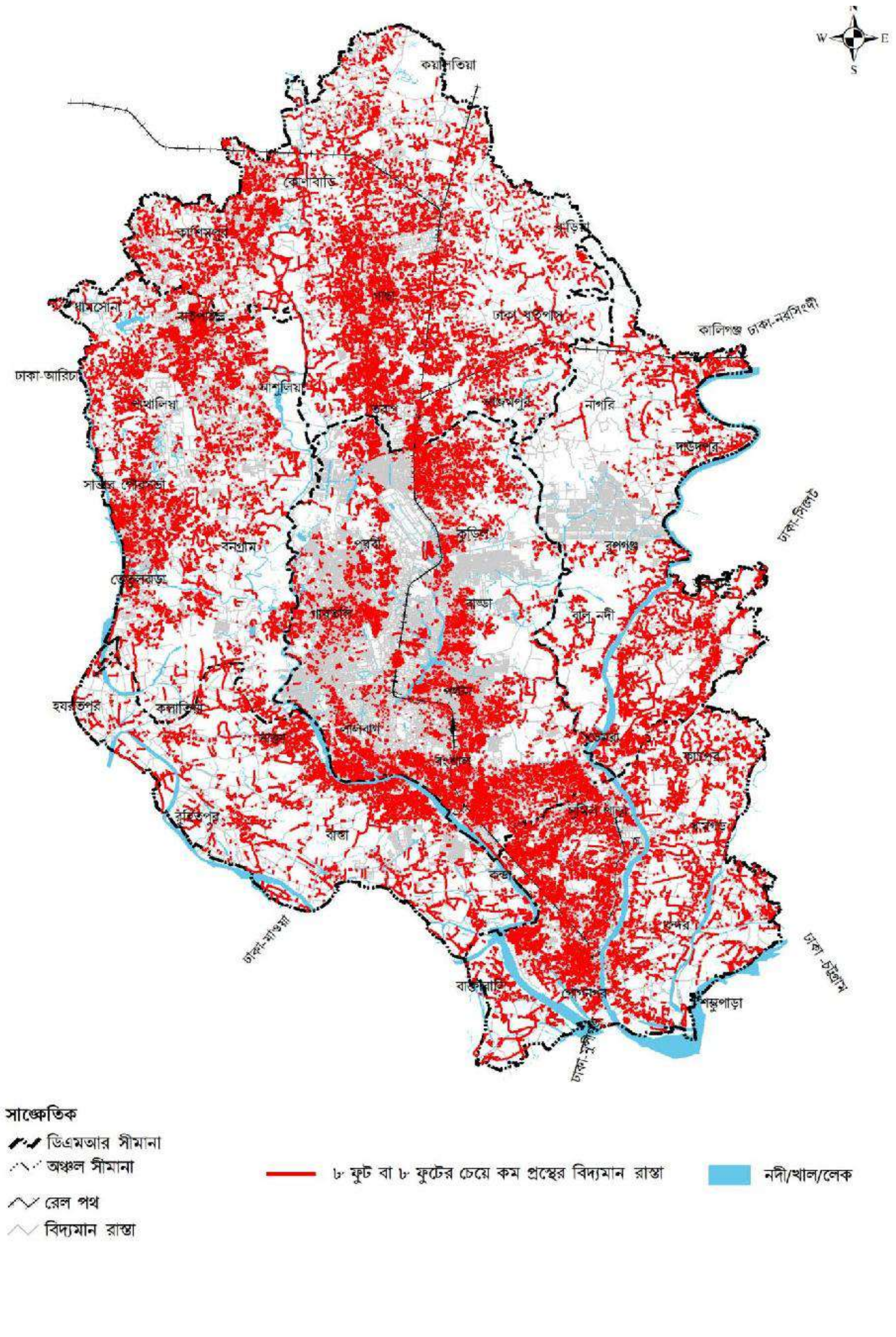


Source: (Detail Area Plan, 2022)

