

# Walkability and Connectivity of Delhi Metro stations at Peri-Urban areas

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**Abstract**— Walkability has an essential role in creating a pollution-free city. If a public transport facility is accessible and connected very well to the origins and destinations of the people, the use of public transport will tend to increase. This will result in the reduction of pollution. So, it is important to study how well public transport is connected and accessible to pedestrians. This research study is representing an analysis of the pedestrian facilities at surrounding areas within 1 km radius of metro stations (MS) located in central and peripheral Delhi. Four metro stations were selected randomly for the research purpose. I collected Qualitative data in order to analyze the condition of existing pedestrian paths around these metro stations. This study is based on a comparative and qualitative approach of analysis. It was found that metro stations located in central Delhi are well connected and more accessible as compared to metro stations located in the peripheral part. Walkability should be regarded as one of the important parts of public transport and pedestrian paths should be designed, considering data of crowd movement in respective areas.

**Index Terms**— Walkability, Connectivity, Metro station, Footpath, Peri-Urban areas, Delhi

## 1 INTRODUCTION

INCREASING the pedestrianization is most important contribution in decreasing pollution, increasing health condition, and inclusion of all group people. The World Health Organization defines “A pedestrian is any person who is travelling by walking for at least part of his or her journey (WHO, 2013). In addition to the ordinary form of walking, a pedestrian may be using various modifications and aids to walking such as wheelchairs, motorized scooters, walkers, canes, skateboards, and roller blades. The person may carry items of varying quantities, held in hands, strapped on the back, placed on the head, balanced on shoulders, or pushed/pulled along. A person is also considered a pedestrian when running, jogging, hiking, or when sitting or lying down in the roadway.”

The pedestrian facilities shall comply with physical characteristics such as footpath surface, footpath width, obstructions, encroachment, potential for vehicle conflict, continuity. In India, Indian Road Congress has given the norms for the footpath and its supporting facilities. Following are the norms for footpath width:

Table 1: Required width of footpath as per Adjacent Land-use

Minimum obstacle free walkways width and residential/ Mixed use areas	1.8 m
Commercial/ Mixed Use areas	2.5 m
Shopping Frontages	3.5 m to 4.5 m
Bus Stops	3 m
High Intensity Commercial Areas	4 m

Source: Guidelines for Pedestrian facilities, IRC: 103-2012

Objectives and goals of this research study is to analyze the pedestrian facilities at surrounding areas within 1 km radius of metro stations located in central and peripheral Delhi and bring methods or tools to analyze the walkability, connectivity & accessibility of metro station in others cities also. Finally, come up with solution based on the results.

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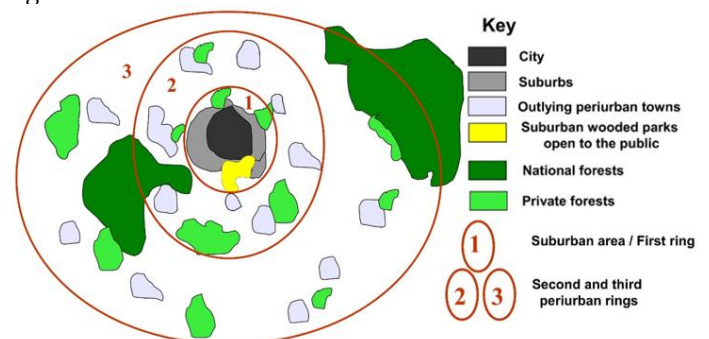
## 2 LITERATURE STUDY

### 2.1 What are peri-urban areas?

The concept of peri-urban emerged due to limitations in the dichotomy between rural and urban. Much research has identified the inadequacy of this simplistic dichotomy, some authors even suggesting its analytical relevance is long past. Others have argued more specifically that only the dichotomous construct has outlived its usefulness not the underlying distinction between degrees of ruralness and urbaness (Rambaud 1973).

