Assessing the Walkability Index in the City of Vadodara, Gujarat.

The study of factors affecting walkability in the urban context

Ar. Fennyben Udaykumar Patel

Abstract— Walkability provides a foundation for a sustainable city (Bhattacharyya & Mitra, 2013). Walking is measured as one of the most sustainable & democratic ways of traveling within the city—the advantages of applying the walkability concept and the factors related to making cities more pedestrian-friendly (TUROŃ et al., 2017). Walkability provides travel safety, security, and comfort for city dwellers (Bhattacharyya & Mitra, 2013). Pedestrian paths must be well planned in width, paving, landscaping, signing, and lighting. A walkable neighborhood or city has a controllable pattern of events to serve daily wants. Pedestrian-friendly transportation is essential for any local area as it increases social gatherings, improves peoples' safety, and improves public health and the overall urban environment. Thus, there is a need to address walkability as an essential transport mode as a revised perspective of sustainable transportation. A walking environment is one of the essential needs to take a step toward sustainable transportation. This research is based primarily on qualitative and qualitative evidence sequentially collected in three phases based on the research objective. In the first phase of research, there are two segments.

The first is the footpath mapping done with the help of QGIS software, which helps identify the availability of the footpath in three areas of Vadodara city. The second is to take a pedestrian perception survey based on the MoUD framework of the walking index based on the IRC Guidelines. The second phase investigated the gap between the existing situation of road sections based on elements affecting the walkability of the proposed road section in the IRC Guidelines. It is a comparative analysis between standard & existing conditions. The last phase was to prepare guidelines & design needs to revise in IRC guidelines after examining the second phase's result. The research concludes by redesigning the existing roads for pedestrian, non-motorized transport vehicles & motorized transport vehicles with wide footpaths and spaces for vendors on the streets & roads that will enhance the walkability in the urban area

Index Terms— Walkability, Urban Area, Walkability Index (WI), India, Pedestrian, Transportation, Infrastructure

1 Introduction

It is critical to plan and design a walking-friendly neighborhood to promote a sustainable environment. Making cities more walkable may increase the number of people who prefer to walk around town and those who cannot be comfortable in a vehicle (Hussain & Mawali, 2014). People in Indian cities prefer vehicular transportation to walk. People in a walkable neighborhood can walk to the store or school without fear of being hit by a car or moped. This research proposal looks into the needs and factors that influence walking behavior. Walkability is one of the city's most environmentally friendly and democratic modes of transportation. New technologies can improve the accessibility, safety, comfort, and security of urban spaces for pedestrians. Eliminating pedestrian space in many cities has created a socially unfriendly environment. Pedestrian-friendly transportation increases the area's social, environmental, and economic value. This thesis investigates the parameters influencing walkability in urban areas and establishes a qualitative assessment of pedestrian facilities, walking conditions, and their long-term durability in comfort, functions, aesthetics, safety, and security. The objectives are defined, such as deriving the current walkability index defined by the MoUD framework for Vadodara and identifying a gap in current guidelines. The study aims to improve walkable conditions and make planners more cautious when planning for a developing walkable city. The term "walkability" refers to how walkable, safe, convenient, comfortable, accessible, and healthy the built environment is. The Walkability Index (WI) is calculated based on the research area's data collection results and observation analysis. Proposals and recommendations were made to improve walkability in an urban area. Three stages were chosen: fully developed, newly developed, and currently developing. Primary data was collected using random survey sampling methods, and secondary data used GIS modeling.

2 Defining Walkability

"walkability is a planning concept that encourages mixed-use, high-density neighborhoods where people can access essential services and amenities by foot." (www.planetizen.com, n.d.). Walkability is different not just from the locality of the specific place but also from the social diversity, high or low population density, variety of building types, diversity in the economic scenario, and employment type. "walking ability, as developed, supports and fosters the community through the comfort of feet and protection, connects people to various destinations in a reasonable amount of time and effort, and offers a visual appeal across the network" (Southworth, 2005).

3 Literature Review

Walkable cities provide city dwellers safety, security, and comfort while traveling. Walkability reduces traffic congestion, pollution, vehicle fuel costs, and fatalities on the road.

