A Comparative Analysis of the Walkability Indices of Bengaluru City Wards: Assessment of Influencing Factors

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Abstract: Bengaluru, one of the fastest growing contemporary cities, has experienced remarkable growth in recent decades. However, this growth has led to excessive dependence on automotives, leading to severe traffic congestion during the day. Additionally, obstacles to pedestrian movement intensify the situation, contributing to increased vehicular usage in the city. Assessment of walkability in a city through walkability indices can help identify diverse factors that affect walkability. To gain a thorough understanding of the dynamics of pedestrian movement in a city, an in-depth review of literature regarding factors affecting walkability and the existing walkability indices was undertaken. Literature review helped identify the diverse influencing factors and these factors were listed and categorized as physical, psychological, social, environmental and policy support factors. Existing walkability indices prevalent in different geographic locations of the world were also studied with respect to the above categories. It was found that there is a need for a walkability index which includes all the above factors and is also applicable to the Indian context. Subsequently, a comprehensive walkability index was formulated that included all the factors and which would be more appropriate to Indian urban environments, considering the country's heterogeneous social matrix. To assess the walkability of Bengaluru city, research was undertaken to apply this walkability index to 2 wards in the city, selected through purposive sampling. These included 1 ward with high population density and poor pedestrian infrastructure and 1 ward with medium population density and moderate pedestrian infrastructure. The research assessed the walkability in each of these wards with respect to the various influencing factors. A comparative analysis of the walkability index of these wards was then completed to identify factors that need immediate attention to make the city more pedestrian friendly. These critical factors need to be addressed as a priority, to ensure a healthy urban environment in Bengaluru city.

Keywords: *Walkability; Walkability indices; Pedestrian spaces; Public amenities; Sidewalk quality*

Introduction

Bengaluru, India's IT hub, holds the 24th position globally in population, according to the World Population Review 2023. The Delhi Statistical Handbook 2023 reports that Bengaluru has overtaken Delhi as the Indian city with the highest number of private cars. As of March 31, 2023, Bengaluru had a total of 2.31 million private cars. However, the city's infrastructure is under severe strain due to heavy traffic volume, resulting in notorious mile-long traffic jams. The city is also severely lacking in pedestrian infrastructure which further increases the use of automobiles, contributing to the city's traffic congestion. Walkable cities are more sustainable due to appropriate usage of the city's traffic and transport infrastructure. To assess the walkability of any city it is important to identify the factors affecting walkability and the status of these factors in any particular city. Many walkability indices have been developed in different countries to assess the critical factors that require immediate attention to make the city more pedestrian friendly. This paper presents a comparative analysis of existing walkability indices through literature review, research gap, formulation of a walkability index more appropriate to the Indian context and application of the walkability index in the selected wards in Bengaluru city to identify crucial impediments to walkability in the city.

Literature Review

Many studies have demonstrated the importance of walkability as a metric of a city's long-term growth trend. Many high-quality research projects have also sought to provide a detailed examination of various features influencing performance indicators for walkability in cities. Several organizations have sought to develop walkability indexes to evaluate cities on a standardized basis.

A thorough review of Existing walkability indices was conducted by Lee and Talin (2014) involving in person as well as secondary auditing methods. Some of the widely used walkability indexes were found to be SPACES, PBIC, WSAF, SLU, IMI, and PEDS. Maghelal and Capp (2011) studied and assessed 25 pedestrian indices developed during the last two decades, including data sources, the scale of measurement, and a list of identifiable features used to build an index.

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Numerous elements that define the qualities of the city to create these indexes are also enumerated. This research also provides a prescriptive framework for quantifying built-environment components that have an influence on walking, that may be applied in future research. The research categorizes measures according to their measurement method: subjective, objective and distinctive.

People perceive space in two ways: visible and moveable. Lee and Talin (2014) through their research also add that, in addition to physical qualities of the built environment, a similar community school of thought and organizational assistance could be essential to increase walkability of cities. Another observation is that in order to maintain objectivity, most walkability indices eliminate place-making and space-making characteristics from their definitions.

Maghelal and Capp (2011) selected variables from a comprehensive analysis of current indices and classified them into 4 dimensions and 10 constructs. Physical route features, sidewalk quality, distance from origin and destination, density, and variation are used to illustrate the city's demographics. The comfort and safety of pedestrians contribute to the overall quality of the environment. According to this study, technological advancements have led to relatively newer indices using technologies on the digital front along with field research to assess walkability. Source of data can classify variables as objective or subjective. As a result, few of the factors can be acquired using GIS, while others may be collected using surveys. Identifying identical factors that may have relevance in multiple subheadings but must be correctly delegated to minimize repetition.