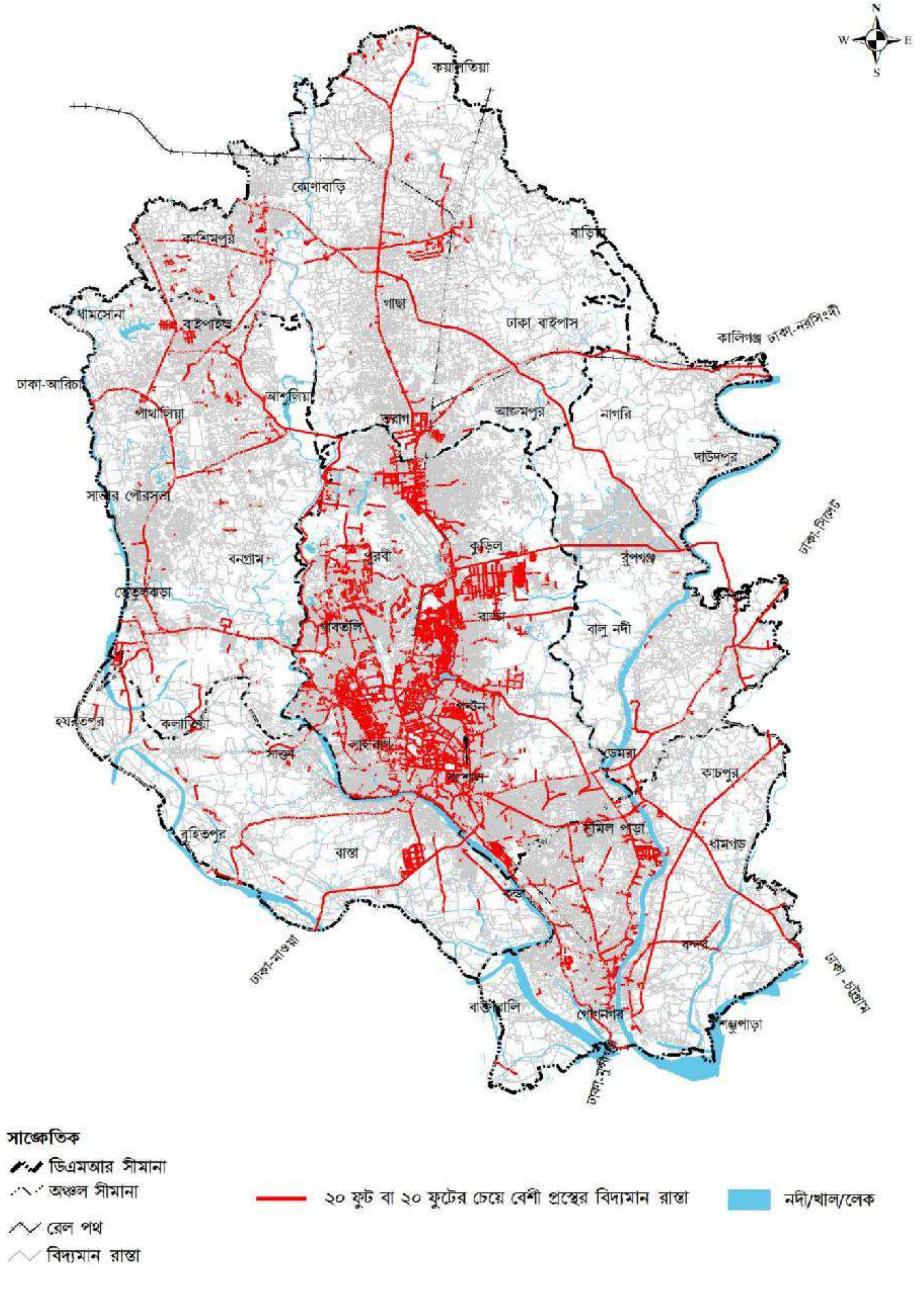
APPENDIX 7: Existing roads with a width of 5 feet or less than 5 feet in the Rajuk planning area (Detail Area Plan, 2022)



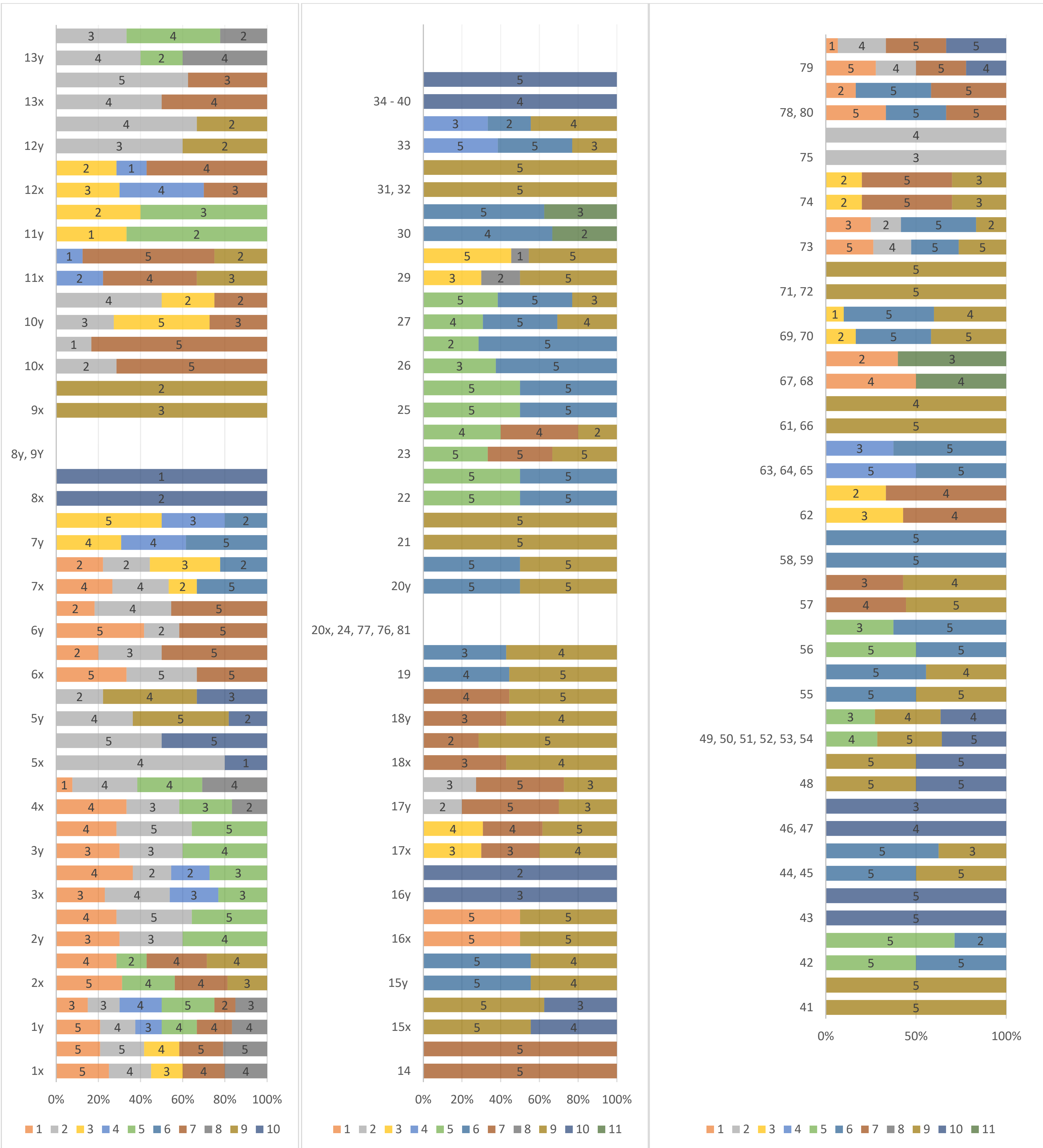
APPENDIX 8: Existing roads with a width of 8 feet or less than 8 feet in the Rajuk planning area (Detail Area Plan, 2022)



APPENDIX 9: Existing roads with a width of 20 feet or less than 20 feet in the Rajuk planning area (Detail Area Plan, 2022)



APPENDIX 10: Segment Evaluation (from Scale 1 To 5) Under Individual Obstruction Criteria.