3.1 Walkability in the Indian context

A serious walkability plan for Siliguri is needed to ensure the

city's long-term viability. Developing culturally applicable news measures for India is a necessary first step in supporting evidence-based interventions against inactivity-related NCDs (Adlakha et al., 2016). This study is the first of its kind in India and has the potential to help researchers better understand the correlates of Physical Activity. By connecting the bus stations, the study attempts to determine the accessibility to each ASF sector by sector. The overlapping grid map with the built-up region aids in the identification of areas with no transit and places with only a few bus stations (Yenisetty & Bahadure, 2021). India's first study of its kind has the potential to help researchers better understand the correlates of pa. It may yield evidence-based recommendations for developing communities that encourage people to be more physically active. Because chronic disease rates are rising in India, public health promotion is critical. Most roads in Bengaluru city are congested and provide poor service. Improving the inter-zonal traffic system and existing intersections to improve traffic flow. Road transportation is critical to the nation's economic development. Various road construction programs have been launched to meet India's future needs.

3.2 Walkability and neighborhood planning scenario

On March 15, 2010, the Stockholm city council adopted the city plan. The plan is part of the city's drive to become a world-class city by 2030. The city plan represents an urban planning paradigm shift toward denser, cohesive, cleaner, and more humane development. Walkable neighborhoods are pedestrian-focused, allowing people the choice and opportunity to move about without using a motor vehicle. Despite growing studies on planning walkable neighborhoods, few have included people with diverse abilities across the age spectrum. The findings could pave the way for innovative approaches to walkable areas. Walkable cities are an idea that aims to create public urban spaces that are available for pedestrians and friendly for walkers. Krasińskiego 8 street, the location of the Silesian University of technology's faculty of transport, receives 93 points, which means it is a walker's paradise. Walkability is one of the most sustainable and democratic ways of traveling within a city. New technologies can improve walkers' accessibility, safety, comfort, and security in urban spaces. Walkability audits are time- and cost-intensive solutions requiring several streetscape observations. Walkability is essential in deciding whether a city is green or sustainable (Tarek et al., 2021). Residents and communities benefit from neighborhood attachment regarding psychological well-being and positive behavioral outcomes. The most important driving forces of neighborhood attachment are proximity, proximity, and security.

3.3 Key Findings of Literature Review

The correlations show a significant relationship between perceived walkability and neighborhood attraction; without significant gaps or obstacles, the path network should be well connected locally and in the larger urban environment. Walkways must be well designed concerning width, paving, pavement, landscape, signs, and lighting. The path context includes the design of roads, architecture, and landscape. Public transportation, walking, and cycling will significantly impact development in the medium and long term.

4 Research Methodology

This study began with a review of the literature. The goal of this thesis has been established based on the critical findings of the literature review. Three objectives have been identified to achieve this goal, dividing the original goal into three parts. A study can be used as a model to improve urban walkability. The literature review and its conclusion identify some factors that influence urban walkability. The city of Vadodara is the study's research area. Three areas are chosen based on their development stage: old, newly, and currently developing. Election ward 2 includes old developed areas like Fatehgaj, Chhani, and New Sama; election ward 10 includes developing areas like Vasna and Bhayali; and election ward 18 includes newly developed areas like Makarpura and Manjalpur.

This study relies on two types of data collection. The first is primary data collection through field and people's perception surveys. The second step is to observe and compare the current situation to the existing guidelines. In this study, 900 samples were collected, 300 from each area using random and snowball sampling methods. Following data collection and compilation, the field survey was analyzed using GIS modeling software and the descriptive analysis method used for the people's perception survey. The results of this study were used to calculate Vadodara's walkability index. The walkability index was computed using a framework developed by India's Ministry of Urban Development (MoUD). The walkability index results and literature review interpretation of the study were recognized, which aided in providing recommendations and proposals to achieve the research's goal. Finally, the thesis concludes with some statements that indicate the future scope of the study.

4.1 Aim & objective

To understand how walkability can be enhanced for urban areas using the walkability index." this thesis investigates the parameters affecting walkability in urban areas. It ascertains qualitative assessment of pedestrian facilities, walking conditions, and their sustained durability in comfort, functions, aesthetics, safety, and security." (Wibowo & Nurhalima, 2018).