Martino et al. (2019) conclude that walkability indices may serve distinct goals after applying two different indices to the Olympic Village in Vancouver. Large scale indices may suggest communities where walking is the primary form of transportation, but they may not fully depict human scale relationships. Important factors in urban design include infrastructure, environmental convenience, and proximity to landmarks.

Soltani et al. (2018) determined that three types of metrics can be added after thoroughly reviewing various walkability audit techniques: functioning, security and visual appeal. The functioning of the pedestal infrastructure that emphasizes convenience and comfort for walkability, the security in terms of lighting, pedestrian crossing and refuge islands and the visual appeal of these elements in the city's fabric can help determine how friendly the city is to walkers. Street-level design features that increase pedestrian safety and aesthetics should be promoted. Some walking tools now contain technological features to assist with covering appropriate ground, and the results are paired with in-person audits and on-site inspections. Digital tools can be utilized for assessing objective characteristics, while questionnaires can aid in establishing qualitative metrics of the walking environment.

Research Gap

Subsequent to study of existing walkability indices including The Global Walkability Index (GWI), Walk Score , SPACES, The Pedestrian and Bicycle Information Center (PBIC), The Walking Suitability Assessment form (WSAF), SLU , IMI (Irvine, Minnesota Inventory), PEDS , CPI , Behavioural Model of Environment (BME), Bicycle and Walkability Evaluation Table (BiWET), The Pedestrian Environmental Quality Index (PEQI) , MOUD Method, it was inferred that multiple indices exist that have been formulated by leading experts in city design and transportation planning. Nevertheless, the argument over the applicability of any universal index remains, due to the intricate social composition of cities created by the existing geographic and cultural contexts. The observation through comparative analysis of existing walkability indices with respect to different factors may be summarized as follows:

Physical factors: Physical factors are the most universal factors for analysis. The presence and condition of sidewalks is a recurring parameter in nearly all walkability indices. However, it appears that other aspects such as signage, building heights, building facades and street geometry that affect the pedestrian environment's physical aspect have not been sufficiently explored.

Psychological factors: Safety and security are predominant concerns to promote a healthy walking environment. Safety from traffic accidents, provision for adequate medians, crossings, refuge islands have been included in many indices. Other psychological factors such as ease of way finding, perceived vs. actual distance find little mention.

Social factors: Social factors are underrepresented in most indices. Cities are a melting pot of diverse socio cultural and socio-economic sectors. Apart from inclusivity for barrier free design, other attributes of the city's social structure have not been tackled, especially community feeling and parallel economies which are essential for social wellbeing of a city.

Environmental factors: Apparent issues such as sidewalks free of garbage have been recorded in some of the indices, but other features such as PHE, climatic response and protection of natural features have not been included.

Policy support: With the exception of GWI, no other index considers policy planning to be a significant factor. Policy and financial support are two essential elements for any development of city planning, that might be outside the citizens' jurisdiction.

Research Method:

The numerous motives for walking in a city have been researched, and utilitarian walking appears to be the most important in terms of time and distance. It may be thus inferred that the following aspects of the walking environment need to be assessed as factors in any comprehensive walkability index.

A. PHYSICAL FACTORS OF THE WALKING ENVIRONMENT- Land use, Street geometry, Street intersections, Landscape and open spaces, Sidewalks, Lighting, Signage, Building height, Building façade

B. PSYCHOLOGICAL FACTORS RELEVANT TO PEDESTRIAN USERS- Legibility , Safety, Security, Comfort, Human scale, Imageability, Aesthetic surroundings, Time distance

C.SOCIAL FACTORS OF THE NEIGHBOURHOOD- Lively, Heterogeneous, Inclusive, Sense of place , Community feeling, Economy of scale

D.ENVIRONMENTAL FACTORS- Clean environment, Pollution free, Natural setting, pleasant climate, public health engineering

E. POLICY SUPPORT- Funding and resources, Adherence to urban design guidelines, Pedestrian safety laws, Pedestrian rights, Civic awareness

An index developed with a rating scale using these factors can not only help assess the walkability of any given neighbourhood but also help identify the aspects that need to be prioritized to make this environment pedestrian friendly. This research utilizes these indicators to assess and analyze the reasons for poor walkability in Bengaluru city.