Base Layer

Brick Tile Damage

Utility Points

Construction Rubbish

Trash

Food Retail Business

Hawker

Water Logging

Bike Parking

Vending Belongings

APPENDIX 11: Pedestrian Flow Rate

	3500 – 4000 pedestrian/hr.	High
	3000 – 3500 pedestrian/hr.	
	2500 – 3000 pedestrian/hr.	Medium
	2000 – 2500 pedestrian/hr.	
	1500 – 2000 pedestrian/hr.	
	1000 – 1500 pedestrian/hr.	Low
	500 – 1000 pedestrian/hr.	
	0 – 500 pedestrian/hr.	

Gate No.	Time	Day			Avg. pedestrian movement per 5 min (of 3 days)	Avg. pedestrian movement per hour (of 3 days)	Avg. pedestrian movement per hour (of 2 times)
		Day-01 (per 5 min.)	Day - 02 (per 5 min.)	Day- 03 (per 5 min.)			
1X	08:30- 10:30 am	210	220	228	219	2632	2572
	03:30 - 05:30 pm	200	210	218	209	2512	
1Y	08:30- 10:30 am	190	200	208	199	2392	2452
	03:30 - 05:30 pm	200	210	218	209	2512	
2X	08:30- 10:30 am	290	300	308	299	3592	3802
	03:30 - 05:30 pm	325	335	343	334	4012	
2Y	08:30- 10:30 am	225	235	243	234	2812	2662
	03:30 - 05:30 pm	200	210	218	209	2512	
3X	08:30- 10:30 am	165	175	183	174	2092	2002
	03:30 - 05:30 pm	150	160	168	159	1912	
3Y	08:30- 10:30 am	215	225	233	224	2692	2752
	03:30 - 05:30 pm	225	235	243	234	2812	
4X	08:30- 10:30 am	140	150	158	149	1792	1852
	03:30 - 05:30 pm	150	160	168	159	1912	
4Y	08:30- 10:30 am	120	130	138	129	1552	1492
	03:30 - 05:30 pm	110	120	128	119	1432	
5X	08:30- 10:30 am	80	90	98	89	1072	1042
	03:30 - 05:30 pm	75	85	93	84	1012	
5Y	08:30- 10:30 am	85	95	103	94	1132	1222
	03:30 - 05:30	100	110	118	109	1312	

	pm						
6X	08:30- 10:30 am	190	200	208	199	2392	2452
	03:30 - 05:30 pm	200	210	218	209	2512	
6Y	08:30- 10:30 am	185	195	203	194	2332	2272
	03:30 - 05:30 pm	175	185	193	184	2212	
7X	08:30- 10:30 am	205	215	223	214	2572	2542
	03:30 - 05:30 pm	200	210	218	209	2512	
7Y	08:30- 10:30 am	145	155	163	154	1852	1882
	03:30 - 05:30 pm	150	160	168	159	1912	
8X	08:30- 10:30 am	175	185	193	184	2212	2302
	03:30 - 05:30 pm	190	200	208	199	2392	
8Y	08:30- 10:30 am	195	205	213	204	2452	2632
	03:30 - 05:30 pm	225	235	243	234	2812	
9X	08:30- 10:30 am	75	85	93	84	1012	1102
	03:30 - 05:30 pm	90	100	108	99	1192	
9Y	08:30- 10:30 am	60	70	78	69	832	892
	03:30 - 05:30 pm	70	80	88	79	952	
10X	08:30- 10:30 am	210	220	228	219	2632	2722
	03:30 - 05:30 pm	225	235	243	234	2812	
10Y	08:30- 10:30 am	265	275	283	274	3292	3412
	03:30 - 05:30 pm	285	295	303	294	3532	
11X	08:30- 10:30 am	165	175	183	174	2092	2152
	03:30 - 05:30 pm	175	185	193	184	2212	
11Y	08:30- 10:30 am	125	135	143	134	1612	1762
	03:30 - 05:30 pm	150	160	168	159	1912	
12X	08:30- 10:30 am	85	95	103	94	1132	1252
	03:30 - 05:30 pm	105	115	123	114	1372	
12Y	08:30- 10:30 am	85	95	103	94	1132	1192
	03:30 - 05:30 pm	95	105	113	104	1252	
13X	08:30- 10:30 am	115	125	133	124	1492	1642
	03:30 - 05:30 pm	140	150	158	149	1792	
13Y	08:30- 10:30 am	130	140	148	139	1672	1792
	03:30 - 05:30 pm	150	160	168	159	1912	