The objective is to derive the current walkability index as defined by the MoUD framework for Vadodara. Identifying a gap in current guidelines by reviewing IRC guidelines and comparing them with the derived walkability index. Policy guideline recommendations that will facilitate walking in the urban area

4.1.1 Sub-objectives

- To investigate the need for pedestrian design guidelines.
- To analyze the parameters which help make space walkable
- To find out the problems faced by pedestrians/ users.

"to acknowledge and evaluate evolving perceptions of pedestrians about the pedestrian facilities provided and their preference for potential facility up-gradation" (Wibowo & Nurhalima, 2018). "To engage, encourage and create aware-

ness among the general public, planners, and policymakers on pedestrian rights" (Wibowo & Nurhalima, 2018).

4.2 Data Collection & Analysis Method

The study consists of a perception survey of pedestrians regarding the walking environment in the city and, at selected points walkability observation survey of research, the area was done. Descriptive analysis is a data analysis technique that helps describe, show, or constructively conclude data points so patterns can emerge.

4.2.1 Samples and Surveys

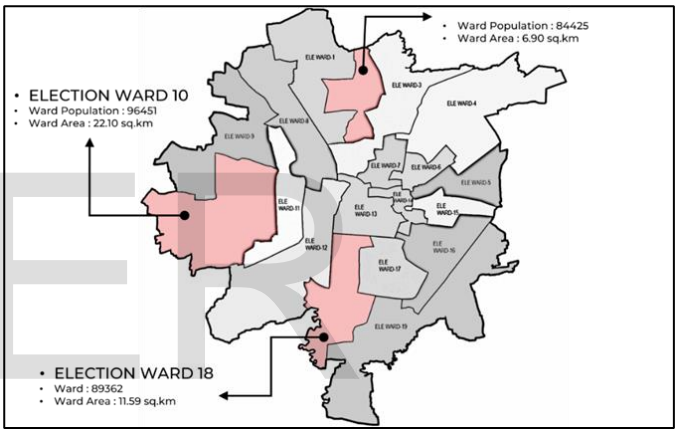
For this research, 900 sample surveys were taken from each area, and 300 samples were taken. Sampling was done through the random sampling survey and snowball sampling survey methods. For random sampling survey, as the name suggests, is an entirely random method of selecting the samples. This sampling method is as easy as assigning numbers to the individual sample, and it was impossible to reach a considerable number of samples individually. So, the snowball survey method is used to achieve many samples, which helps achieve a firm rating of people's perception of pedestrian facility ratings.

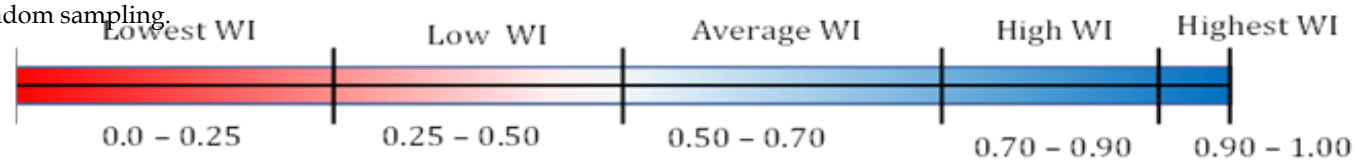
4.2.2 Calculate the walkability index as per MOUD

To calculate the walkability measured as per the framework of MoUD. Walkability index = [(0.5 x availability of footpath) + (0.5 x pedestrian facility rating)], where availability of footpath was measured and derived from the on-site observation and gis modeling (Study on Traffic and Transportation Policies And Strategies in Urban Areas in India , 2008) The people's perception survey method chooses to analyze data for gis modeling – QGIS software, and for the pedestrian facility rating. A total of 900 samples took from the study area. The sample size for the survey was 300, and the method adopted was random sampling.