Research Work:

An in-depth Review of Literature related to walkability, walkability indices and their application in diverse contexts has shown that it is not a one size fits all. There is a need to formulate a walkability index that is applicable to a heterogenous walking community in a diverse demographic for the Indian context. A walkability index has thus been formulated to include relevant factors from different prevalent walkability indices across the globe and tailor make the index for the city of Bengaluru. The wards selected for study have been assessed through this index as a matrix of Physical, Psychological, Social, Environmental and Policy support factors.

It has also been observed that most of these walk scores have a score ranging from 1 to 100. However, with inclusion of social factors and policy support, it is not possible to limit the score to 100 to avoid fractional and decimal outputs. Hence the walkability index which has been formulated based on all the above inputs has a score from 0 to 200. The scale ranges from Always, Mostly, Seldom to Never and not applicable. Points are assigned accordingly from 2, 1, 0.5 to 0 based on the observation study of the neighbourhood. Terminology from most walkable to least walkable will however follow the same percentages as described in the prevalent walkability indices. After a comprehensive matrix is framed, the walk score will be assessed through a universal formula. The above factors for the selected location for the sample survey will be recorded. The walk score will be generated based on a Likert scale and the neighbourhood will be termed walkable based on the cumulative score generated as follows:

- Highly walkable: 160 to 200

- Moderate walkability: 120 to 159

- Low walkability: 80 to 119

- Poor walkability: 40 to 79

- Extremely uncomfortable to walk: <39

To assess the walkability of Bengaluru city, research was undertaken to apply this walkability index to 2 wards in the city, selected through purposive sampling. These included 1 ward with high population density and poor pedestrian infrastructure (Shivaji Nagar Ward) and 1 ward with medium population density and moderate pedestrian infrastructure (Radhakrishna Temple ward). The tabulation below shows the walkability index calculated for both the wards as a matrix of all the factors.

WALKABILITY INDEX – SHIVAJINAGAR

Table 1. Walkability Index: Shivaji Nagar

WALKABILITY INDEX- SHIVAJI NAGAR					
		SCALE			
NEIGHBOURHOOD CHARACTERISTICS	ALWAYS	MOSTLY	SELDOM	NEVER	NOT APPLICABLE
	2 POINTS	1 POINT	0.5 POINTS	0 POINT	0 POINT
A. PHYSICAL FACTORS					
I LANDUSE & AMENITIES					
1 Is there a School within 1.0 km radius ?	2				
2 Is there a Medical facility within 1.0 km radius ?	2				
3 Is there a Grocery/ Convenience store within 1.0 km radius ?	2				
4 Is there a Bus stop/ Metro station/ para transit hub within 1.0 km radius ?	2				
II STREET GEOMETRY					
1 Are the roads meandering ?		1			
2 Are the roads on a flat topography?		1			
3 Are the streets continous?		1			
III STREET INTERSECTIONS					
1 Is there a well marked pedestrain crossing at all intersections?			0.5		
2 Is there an overhead bridge or an underpass at major intersections?			0.5		
3 Are there proper medians to separate the traffic?			0.5		
4 Are there Refuge Islands in High Traffic zones?			0.5		
5 Are the signal lights in good working condition?		1			
6 Are there traffic calming measures such as speed bumps, etc?			0.5		
7 Is the signal crossing time enough?		1			
B. PSYCHOLOGICAL FACTORS					
I LEGIBILITY					
1 Is it easy to find your way around as a local in the city?		1			
2 Are there urban landmarks present?		1			
II SAFETY					
1 Do motorists stop for pedestrians?			0.5		
2 Do you feel safe while crossing busy roads?			0.5		
3 Do motorists stay away from foot paths?			0.5		
4 Do motorists drive within speed limits?			0.5		
5 Is the neighbourhood free of stray animals?			0.5		
III SECURITY					
1 Do tyou feel safe from any perceived threat or crime, while walking in your area?		1			
2 Do the facades of adjacent buildings have enough windows overlooking the street?	2				
3 Are the CCTV/ Traffic cameras in working condition?			0.5		
4 Do you have immediate access to public transport, in the event of any perceived threat?	2				
IV HUMAN SCALE					
1 Do the width of the roads correspond to aneighbourhood scale (and not a highway) ?	2				
2 Do you feel connected to your neighbourhood?		1			
V IMAGEABILITY					
1 Do you feel familiar with the existing streetscape and buildings in your locality?		1			
2 Do you feel nostalgic when you walk in your streets?		1			
VI AESTHETIC SURROUNDINGS					
1 Do you feel appreciative of your beautiful surroundings when you walk?			0.5		
2 Are the surroundings interesting?			0.5		
VII TIME DISTANCE FOCI					
1 Is there visibility to your destination?			0.5		
2 Do you feel familiar with the route to your daily and popular destinations?	2				
3 Is the actual time and perceived time to your destination the same?		1			
TOTAL	8	7	4.5	0	0
TOTAL (OUT OF 40)			19.5		
C. SOCIAL FACTORS					
I LIVELY					
1 Are there street vendors for daily produce?	2				
2 Are there any street activities?		1			
II HETEROGENOUS					
1 Does the walking population include diverse age groups?	2				
2 Does the walking population include different genders?	2				
3 Does the walking population include diverse ethnic groups?	2				
4 Does the walking population include diverse income groups?	2				
III INCLUSIVE					
1 Does the walking population include ethnic and gender minorities?	2				
2 Does the walking population include differently abled ?	2				
IV SENSE OF PLACE					
1 Do you feel an integral part of the city?	2				
2 Do you feel like like calling your neighbourhood your own?		1			
V COMMUNITY FEELING					
1 Is there a religious place of your chosen faith within 1.0 km radius ?		1			
2 Is there a place for congregation for a common activity (community hall/ library) within 1.0 km radius ?		1			
VI ECONOMY OF SCALE					
1 Is the para transit/ public transpoort affordable?		1			
2 Do you have to pay for parking?		1			
3 Is daily produce more affordable on road side carts?	2				
TOTAL	18	6	0		
TOTAL (OUT OF 30)			24		