A Peri-urban area refers to a transition or interaction zone, where urban and rural activities are juxtaposed, and landscape features are subject to rapid modifications, inducing by human activities (Douglas, 2006). Peri-urban areas, which might include valuable protected areas, forested hills, preserved woodlands, prime agricultural lands and important wetlands, can provide essential life support services for urban residents.

Figure 1: Peri- Urban areas



Source: <https://journals.openedition.org/rga/docannexe/image/1633/img-1>  
McGranahan et al. (2004) observed that peri-urban zones are often far more environmentally unstable than either urban or rural settings. From ecosystem’s point of view, physical, chemical and biological factors generally interact among themselves, and are interrelated with socioeconomic forces. These

factors have their own functions, which can be enhanced or reduced depending on the conditions of other factors in the same system (Fang et al., 2005).

A peri-urban area is not only a zone of direct impact experiencing the immediate impacts of land demands from urban growth and pollution, but is also a wider market-related zone of influence that is recognizable in terms of the handling of agricultural and natural resource products (Simon et al., 2006). When urban grows disorderedly and sprawls to peri-urban area, this process can be referred as peri-urbanization. Peri-urbanization can be regarded both as a driver and an effector of global environmental changes. Observing land use and land cover change over time can perceive effects and impacts of urbanization on peri-urban areas. The complex interactions between urban land use, environmental change, and socio-economic system on peri-urban area must be approached from systems perspective to understand their dynamic interactions and function and services of peri-urban's ecosystems provide to cities.

## 2.2 What is walkability and connectivity?

"Walkability" is a term used to describe and measure the connectivity and quality of walkways, footpaths or sidewalks in cities. It can be measured through a comprehensive assessment of available infrastructure for pedestrians and studies linking demand and supply (Herbert Fabian 2010).

In India, a walkability index was used in one of the studies commissioned by the Ministry of Housing and Urban Affairs (MoHUA). The index was a function of the availability of footpaths and pedestrian facility rating (Ministry of Urban Development 2008). The perception of pedestrians was gauged on the availability and quality of footpaths, obstructions, maintenance, lighting, security from crime, safety in crossings and other qualitative factors. A low rank indicates inadequate and substandard pedestrian facilities. The national average index in 2008 was 0.52 ((CSE) 2009). In addition, the MoHUA also developed an urban transport benchmarking tool that uses three indicators to calculate the pedestrian facility rating - (1) signalized intersection delay(s)/pedestrian, (2) street lighting (Lux) and (3) % of city covered with footpaths wider than 1.2 m.

Some cities have undertaken comprehensive studies and city plans for improving walkability like the Transport for London, defines walkability as "the extent to which walking is readily available to the consumer as a safe, connected, accessible and pleasant activity" (London 2009). For New Zealand, it was defined as the extent to which the built environment is walk friendly (New Zealand Transport Authority, 2009). Abu Dhabi has developed an Urban Street Design Manual which integrates the concept of pedestrian realm to the overall street composition (Council 2010).

A popular website, "www.walkscore.com" calculates the walkability based on the distance from your house to nearby amenities. Walk Score measure the ease of a car-free lifestyle, but it does not include an assessment of the quality of pedestrian facilities like street width and block length, street design, safety from crime and crashes, pedestrian-friendly community design, and topography. Many Asian cities can have high

scores in Walk Score because of the traditionally mixed-use character of the cities.

Walkability is a measure of how friendly an area is to walking. Walkability has health, environmental, and economic benefits. Factors influencing walkability include the presence or absence and quality of footpaths, sidewalks or other pedestrian rights-of-way, traffic and road conditions, land use patterns, building accessibility, and safety (Westaby 2019). "The extent to which the built environment is friendly to the presence of people living, shopping, visiting, enjoying or spending time in an area" (Burden 2010).