4.2.3 Research Area Location

There is 3 area selected for the study, located in Vadodara. They were selected based on the development stage of the area. Ward 2 is a fully developed area, ward ten is currently developing, and ward 18 is a newly developed area located in the respective north, south and east parts of the Vadodara municipal corporation (VMC) area. There is 3 area selected for the study, located in Vadodara. They were selected based on the development stage of the area. Ward 2 is a fully developed area, ward ten is currently developing, and ward 18 is newly developed. Election ward two is located in the northern area of Vadodara, fully developed and the oldest neighborhood in the city, including the Fateh Ganj, Sama, and Chhani areas. Election ward ten is located in the western part of Vadodara, which is in the early stage of development and includes the Vasna - Bhayali area. Furthermore, election ward eighteen is located in the southern part of Vadodara, including Makarpura and Manjalpur, newly developed areas.





5 RESULTS AND DISCUSSION

5.1 Parameters of survey-based data collection

Table 1 Parameters of Survey

Field walkability survey	Perception survey of pedestrians	Amenities available and safety concerns and comfort of citizens
• Type of footpath • Overall cleanliness of the segment • Curvilinear or curb cuts on the footpath • Type of land use • The material used for constructing the footpath	• Mode of transport used for less than 2km • Fear while crossing the busy road • Respond given by drivers to pedestrians • Rating on pedestrian facilities • Improvements like to have in pedestrian infrastructure • Proper management of hawkers • Feeling safe to walk during night-time • Types of vehicles causing havoc to	• Facilities available in the area • Shading on walkways • Lighting on footpath • Grading of pedestrian walkways (overall)

• Width of footpath • Accessibility of wheelchair to the footpath	pedestrians • Any location people like to walk but are currently unable • Children prefer to walk on the footpath	

5.2 Existing footpath mapping through GIS

Figure 2 Watd – 2

(Source: Author)

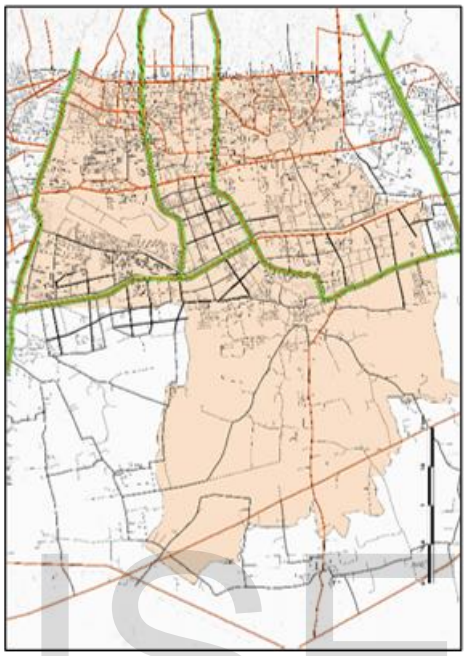


Figure 2 Ward – 10

(Source: Author)

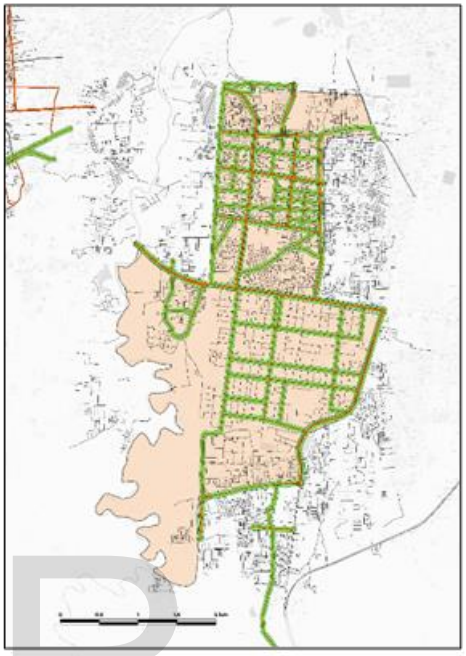


Figure 3 Ward – 18

(Source: Author)

Ward – 2	
Ward population (census 2011)	84425
Length of the road network	345.91 km
Ward area	6.90 sq. km

Ward – 10	
Ward population (census 2011)	96451
Length of the road network	614.73 km
Ward area	22.10 sq.km

Ward – 18	
Ward population (census 2011)	89362
Length of the road network	423.78 km
Ward area	11.59 sq.km

5.3 Results of Descriptive Statics of Study Variables

A total of 900 surveys was taken by random sampling survey method for 300 survey sample from each area. From total samples taken; male and female samples are respectively, in wards 2, 10,18 are 60% m & 40% f, 66% m & 34% f, and 62% m & 38% f.