14	08:30- 10:30 am	230	240	248	239	2872	3052
	03:30 - 05:30 pm	260	270	278	269	3232	
15X	08:30- 10:30 am	20	30	38	29	352	412
	03:30 - 05:30 pm	30	40	48	39	472	
15Y	08:30- 10:30 am	125	135	143	134	1612	1732
	03:30 - 05:30 pm	145	155	163	154	1852	
16	08:30- 10:30 am	75	85	93	84	1012	1162
	03:30 - 05:30 pm	100	110	118	109	1312	
17X	08:30- 10:30 am	90	100	108	99	1192	1342
	03:30 - 05:30 pm	115	125	133	124	1492	
17Y	08:30- 10:30 am	105	115	123	114	1372	1522
	03:30 - 05:30 pm	130	140	148	139	1672	
18X	08:30- 10:30 am	70	80	88	79	952	1012
	03:30 - 05:30 pm	80	90	98	89	1072	
18Y	08:30- 10:30 am	125	135	143	134	1612	1732
	03:30 - 05:30 pm	145	155	163	154	1852	
19	08:30- 10:30 am	105	115	123	114	1372	1402
	03:30 - 05:30 pm	110	120	128	119	1432	
20X	08:30- 10:30 am	185	195	203	194	2332	2482
	03:30 - 05:30 pm	210	220	228	219	2632	
22	08:30- 10:30 am	40	50	58	49	592	532
	03:30 - 05:30 pm	30	40	48	39	472	
23	08:30- 10:30 am	215	225	233	224	2692	2872
	03:30 - 05:30 pm	245	255	263	254	3052	
24	08:30- 10:30 am	240	250	258	249	2992	3202
	03:30 - 05:30 pm	275	285	293	284	3412	
26	08:30- 10:30 am	155	165	173	164	1972	2092
	03:30 - 05:30 pm	175	185	193	184	2212	
27	08:30- 10:30 am	100	110	118	109	1312	1342
	03:30 - 05:30 pm	105	115	123	114	1372	
28	08:30- 10:30 am	130	140	148	139	1672	1822
	03:30 - 05:30 pm	155	165	173	164	1972	
29	08:30- 10:30	150	160	168	159	1912	1852

	am						
	03:30 - 05:30 pm	140	150	158	149	1792	
30	08:30- 10:30 am	145	155	163	154	1852	1912
	03:30 - 05:30 pm	155	165	173	164	1972	
31	08:30- 10:30 am	155	165	173	164	1972	2062
	03:30 - 05:30 pm	170	180	188	179	2152	
32	08:30- 10:30 am	135	145	153	144	1732	1912
	03:30 - 05:30 pm	165	175	183	174	2092	
33	08:30- 10:30 am	95	105	113	104	1252	1342
	03:30 - 05:30 pm	110	120	128	119	1432	
34	08:30- 10:30 am	25	35	43	34	412	382
	03:30 - 05:30 pm	20	30	38	29	352	
35	08:30- 10:30 am	115	125	133	124	1492	1522
	03:30 - 05:30 pm	120	130	138	129	1552	
36	08:30- 10:30 am	110	120	128	119	1432	1372
	03:30 - 05:30 pm	100	110	118	109	1312	
37	08:30- 10:30 am	145	155	163	154	1852	1972
	03:30 - 05:30 pm	165	175	183	174	2092	
38	08:30- 10:30 am	120	130	138	129	1552	1732
	03:30 - 05:30 pm	150	160	168	159	1912	
39	08:30- 10:30 am	235	245	253	244	2932	3262
	03:30 - 05:30 pm	290	300	308	299	3592	
40	08:30- 10:30 am	260	270	278	269	3232	3472
	03:30 - 05:30 pm	300	310	318	309	3712	
41	08:30- 10:30 am	135	145	153	144	1732	1912
	03:30 - 05:30 pm	165	175	183	174	2092	
42	08:30- 10:30 am	140	150	158	149	1792	2062
	03:30 - 05:30 pm	185	195	203	194	2332	
43	08:30- 10:30 am	190	200	208	199	2392	2452
	03:30 - 05:30 pm	200	210	218	209	2512	
44X	08:30- 10:30 am	230	240	248	239	2872	3052
	03:30 - 05:30 pm	260	270	278	269	3232	
44Y	08:30- 10:30 am	185	195	203	194	2332	2542

`	03:30 - 05:30 pm	220	230	238	229	2752	
45	08:30- 10:30 am	50	60	68	59	712	742
	03:30 - 05:30 pm	55	65	73	64	772	
55	08:30- 10:30 am	80	90	98	89	1072	1252
	03:30 - 05:30 pm	110	120	128	119	1432	
56	08:30- 10:30 am	90	100	108	99	1192	1282
	03:30 - 05:30 pm	105	115	123	114	1372	
58	08:30- 10:30 am	160	170	178	169	2032	2122
	03:30 - 05:30 pm	175	185	193	184	2212	
59	08:30- 10:30 am	130	140	148	139	1672	1852
	03:30 - 05:30 pm	160	170	178	169	2032	
60X	08:30- 10:30 am	150	160	168	159	1912	2122
	03:30 - 05:30 pm	185	195	203	194	2332	
61	08:30- 10:30 am	155	165	173	164	1972	2092
	03:30 - 05:30 pm	175	185	193	184	2212	
62	08:30- 10:30 am	275	285	293	284	3412	3652
	03:30 - 05:30 pm	315	325	333	324	3892	
63	08:30- 10:30 am	60	70	78	69	832	862
	03:30 - 05:30 pm	65	75	83	74	892	
64	08:30- 10:30 am	100	110	118	109	1312	1492
	03:30 - 05:30 pm	130	140	148	139	1672	
65	08:30- 10:30 am	50	60	68	59	712	802
	03:30 - 05:30 pm	65	75	83	74	892	
66	08:30- 10:30 am	100	110	118	109	1312	1522
	03:30 - 05:30 pm	135	145	153	144	1732	
67	08:30- 10:30 am	100	110	118	109	1312	1552
	03:30 - 05:30 pm	140	150	158	149	1792	
68	08:30- 10:30 am	200	210	218	209	2512	2722
	03:30 - 05:30 pm	235	245	253	244	2932	
70	08:30- 10:30 am	85	95	103	94	1132	1072
	03:30 - 05:30 pm	75	85	93	84	1012	
71	08:30- 10:30 am	75	85	93	84	1012	1132
	03:30 - 05:30	95	105	113	104	1252	