## 2.3 Walkability and connectivity in Delhi

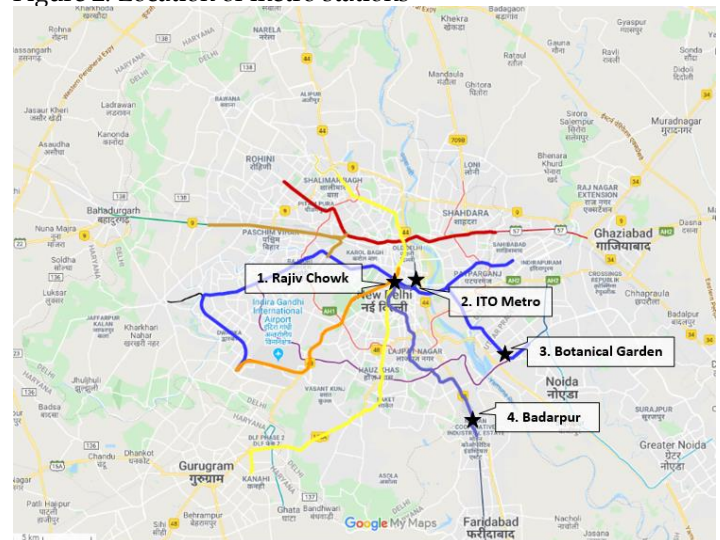
Delhi is a Metropolitan city where one can find all types of planned/unplanned housing, formal/informal activities, people from all over India with a wide range of income. Metro Transit was being started for ease and safety of the pedestrians. In order to succeed, we should keep in mind that connectivity and walkability are also important that will encourage people to use public transit.

A continuous unobstructed footpath on each side of all streets with ROW wider than 12m. Minimum width of footpath should be 1.8 m (with clear height 2.4 m.) in addition to space for trees/greenery/vending spaces and surface utilities. Width of footpath shall be determined based on pedestrian volume and have to be wider than 1.8 m wherever required. Footpath level should never be more than 150 mm above adjoining carriageway level (MPD-2021).

## 3 METHODOLOGY AND DATA COLLECTION

Qualitative data is collected for four stations of Delhi metro. These four metro stations are selected randomly as per their locations. Two metro stations are located in the central Delhi and other two metro stations are located in peri - urban areas of Delhi. Comparison of metro stations being done for the research analysis. Following are the metro stations considered for the study:

Figure 2: Location of metro stations



Source: Google Maps, Edited by Author

a) Centrally Located stations



- Rajiv Chowk
- ITO
- b) Peripherally Located stations
  - Botanical Garden
  - Badarpur Border

Data is collected through photographic survey and observation survey.

Connectivity and walkability of area within the radius of 1 km around the metro stations has been analyzed in the research study. For analyzing the connectivity and walkability of the pedestrian pathway parameters such as footpath continuity, footpath availability, Footpath condition, footpath width, eye on the street, lighting, crossing facility, foot-over bridge condition, subway (pedestrian underpass) condition, at-grade crossing, plantation, and footpath encroachment are considered.

#### 4 DATA ANALYSIS

For analysis, the qualitative data is converted into quantitative data by given weightage. The ten points at surrounding 1km are selected randomly. If footpath is available then the weightage given is 1 and if footpath is not available then the weightage given is 0. Similarly for footpath continuity, footpath cleanliness. In case of footpath encroachment and delay in time weightage is 0 if it is present and weightage is 1 if not present. In case of foot-over bridge/ pedestrian underpass/ zebra crossing, if either one of facility is available then the weightage will be 1 and if not then 0. If footpath width is enough (as per the norms) then weightage is 1 and if not then 0. For the other facilities such as toilets, sit-outs and bicycle no weightage is given, however, if these facilities are available, they will positively affect the walkability. Table 2: Criteria for calculating the Walkability and Accessibility of Metro Stations