The survey result shows that people prefer to walk maximum for travel distance less than 2 km. Moreover, most 0% of people use public transport for the same. Moreover, the second-highest mode is motorcycle/ scooter/ moped (2-wheeler) to commute less than 2 km

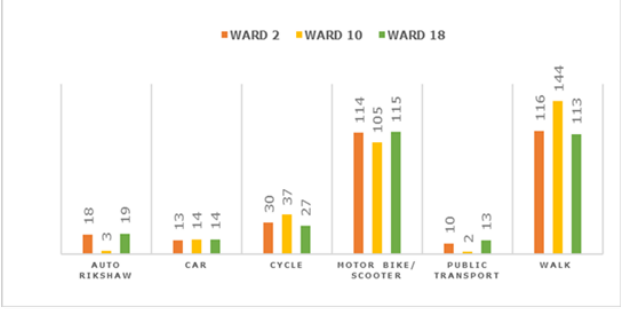


Figure 1 mode of transportation used to travel less than 2

(Source: Author)

Fear while crossing roads is stated to be very high. 52% of people of ward no. 2 feel fear while crossing the road. 4% of people in ward no. 10 feel fear while crossing the road. 51% of people in ward no. 18 feel fear while crossing the road

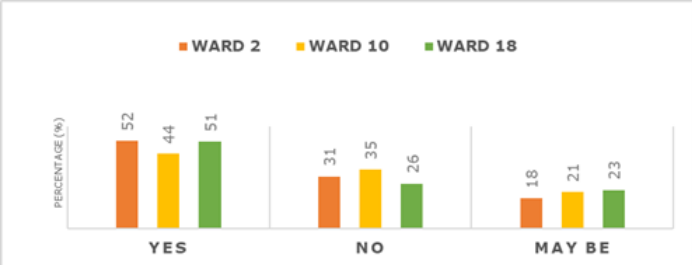


Figure 1 feel fear while crossing the road on foot

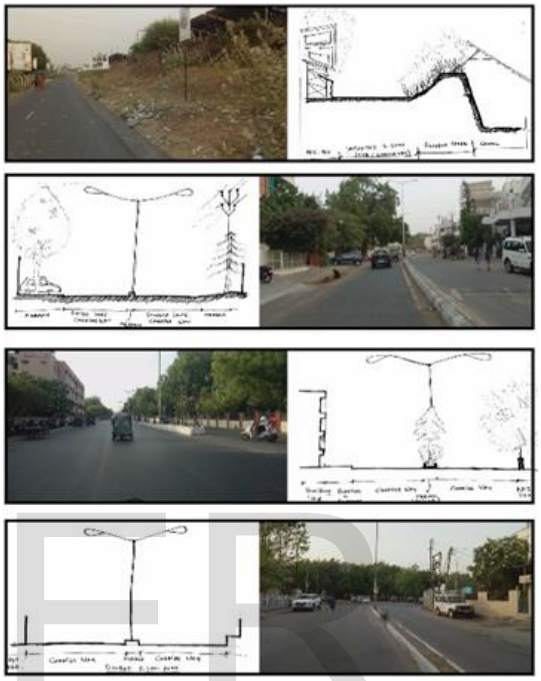
(Source: Author)

In the study area, a maximum number of students prefer to walk. In ward 2, 10, 18 respectively 51%, 42%, 32%. As in ward 18, 47% of employed people in the surveyed area choose to walk due to Manjalpur GIDC. The survey result shows that about 40 to 42 percent of people admit that drivers do not give care to walking people. 34 to 39 percent of people admit that drivers give care to walking people. Furthermore, 21 to 24 percent of people are not sure whether drivers give care to walking people or not. It is observed in the study area, and people admit that it is required to manage hawkers and vendors properly. 76 to 81 percent of the surveyed sample strongly agree on managing space for the hawkers. Parents do not prefer to let their children walk alone on the streets in the study area. Approximately 45% of the total study says that walking alone for children is not safe. And approx. 36 % of people agreed to let their people walk on the streets. The survey result depicts 46 to 52 percent of people feeling safe while walking at night-time. These numbers show the low crime rate in the study area. The study depicts that around 15 to 21 percent of the roads have footpaths on both sides, whereas 13 to 30 % have footpaths only on one side. Unfortunately, 55 to 66% of the roads do not have footpaths.