	pm						
72	08:30- 10:30 am	100	110	118	109	1312	1492
	03:30 - 05:30 pm	130	140	148	139	1672	
73	08:30- 10:30 am	150	160	168	159	1912	2062
	03:30 - 05:30 pm	175	185	193	184	2212	
74	08:30- 10:30 am	225	235	243	234	2812	2932
	03:30 - 05:30 pm	245	255	263	254	3052	
75	08:30- 10:30 am	150	160	168	159	1912	2002
	03:30 - 05:30 pm	165	175	183	174	2092	
76	08:30- 10:30 am	200	210	218	209	2512	2692
	03:30 - 05:30 pm	230	240	248	239	2872	
77	08:30- 10:30 am	250	260	268	259	3112	3232
	03:30 - 05:30 pm	270	280	288	279	3352	
78X	08:30- 10:30 am	110	120	128	119	1432	1612
	03:30 - 05:30 pm	140	150	158	149	1792	
78Y	08:30- 10:30 am	170	180	188	179	2152	2272
	03:30 - 05:30 pm	190	200	208	199	2392	
79	08:30- 10:30 am	120	130	138	129	1552	1612
	03:30 - 05:30 pm	130	140	148	139	1672	
80	08:30- 10:30 am	225	235	243	234	2812	2962
	03:30 - 05:30 pm	250	260	268	259	3112	
81	08:30- 10:30 am	240	250	258	249	2992	3142
	03:30 - 05:30 pm	265	275	283	274	3292	

APPENDIX 12: Level of Service (LOS) Analysis

LOS 'A'	
LOS 'B'	
LOS 'C'	
LOS 'D'	
LOS 'E'	
LOS 'F'	

Sl No.	Ref No.	Flow Rate (ped/min/m)	Space sqm/person	Space sqm/person	LOS	Recomended Width space/.6m	Recomended Width space/.6m	Recomended Width space/.6m	Recomended Width walkways with views (+.5m)	Recomended Width (m)	Available width	Obstruction	Available Effective Width
1	1X	42	0.61	0.57	F	1.02	0.96	1.5	1.49	2.0	3.05	1.83	1.22
2	1Y	38	0.56	0.52	F	0.93	0.87	1.5	1.40	2	3.05	1.83	1.22
3	2X	58	0.85	0.79	E	1.41	1.32	1.5	1.87	2	1.52	0.91	0.61
4	2Y	45	0.66	0.61	F	1.10	1.02	1.5	1.56	2	2.44	1.52	0.91
5	3X	33	0.48	0.45	F	0.80	0.75	1.5	1.28	2	2.44	1.07	1.37
6	3Y	43	0.63	0.59	F	1.05	0.98	1.5	1.51	2	2.44	1.07	1.37
7	4X	28	0.41	0.38	F	0.68	0.64	1.5	1.16	2	1.52	0.30	1.22
8	4Y	24	0.35	0.33	F	0.58	0.55	1.5	1.07	2	2.44	1.22	1.22
9	5X	16	0.23	0.22	F	0.39	0.36	1.5	0.88	2	1.83	0.61	1.22
10	5Y	17	0.25	0.23	F	0.41	0.39	1.5	0.90	2	2.74	1.52	1.22
11	6X	38	0.56	0.52	F	0.93	0.87	1.5	1.40	2	2.74	1.52	1.22
12	6Y	37	0.54	0.51	F	0.90	0.84	1.5	1.37	2	1.83	1.22	0.61
13	7X	41	0.60	0.56	F	1.00	0.93	1.5	1.47	2	2.44	1.52	0.91
14	7Y	29	0.42	0.40	F	0.71	0.66	1.5	1.18	2	1.83	1.07	0.76
15	8X	35	0.51	0.48	F	0.85	0.80	1.5	1.32	2	1.22	0.00	1.22
16	8Y	39	0.57	0.53	F	0.95	0.89	1.5	1.42	2	1.22	0.00	1.22
17	9X	15	0.22	0.20	F	0.37	0.34	1.5	0.85	2	1.52	0.76	0.76
18	9Y	12	0.18	0.16	F	0.29	0.27	1.5	0.78	2	1.22	0.00	1.22
19	10X	42	0.61	0.57	F	1.02	0.96	1.5	1.49	2	2.44	1.52	0.91
20	10Y	53	0.77	0.72	E	1.29	1.21	1.5	1.75	2	2.44	0.91	1.52
21	11X	33	0.48	0.45	F	0.80	0.75	1.5	1.28	2	2.44	1.98	0.46
22	11Y	25	0.37	0.34	F	0.61	0.57	1.5	1.09	2	2.44	0.91	1.52
23	12X	17	0.25	0.23	F	0.41	0.39	1.5	0.90	2	2.44	1.52	0.91
24	12Y	17	0.25	0.23	F	0.41	0.39	1.5	0.90	2	2.44	0.91	1.52
25	13X	23	0.34	0.31	F	0.56	0.52	1.5	1.04	2	2.44	1.22	1.22
26	13Y	26	0.38	0.36	F	0.63	0.59	1.5	1.11	2	2.74	1.52	1.22
27	14	46	0.67	0.63	F	1.12	1.05	1.5	1.58	2	0.00	0.00	0.00
28	15X	4	0.06	0.05	F	0.10	0.09	1.5	0.59	2	2.13	2.13	0.00
29	15Y	25	0.37	0.34	F	0.61	0.57	1.5	1.09	2	3.05	2.13	0.91
30	16	15	0.22	0.20	F	0.37	0.34	1.5	0.85	2	0.00	0.00	0.00
31	17X	18	0.26	0.25	F	0.44	0.41	1.5	0.92	2	1.52	0.61	0.91