Metro stations	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10
Footpath Available	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1
Footpath Width	E-1	E-1	E-1	E-1	E-1	E-1	E-1	E-1	E-1	E-1
Footpath Condition	G-1	G-1	G-1	G-1	G-1	G-1	G-1	G-1	G-1	G-1
Footpath Continuity	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1
Footpath Encroachment	N-0	N-0	N-0	N-0	N-0	N-0	N-0	N-0	N-0	N-0
Footpath Cleanliness	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1
FOB/ PU/ AGC Avail.	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1
Street Lights Avail.	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1
Eyes on Street	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1
Delay in time	Y-0	Y-0	Y-0	Y-0	Y-0	Y-0	Y-0	Y-0	Y-0	Y-0
Plantation	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1	Y-1
*O.F. Avail.	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
*O.F. Condn.	G/B	G/B	G/B	G/B	G/B	G/B	G/B	G/B	G/B	G/B

Source: Prepared by author, October 2019

Note: P= Point, Y= Yes, N= No, E= Enough (according to norms), NE= Not Enough, G= Good, B= Bad, FOB= Foot-over Bridge, PU= Pedestrian Underpass, AGC= At-Grade Crossing (Zebra Crossing), O.F. = Other Facilities

There are total 10 points selected for 1 metro station and there are 12 criterias. So, the total weightage will be 120. The metro

station with high weight will be more walkable with good connectivity and accessibility. After that the normalized weightage % will be out of 100. Table 3: Quality of walkability, connectivity and accessibility of Metro Stations

Quality	Very Poor	Poor	Satisfactory	Good	Very Good
Range%	1-20	21-40	41-60	61-80	81-100

Source: Prepared by author, October 2019

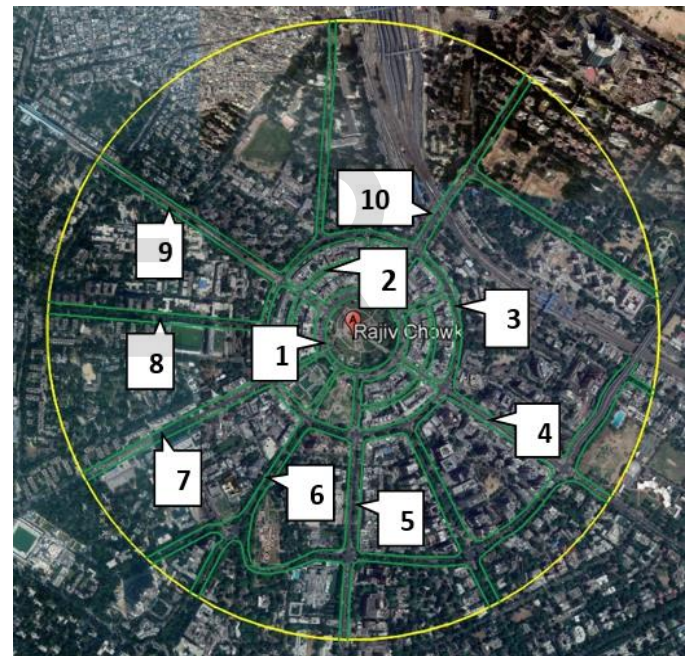
The less is the weightage % - the poor is the walkability, accessibility and connectivity. If the weightage % is 1-20 then it is very poor, if 21-40 then it is poor and so on.

#### 4.1 Centrally located stations

The green, orange and red colors are only showing the footpath availability, continuity and unavailability. "Green" color means footpath is available and continuous. "Orange" color means footpath is available but not continuous. "Red" color means footpath is not available.