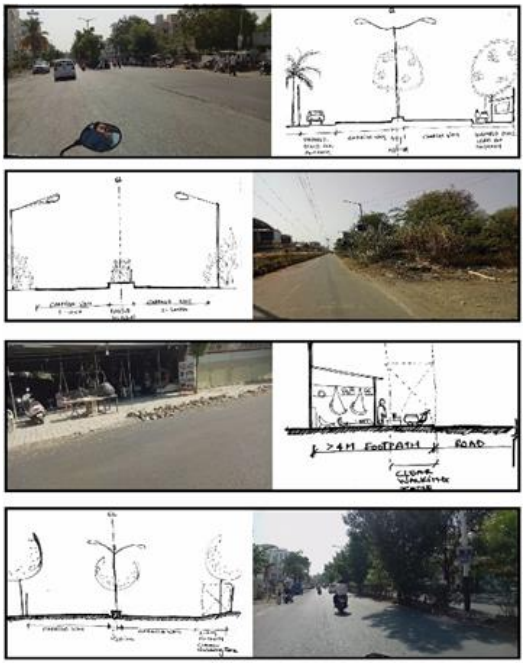
5.4 Review of IRC guidelines v/s existing scenario

The review of existing guidelines related to this study is IRC–103-2012; guidelines for pedestrian facilities & IRC:86-2018 geometric design standard for urban roads and streets. This review will give information about the standards and compare it with an existing scenario in the study area; identifying gaps in practice will help provide recommendations for the future to achieve the aim and objective. IRC is a guideline and not a rule; this is proved in the previous thesis pedestrian inclusivity and fixed physical elements: an examination of 'making of footpaths' for ease of movement' in Vadodara city (Tewari, 2018) So, it is a significant loophole in our system that planners do not incorporate the guidelines given in IRC, in practice. Makinguidelines to enhance walkability (Tewari, 2018). A footpath should consist of a dead or frontage zone, a pedestrian zone, and a multi-functional zone. Paths should be at least 1800 mm wide for adults and children to walk together(IRC, 2018). If existing paths are less than 1800 mm wide, provision of passing places, 1800 mm wide and 2500 mm long, the minimum 1.8 m (width) x 2.2 m (height) walking zone should be clear of all obstructions – both horizontally and vertically(IRC, 2018). No utility ducts, poles, electric, water, telecom boxes, trees, signage, or obstruction should be placed within the "walking zone" (IRC, 2018).

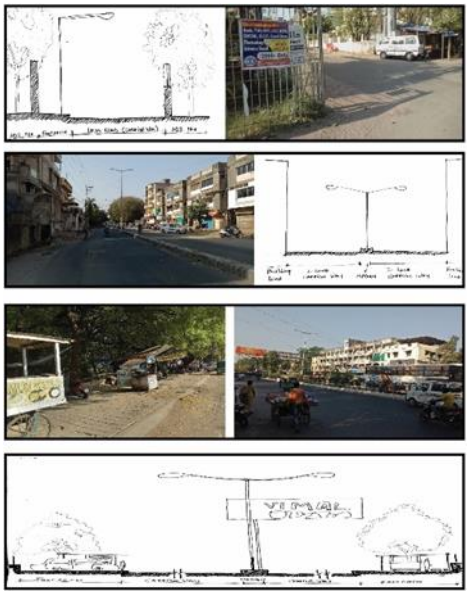
5.5 Results & analysis of the existing condition



Ward - 2 Existing road section



Ward - 10 Existing road section



Ward - 18 Existing road section

6 Findings And Inferences

As per MoUD guidelines, there are nine parameters, 1. Availability of footpath 2. Footway width 3. Presence of obstruction 4. Maintenance of footpath 5. Street lights & other amenities 6. Security from crime 7. Walking path conflicts 8. Availability of pedestrian crossing 9. Safety in crossing Many other parameters affect peoples' perception of walkability from the literature review.