32	17Y	21	0.31	0.29	F	0.51	0.48	1.5	0.99	2	3.35	1.52	1.83
33	18X	14	0.20	0.19	F	0.34	0.32	1.5	0.83	2	3.35	2.13	1.22
34	18Y	25	0.37	0.34	F	0.61	0.57	1.5	1.09	2	3.35	2.13	1.22
35	19	21	0.31	0.29	F	0.51	0.48	1.5	0.99	2	3.35	2.13	1.22
36	20X	37	0.54	0.51	F	0.90	0.84	1.5	1.37	2	3.35	0.00	3.35
37	20Y	0	0.00	0.00		0.00	0.00	1.5	0.50	2	0.00	0.00	0.00
38	22	8	0.12	0.11		0.19	0.18	1.5	0.69	2	0.00	0.00	0.00
39	23	43	0.63	0.59	F	1.05	0.98	1.5	1.51	2	2.44	1.52	0.00
40	24	48	0.70	0.66	F	1.17	1.09	1.5	1.63	2	2.44	1.22	1.22
41	25	0	0.00	0.00		0.00	0.00	1.5	0.50	2	0.00	0.00	0.00
42	26	31	0.45	0.42	F	0.76	0.71	1.5	1.23	2	0.00	0.00	0.00
43	27	20	0.29	0.27	F	0.49	0.46	1.5	0.97	2	0.00	0.00	0.00
44	28	26	0.38	0.36	F	0.63	0.59	1.5	1.11	2	0.00	0.00	0.00
45	29	30	0.44	0.41	F	0.73	0.68	1.5	1.21	2	0.00	0.00	0.00
46	30	29	0.42	0.40	F	0.71	0.66	1.5	1.18	2	0.00	0.00	0.00
47	31	31	0.45	0.42	F	0.76	0.71	1.5	1.23	2	0.00	0.00	0.00
48	32	27	0.39	0.37	F	0.66	0.61	1.5	1.14	2	0.00	0.00	0.00
49	33	19	0.28	0.26	F	0.46	0.43	1.5	0.95	2	1.22	0.61	0.61
50	34	5	0.07	0.07		0.12	0.11		0.62	0.5	1.22	0.91	0.00
51	35	23	0.34	0.31	F	0.56	0.52	1.5	1.04	2	1.22	0.91	0.30
52	36	22	0.32	0.30	F	0.54	0.50	1.5	1.02	2	1.22	0.91	0.30
53	37	29	0.42	0.40	F	0.71	0.66	1.5	1.18	2	1.22	0.91	0.30
54	38	24	0.35	0.33		0.58	0.55		1.07	0.5	1.22	0.91	0.30
55	39	47	0.69	0.64	F	1.15	1.07	1.5	1.61	2	0.91	0.76	0.15
56	40	52	0.76	0.71	F	1.27	1.18	1.5	1.73	2	0.91	0.76	0.15
57	41	27	0.39	0.37	F	0.66	0.61	1.5	1.14	2	0.00	0.00	0.00
58	42	28	0.41	0.38	F	0.68	0.64	1.5	1.16	2	0.00	0.00	0.00
59	43	38	0.56	0.52	F	0.93	0.87	1.5	1.40	2	0.00	0.00	0.00
60	44X	46	0.67	0.63	F	1.12	1.05	1.5	1.58	2	0.00	0.00	0.00
61	44Y	37	0.54	0.51	F	0.90	0.84	1.5	1.37	2	0.00	0.00	0.00
62	45	10	0.15	0.14	F	0.24	0.23	1.5	0.74	2	0.00	0.00	0.00
63	55	16	0.23	0.22	F	0.39	0.36	1.5	0.88	2	0.00	0.00	0.00
64	56	18	0.26	0.25	F	0.44	0.41	1.5	0.92	2	0.00	0.00	0.00
65	57	0	0.00	0.00	F	0.00	0.00	1.5	0.50	2	3.35	2.13	1.22
66	58	32	0.47	0.44	F	0.78	0.73	1.5	1.25	2	3.66	2.44	1.22
67	59	26	0.38	0.36	F	0.63	0.59	1.5	1.11	2	2.44	1.22	1.22
68	60X	30	0.44	0.41	F	0.73	0.68	1.5	1.21	2	1.52	0.00	1.52
69	60Y	0	0.00	0.00	F	0.00	0.00	1.5	0.50	2	0.00	0.00	0.00
70	61	30	0.44	0.41	F	0.73	0.68	1.5	1.21	2	2.44	2.13	0.30
71	62	55	0.80	0.75	E	1.34	1.25	1.5	1.80	2	2.44	1.83	0.61
72	63	12	0.18	0.16	F	0.29	0.27	1.5	0.78	2	1.22	1.22	0.00
73	64	20	0.29	0.27	F	0.49	0.46	1.5	0.97	2	0.00	0.00	0.00
74	65	10	0.15	0.14	F	0.24	0.23	1.5	0.74	2	0.00	0.00	0.00
75	66	20	0.29	0.27	F	0.49	0.46	1.5	0.97	2	3.35	3.35	0.00
76	67	20	0.29	0.27	F	0.49	0.46	1.5	0.97	2	0.00	0.00	0.00
77	68	40	0.58	0.55	F	0.97	0.91	1.5	1.44	2	2.44	0.30	2.13

78	70	17	0.25	0.23	F	0.41	0.39	1.5	0.90	2	1.52	1.52	0.00
79	71	15	0.22	0.20	F	0.37	0.34	1.5	0.85	2	0.91	0.91	0.00
80	72	20	0.29	0.27	F	0.49	0.46	1.5	0.97	2	0.76	0.76	0.00
81	73	30	0.44	0.41	F	0.73	0.68	1.5	1.21	2	3.05	1.52	1.52
82	74	45	0.66	0.61	F	1.10	1.02	1.5	1.56	2	3.05	1.83	1.22
83	75	30	0.44	0.41	F	0.73	0.68	1.5	1.21	2	2.44	0.00	2.44
84	76	40	0.58	0.55	F	0.97	0.91	1.5	1.44	2	2.44	0.00	2.44
85	77	50	0.73	0.68	F	1.22	1.14	1.5	1.68	2	2.44	0.00	2.44
86	78X	22	0.32	0.30	F	0.54	0.50	1.5	1.02	2	2.44	1.52	0.91
87	78Y	34	0.50	0.46	F	0.83	0.77	1.5	1.30	2	3.35	1.83	1.52
88	79X	24	0.35	0.33	F	0.58	0.55	1.5	1.07	2	3.05	1.52	1.52
89	79Y	22	0.32	0.30	F	0.54	0.50	1.5	1.02	2	2.74	1.52	1.22
90	80	45	0.66	0.61	F	1.10	1.02	1.5	1.56	2	1.83	1.37	0.46
91	81	48	0.70	0.66	F	1.17	1.09	1.5	1.63	2	2.74	0.00	2.74