##### 1. Rajiv Chowk Metro station

Figure 3: Points taken around Rajiv Chowk MS



Source: Google Maps, Edited by Author

Table 4: Walkability and Accessibility of Rajiv Chowk MS

Rajiv Chowk Metro Station	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	Total
Footpath Available	1	1	1	1	1	1	1	1	1	1	10
Footpath Width	1	1	1	1	1	1	1	1	1	1	10
Footpath Condition	1	0	1	1	1	1	1	1	1	1	9
Footpath Continuity	1	1	1	1	1	1	1	1	1	1	10
Footpath Encroachment	1	0	1	1	1	1	1	1	1	1	9
Footpath Cleanliness	1	1	1	1	1	1	1	1	1	1	10
FOB/ PU/ AGC Available	1	1	1	1	1	1	1	1	1	1	10
FOB/ PU/ AGC Condition	1	1	1	1	1	1	1	1	1	1	10
Street Lights Avail.	1	1	1	1	1	1	1	1	1	1	10
Eyes on Street	1	1	1	1	1	1	1	1	1	1	10
Delay in time	1	1	1	1	1	1	1	1	1	1	10
Plantation	1	0	1	1	1	1	1	1	1	1	9
Total	12	9	12	12	12	12	12	12	12	12	117
*O.F. Avail.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	-
*O.F. Condn.	G	G	G	G	G	G	G	G	G	G	-

Source: Prepared by author, October 2019

Below are the points selected around the MS:



Image 1: Toilet Facility near MS



Source: Author, October 2019

Image 2: Point 1



Source: Author, October 2019

Image 3: Point 3



Source: Author, October 2019

Image 4: Point 4

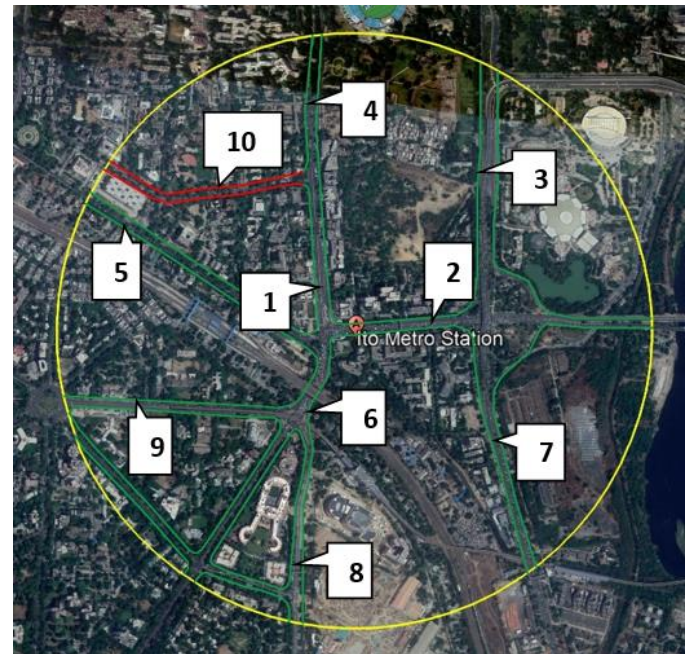


Source: Author, October 2019

The total weightage for Rajiv Chowk Metro is 117.

1. ITO metro station

Figure 4: Points taken around ITO MS



Source: Google Maps, Edited by Author

Image 5: Sit-outs at ITO MS



Source: Author, October 2019

Table 5: Walkability and Accessibility of ITO MS

ITO Metro Station	P- 1	P- 2	P- 3	P- 4	P- 5	P- 6	P- 7	P- 8	P- 9	P- 10	Total
Footpath Available	1	1	1	1	1	1	1	1	1	0	9
Footpath Width	1	1	1	1	1	1	1	1	1	0	9
Footpath Condition	1	1	1	1	1	1	1	1	1	0	9
Footpath Continuity	1	1	1	1	1	1	1	1	1	0	9
Footpath Encroachment	1	1	1	1	1	1	1	1	1	0	9
Footpath Cleanliness	1	1	1	1	1	1	1	1	1	0	9
FOB/ PU/ AGC Available	1	1	1	1	1	1	1	1	1	0	9
FOB/ PU/ AGC Condition	1	1	1	1	1	1	1	1	1	0	9
Street Lights Avail.	1	1	1	1	1	1	1	1	1	1	10
Eyes on Street	1	1	1	1	1	1	1	1	1	1	10
Delay in time	1	1	1	1	1	1	1	1	1	0	9
Plantation	1	1	1	1	1	1	1	1	1	0	9
Total	12	12	12	12	12	12	12	12	12	2	110
*O.F. Avail.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	—
*O.F. Condn.	G	G	G	G	G	G	G	G	G	G	—

\*Other Facilities includes toilets, sit-outs

Source: Prepared by author, October 2019

Below are the points selected around the MS:



Image 6: Point 1



Source: Author, October 2019

Image 7: Point 2



Source: Author, October 2019

Image 8: Point 3



Source: Author, October 2019

The total weightage for ITO Metro is 110.