Ward - 2	Ward - 10	Ward - 18
Road length: 345.91 km	Road length: 614.73 km	Road length: 423.78 km
Footpath length: 35.25 km	Footpath length: 40.74 km	Footpath length: 70.89 km
Avg rating of people: 3.03/5 (MoUD)	Avg rating of people: 2.83/5 (MoUD)	Avg rating of people: 2.71/5 (MoUD)
WI=[(0.5 x availability of footpath) + (0.5 x pedestrian facility rating)]		
WI = [(0.5 x (35.25/345.91)) + (0.5 x (3.03/5)]	WI = [(0.5 x (40.74/614.73)) + (0.5 x (2.83/5)]	WI = [(0.5 x (70.89/423.78)) + (0.5 x (2.71/5)]
WI = 0.35	**WI = 0.32**	**WI = 0.35**

Parameters like distance of origin to destination, actual distance; availability and connectivity of sidewalks, the width of sidewalks or footpaths; road connectivity, frequency, and volume of pedestrian and vehicular movements, improvement of width in driveway and carriageway; intersections; density of population, comfort, safety, size of the crosswalk, signalization, availability of footpath, curb cuts, synchronization signalization; demographics details like housing density, employment density, ethnic minority density, transit commuters, bike commuters, pedestrian commuters and usage of the footpath, a household with cars and 2 – wheelers; land-use diversity; land use classification, multimodal facilities on the bases of compactness of pedestrian-friendly amenities; travel demand; comfort and convenience like lighting, street trees, benches, local architecture, building frontage, topography, shades and rain covers, weather/climate are the variables affected walkability. These parameters and variables must be incorporated into policy, project proposals, and implementation strategies to enhance walkability at the city level or make an action plan for a walkable city.

6.1 Conclusion

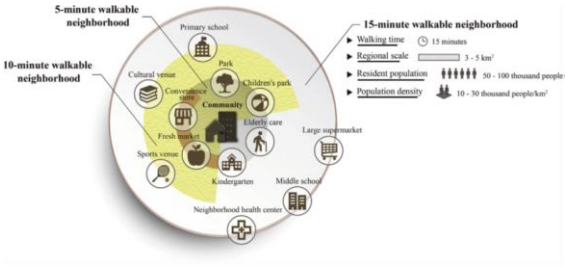
It is resolute that current arterial, sub-arterial, and collector roads require remodeling. The study findings reveal that the IRC:103-2012 design is non-walkable since Indian cities feature living components.

To retain these qualities, it divides public transportation lanes, separates motorized and non-motorized vehicle lanes, and provides sufficient pedestrian areas to benefit all road users. Making local places more pedestrian-friendly offers several benefits like boosting the neighborhood's social, environmental, and economic value. However, contrary to previous research, there was no indication that one element had the most significant impact on the area's walkability.

Safety has been upgraded while walking. Traffic circulation patterns will increase traffic congestion, and random traffic movement will decrease. Sidewalks, additional attractions close to home, and shade trees were all factors that might encourage people to walk more. (Patel, 2022)

6.2 Future research

Develop a 15-minute walkable neighborhood concept: planners and decision-makers should work with many suppliers on physical and social projects to improve access to amenities within walking distance. Prepare a walkable action plan for the city for the next 20 to 25 years to implement design and policy guidelines for improving the quality of pedestrian facilities based on the green city concept, which uses a bottom-up approach to encourage public participation. Pedestrian-friendly transportation is necessary to accommodate walkability principles and provide complete pedestal facilities, comfort, equality, and safety. Inclusive planning of green open spaces: a skywalk connects sorrel areas such as residential areas, offices, and recreational areas. This inclusive planning of green open spaces such as buffer zones, multipurpose paths, natural furniture, attached green canopies, and other amenities is needed; a public-private partnership scheme and a sustainable management approach involving cooperation between the public and private community are all required.



15-min walkable neighborhood concept (Min Weng, 2019)

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