APPENDIX 13: Sidewalk Condition Index (SCI) Analysis Result

SCI	Rating	
0-28	Failed	
29-45	Poor	
46-55	Fair	
56-71	Good	
72-85	Very Good	
86-100	Excellent	

wI	2	2	1	2	3	5	5	2	4	5	2		33			
REF NO.	1 BASE LAYER DAMAGE	2 BRICK TILE MISSING	3 UTILITY CUT HOLE	4 CONSTRUCTION RUBBISH	5 TRASH	6 FOOD RETAIL BUSINESS	7 HAWKER	8 WATER CLOGGING	9 BIKE/RICKSHAW	10 VENDING BELONGINGS	11 DRAIN COVER MISSING		RDV	FDV	CAL. SCI	FINAL SCI
1x	5	4	3				4	4				20				
	5	5	4				5	5				24				
	330	297	231	0	0	0	297	297	0	0	0		132	20	80	41.33
1y	5	4		3	4		4	4				24				
	3	3		4	5		2	3				20				
	264	231	0	231	297	0	198	231	0	0	0		132	20	80	41.33
2x	5				4		4		3			16				
	4				2		4		4			14				
	297	0	0	0	198	0	264	0	231	0	0		90	13.6364	86.36	38.79
2y	3	3			4							10				
	4	5			5							14				
	231	264	0	0	297	0	0	0	0	0	0		72.00	10.9091	89.1	37.70
3x	3	4		3	3							13				
	4	2		2	3							11				
	231	198	0	165	198	0	0	0	0	0	0		72.00	10.9091	89.1	37.70
3y	3	3			4							10				
	4	5			5							14				
	231	264	0	0	297	0	0	0	0	0	0		72.00	10.9091	89.1	37.70
4x	4	3			3			2				12				
	1	4			4			4				13				
	165	231	0	0	231	0	0	198	0	0	0		75.00	11.3636	88.64	37.88
5x		4								1		5				
		5								5		10				
	0	297	0	0	0	0	0	0	0	198	0		45.00	6.81818	93.2	36.06
5y		4							5	2		11				
		2							4	3		9				
	0	198	0	0	0	0	0	0	297	165	0		60.00	9.09091	90.91	36.97
6x	5	5					5					15				

	2	3					5					10				
	231	264	0	0	0	0	330	0	0	0	0		75.0 0	11.36 36	88.6 4	37.88
6y	5	2					5					12				
	2	4					5					11				
	231	198	0	0	0	0	330	0	0	0	0		69.0 0	10.45 45	89.5 5	37.52
7x	4	4	2			5						15				
	2	2	3			2						9				
	198	198	165	0	0	231	0	0	0	0	0		72.0 0	10.90 91	89.0 9	37.70
7y			4	4		5						13				
			5	3		2						10				
	0	0	297	231	0	231	0	0	0	0	0		69.0 0	10.45 45	89.5 5	37.52
8x										2		2				
										1		1				
	0	0	0	0	0	0	0	0	0	99	0		9.00	1.363 64	98.6 4	33.88
9x									3			3				
									2			2				
	0	0	0	0	0	0	0	0	165	0	0		15.0 0	2.272 73	97.7 3	34.24
10 x		2					5					7				
		1					5					6				
	0	99	0	0	0	0	330	0	0	0	0		39.0 0	5.909 09	94.0 9	35.70
10 y		3	5				3					11				
		4	2				2					8				
	0	231	231	0	0	0	165	0	0	0	0		57.0 0	8.636 36	91.3 6	36.79
11 x				2			4		3			9				
				1			5		2			8				
	0	0	0	99	0	0	297	0	165	0	0		51.0 0	7.727 27	92.2 7	36.42
11 y			1		2							3				
			2		3							5				
	0	0	99	0	165	0	0	0	0	0	0		24.0 0	3.636 36	96.3 6	34.79
12 x			3	4			3					10				
			2	1			4					7				
	0	0	165	165	0	0	231	0	0	0	0		51.0 0	7.727 27	92.2 7	36.42
12 y		3							2			5				
		4							2			6				
	0	231	0	0	0	0	0	0	132	0	0		33.0 0	5	95.0 0	35.33
13 x		4					4					8				
		5					3					8				
	0	297	0	0	0	0	231	0	0	0	0		48.0 0	7.272 73	92.7 3	36.24
13 y		4			2			4				10				
		3			4			2				9				
	0	231	0	0	198	0	0	198	0	0	0		57.0	8.636	91.3	36.79