## 4.2 Peripherally located stations

### 1. Botanical Garden Metro station

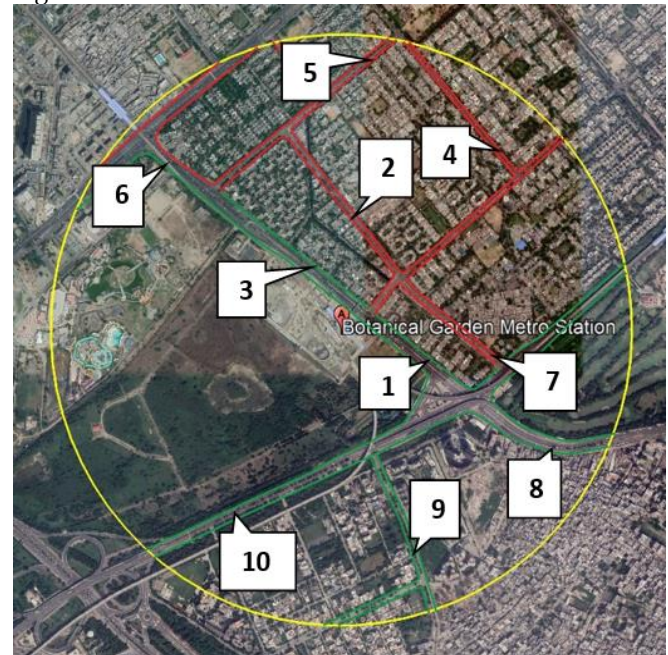
Table 6: Walkability and Accessibility of Botanical Garden MS

Botanical Metro Station	P- 1	P- 2	P- 3	P- 4	P- 5	P- 6	P- 7	P- 8	P- 9	P- 10	Total
Footpath Available	1	0	0	0	1	0	0	1	1	1	5
Footpath Width	0	0	0	0	0	0	0	1	1	1	3
Footpath Condition	1	0	0	0	0	0	0	1	1	1	4
Footpath Continuity	1	0	0	0	0	0	0	1	1	1	4
Footpath Encroachment	1	0	0	0	0	0	0	1	1	1	4
Footpath Cleanliness	1	1	0	0	0	0	0	1	1	1	5
FOB/ PU/ AGC Available	1	1	1	1	1	1	1	1	1	1	10
FOB/ PU/ AGC Condition	1	0	1	0	0	1	0	1	1	1	6
Street Lights Avail.	1	1	1	1	1	1	1	1	1	1	10
Eyes on Street	0	1	1	1	1	1	1	1	1	1	9
Delay in time	1	0	1	0	0	1	0	1	1	1	6
Plantation	0	1	1	0	0	0	1	1	1	1	6
Total	9	5	6	3	4	5	4	12	12	12	72
*O.F. Avail.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	-
*O.F. Condn.	G	G	G	G	G	G	G	G	G	G	-

\*Other Facilities includes sit-outs

Source: Prepared by author, October 2019

Figure 5: Points taken around Botanical Garden MS



Source: Google Maps, Edited by Author

Image 9: Botanical Garden MS



Source: Author, October 2019

Below are the points selected around the MS:

Image 10: Point 1



Source: Author, October 2019



Image 11: Point 2



Source: Author, October 2019

Image 12: Point 3



Source: Author, October 2019

Image 13: Point 4



Source: Author, October 2019

Image 14: Point 5



Source: Author, October 2019

Image 15: Point 6

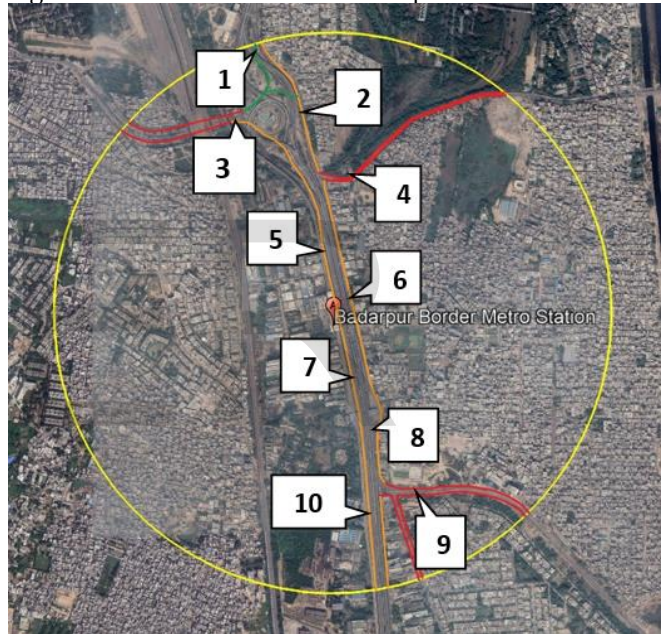


Source: Author, October 2019

The total weightage for Botanical Metro is 72.

## 2. Badarpur Border Metro station

Figure 6: Points taken around Badarpur border MS



Source: Google Maps, Edited by Author

Image 16: Pedestrian Underpass



Source: Author, October 2019

Table 7: Walkability and Accessibility of Badarpur MS



Badarpur Metro Station	P- 1	P- 2	P- 3	P- 4	P- 5	P- 6	P- 7	P- 8	P- 9	P- 10	Total
Footpath Available	1	1	1	0	1	1	1	1	0	1	8
Footpath Width	0	0	0	0	0	0	0	0	0	0	0
Footpath Condition	0	0	0	0	0	0	0	0	0	0	0
Footpath Continuity	0	0	0	0	0	0	0	0	0	0	0
Footpath Encroachment	0	0	0	0	0	0	0	0	0	0	0
Footpath Cleanliness	0	0	0	0	0	0	0	0	0	1	1
FOB/ PU/ AGC Available	1	1	1	1	1	1	1	1	1	1	10
FOB/ PU/ AGC Condition	0	0	0	0	0	0	0	0	0	0	0
Street Lights Avail.	1	1	1	1	1	1	1	1	1	1	10
Eyes on Street	1	1	1	0	1	1	0	1	1	0	7
Delay in time	0	0	0	0	0	0	0	0	0	0	0
Plantation	1	0	1	0	0	0	0	0	0	1	3
Total	5	4	5	2	4	4	3	4	3	5	39
*O.F. Avail.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	-
*O.F. Condn.	G	G	G	G	G	G	G	G	G	G	-

\*Other Facilities includes toilets

Source: Prepared by author, October 2019

Below are the points selected around the MS:

Image 17: Point 1



Source: Author, October 2019

Image 18: Point 2



Source: Author, October 2019

Image 19: Point 4



Source: Author, October 2019

Image 20: Point 5



Source: Author, October 2019

Image 21: Point 6



Source: Author, October 2019

Image 22: Point 9



Point 9

Source: Author, October 2019

The total weightage for Badarpur Metro is 39.

## 5 RESULTS

It is found that two metro stations located in central Delhi are having higher weightage % and other two metro stations located in peripheral Delhi are having low weightage %.