													0	36	6	
14							5					5				
							5					5				
	0	0	0	0	0	0	330	0	0	0	0		30.00	4.54545	95.45	35.15
15 x									5	4		9				
									5	3		8				
	0	0	0	0	0	0	0	0	330	231	0		51.00	7.72727	92.27	36.42
15 y						5			4			9				
						5			4			9				
	0	0	0	0	0	330	0	0	264	0	0		54.00	8.18182	91.82	36.61
16 x	5								5			10				
	5								5			10				
	330	0	0	0	0	0	0	0	330	0	0		60.00	9.09091	90.91	36.97
16 y										3		3				
										2		2				
	0	0	0	0	0	0	0	0	0	165	0		15.00	2.27273	97.73	34.24
17 x			3				3		4			10				
			4				4		5			13				
	0	0	231	0	0	0	231	0	297	0	0		69.00	10.4545	89.55	37.52
17 y		2					5		3			10				
		3					5		3			11				
	0	165	0	0	0	0	330	0	198	0	0		63.00	9.54545	90.45	37.15
18 x							3		4			7				
							2		5			7				
	0	0	0	0	0	0	165	0	297	0	0		42.00	6.36364	93.64	35.88
18 y							3		4			7		0		
							4		5			9		0		
	0	0	0	0	0	0	231	0	297	0	0		48.00	7.27273	92.73	36.24
19						4			5			9				
						3			4			7				
	0	0	0	0	0	231	0	0	297	0	0		48.00	7.27273	92.73	36.24
20 y						5			5			10				
						5			5			10				
	0	0	0	0	0	330	0	0	330	0	0		60.00	9.09091	90.91	36.97
21									5			5				
									5			5				
	0	0	0	0	0	0	0	0	330	0	0		30.00	4.54545	95.45	35.15
22					5	5						10				
					5	5						10				
	0	0	0	0	330	330	0	0	0	0			66.00	10	90.00	36.67

23					5		5		5			15				
					4		4		2			10				
	0	0	0	0	297	0	297	0	231	0	0		75.00	11.3636	88.64	37.88
25					5	5						10				
					5	5						10				
	0	0	0	0	330	330	0	0	0	0	0		60.00	9.09091	90.91	36.97
26					3	5						8				
					2	5						7				
	0	0	0	0	165	330	0	0	0	0	0		45.00	6.81818	93.18	36.06
27					4	5			4			13				
					5	5			3			13				
	0	0	0	0	297	330	0	0	231	0	0		78.00	11.8182	88.18	38.06
29			3					2	5			10				
			5					1	5			11				
	0	0	264	0	0	0	0	99	330	0	0		63.00	9.54545	90.45	37.15
30						4					2	6				
						5					3	8				
	0	0	0	0	0	297	0	0	0	0	165		42.00	6.36364	93.64	35.88
31, 32									5			5				
									5			5				
	0	0	0	0	0	0	0	0	330	0	0		30.00	4.54545	95.45	35.15
33				5		5			3			13				
				3		2			4			9				
	0	0	0	264	0	231	0	0	231	0	0		66.00	10	90.00	37.33
34-40										4		4				
										5		5				
	0	0	0	0	0	0	0	0	0	297	0		27.00	4.09091	95.91	34.97
41									5			5				
									5			5				
	0	0	0	0	0	0	0	0	330	0	0		30.00	4.54545	95.45	35.15
42					5	5						10				
					5	2						7				
	0	0	0	0	330	231	0	0	0	0	0		51.00	7.72727	92.27	36.42
43										5		5				
										5		5				
	0	0	0	0	0	0	0	0	0	330			33.00	5	95.00	35.00
44, 45						5			5			10				
						5			3			8				
	0	0	0	0	0	330	0	0	264	0	0		54.00	8.18182	91.82	36.61
46,										4		4				

47																
										3		3				
	0	0	0	0	0	0	0	0	0	231	0		21.00	3.18182	96.82	34.61
48									5	5		10				
									5	5		10				
	0	0	0	0	0	0	0	0	330	330	0		60.00	9.09091	90.91	36.97
49, 50, 51, 52, 53, 54					4				5	5		14				
					3				4	4		11				
	0	0	0	0	231	0	0	0	297	297	0		75.00	11.3636	88.64	37.88
55						5			5			10				
						5			4			9				
	0	0	0	0	0	330	0	0	297	0	0		57.00	8.63636	91.36	36.79
56					5	5						10				
					3	5						8				
	0	0	0	0	264	330	0	0	0	0	0		54.00	8.18182	91.82	36.61
57							4		5			9				
							3		4			7				
	0	0	0	0	0	0	231	0	297	0	0		48.00	7.27273	92.73	36.24
58, 59						5						5				
						5						5				
	0	0	0	0	0	330	0	0	0	0	0		30.00	4.54545	95.45	35.15
62			3				4					7				
			2				4					6				
	0	0	165	0	0	0	264	0	0	0	0		39.00	5.90909	94.09	35.70
63, 64, 65				5		5						10				
				3		5						8				
	0	0	0	264	0	330	0	0	0	0	0		54.00	8.18182	91.82	36.61
61, 66									5			5				
									4			4				
	0	0	0	0	0	0	0	0	297	0	0		27.00	4.09091	95.91	34.97
67, 68	4										4	8				
	2										3	5				
	198	0	0	0	0	0	0	0	0	0	231		39.00	5.90909	94.09	35.70

69, 70			2			5			5			12				
			1			5			4			10				
	0	0	99	0	0	330	0	0	297	0	0		66.00	10	90.00	37.33
71, 72									5			5				
									5			5				
	0	0	0	0	0	0	0	0	330	0	0		30.00	4.54545	95.45	35.15
73	5	4				5			5			19				
	3	2				5			2			12				
	264	198	0	0	0	330	0	0	231	0	0		93.00	14.0909	85.91	38.97
74			2				5		3			10				
			2				5		3			10				
	0	0	132	0	0	0	330	0	198	0	0		60.00	9.09091	90.91	36.97
75		3										3				
		4										4				
	0	231	0	0	0	0	0	0	0	0	0		21.00	3.18182	96.82	34.61
78, 80	5					5	5					15				
	2					5	5					12				
	231	0	0	0	0	330	330	0	0	0	0		81.00	12.2727	87.73	38.24
79	5	4					5			4		18				
	1	4					5			5		15				
	198	264	0	0	0	0	330	0	0	297	0		99.00	15	85.00	39.33