Table 8: Comparison of four Metro Stations

Metro Stations	Rajiv Chowk	ITO	Botanical Garden	Badarpur Border
Footpath Available	10	9	5	8
Footpath Width	10	9	3	0
Footpath Condition	9	9	4	0
Footpath Continuity	10	9	4	0
Footpath Encroachment	9	9	4	0
Footpath Cleanliness	10	9	5	1
FOB/ PU/ AGC Available	10	9	10	10
FOB/ PU/ AGC Condition	10	9	6	0
Street Lights Avail.	10	10	10	10
Eyes on Street	10	10	9	7
Delay in time	10	9	6	0
Plantation	9	9	6	3
Total	117	110	72	39
Normalised Weightage %	97.5%	91.6%	60.0%	33.0%
Quality	Very Good	Very Good	Satisfactory	Poor
Range %	81-100	81-100	41-60	21-40

Source: Prepared by author, October 2019

The Rajiv Chowk and ITO Metro Stations are coming under very good category with 97.5% and 91.6% weightage. Botanical Garden Station is coming under satisfactory category with 60% weightage and Badarpur Station is coming in the poor category with 33% weightage.

## 6 CONCLUSION

Metro stations in peripheral Delhi are not walkable and not connected properly. Walkways are not nicely constructed. There is lack of maintenance also where some facilities are available. We need to provide user specific designs of pedestrian paths and walkways. Metro stations in central Delhi are walkable and connected properly, and they need continuous maintenance to keep its quality in very good category.

## 7 SCOPE FOR FURTHER RESEARCH

- Other cities can also be analyzed using the method.
- Each metro station can be weighted and ranked according to the facilities availability, accessibility and maintenance. Cleanliness factor should also be summed up to calculate the walkability and connectivity to fight COVID-19.
- Now more parameters can be added due to COVID-19 such as marks or signs on ground for keeping distance between individuals, facility for cleanliness of footwears and backpacks, metro station cleaning and sanitizing frequency, thermal scanning, and other measures to against COVID-19.

## ACKNOWLEDGMENT

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## REFERENCES

- [1] (CSE), Centre for Science and Environment. "Footfalls: Obstacle Course to Livable Cities." New Delhi, India, 2009.
- [2] Burden, D. "The early history of walkability." 2010.

- [3] Council, Abu Dhabi Urban Planning. "Urban Street Design Manual." 2010.
- [4] D. Simon, D. McGregor, and D. Thompson. "Contemporary perspectives on the peri-urban zones of cities in development areas." In *Peri-Urban Interface: Approaches to Sustainable Natural and Human Resource Use*, 2006: 3-17.
- [5] Douglas, I. "Peri-urban ecosystems and societies transitional zones and contrasting values." In *Peri-Urban Interface: Approaches to Sustainable Natural and Human Resource Use*, 2006.
- [6] G. McGranahan, D. Satterthwaite, and C. Tacoli. "Urban-rural change, boundary problems and environmental burdens." *International Institute for Environment and Development*, 2004.
- [7] Herbert Fabian, Sudhir Gota, Alvin Mejia, James Leather. *Walkability and Pedestrian Facilities in Asian Cities: State and Issues*. 6 ADB Avenue, Mandaluyong City, 1550 Metro Manila, Philippines: Asian Development Bank, 2010, 11-12.
- [8] London, Transport for. "Meeting on Surface Transport." 2009.
- [9] Ministry of Urban Development, Government of India. *Study on Traffic and Transportation Policies and Strategies in Urban Areas in India*. Willber Smith Associates, 2008.
- [10] Rambaud, Placide. "Village and Urbanization: Sociological Problems." *Étude Rurales: revue trimestrielle d'histoire, géographie, sociologie économie des campagnes*, 1973: 14-32.
- [11] S. Fang, G.Z.Gertner, Z. Sum, and A.A. Anderson. "The impact of interactions in spatial simulation of the dynamics of urban sprawl, Landscape and Urban Planning, 73." 2005.
- [12] Westaby, Katherine A. "Walkability Means Better Business." *Downtown Economics*, July 2019.
- [13] Delhi Development Authority, "Master Plan for Delhi -2021," New Delhi 2017.
- [14] Indian Road Congress, "Guideline for Pedestrian Facilities," 2012.
- [15] World Health Organization