D. ENVIRONMENTAL FACTORS						
I	CLEAN ENVIRONMENT					
1	Is the foot path free of garbage?			0.5		
2	Are the drains (if any) near the footpath covered?			0.5		
3	Are there proper manhole covers?			0.5		
II	POLLUTION FREE					
1	Does the air feel pure for breathing?			0.5		
2	Does the air feel dust free?			0.5		
3	Does the air feel free of any undesirable odours?			0.5		
4	Is the traffic decibel level bearable?			0.5		
5	Is the air free of allergens?			0.5		
III	NATURAL SETTING					
1	Is there any natural scenery (lake/ open spaces/ mountains/ etc.;) along your walking route?				0	
2	Do you feel invigorated walking near this natural setting?				0	
3	Is the natural setting well maintained?				0	
IV	PLEASANT CLIMATE					
1	Does the temperature feel comfortable to walk throughout the year?	2				
2	With minimal weather gear (umbrella/ raincoat/ etc) , are you able to access your neighbourhood areas ?	2				
V	PUBLIC HEALTH ENGINEERING					
1	Are the storm water drains well maintained ?			0.5		
2	Is there an efficient garbage seggregation and coollection system in your neighbourhood?			0.5		
	TOTAL	4	0	5	0	0
	TOTAL (OUT OF 30)			9		

E. POLICY SUPPORT						
I	FUNDING AND RESOURCES					
1	Is there a municipal budget allocation for developing neighbourhood streets?	2	1			
2	Is there a municipal budget allocation for developing neighbourhood parks?	2				
3	Are there any NGOs working towards funding for maintenance of streets?	2				
II	ADHERENCE TO URBAN DESIGN GUIDELINES					
1	As per standards, is there adequate width for foot path?			0.5		
2	Is the open area ratio maintained?			0.5		
3	Does the CMP include pedestrian concerns?	2				
III	PEDESTRIAN SAFETY LAWS					
1	Are there any laws to protect pedestrian rights?	2				
2	Do pedestrian accidents get suffciently compensated?		1			
3	Are there any laws against drunken driving?	2				
4	Are there any laws agains jay walking?	2				
IV	PEDESTRIAN RIGHTS					
1	Do pedestrians have right of way in busy intersections?		1			
2	Are there any one way streets?		1			
V	CIVIC AWARENESS					
1	Is your neighbourhood community responsible towards maintaining cleanliness as a civic duty?		1			
2	Are there any local help groups or local support groups that organising street cleaning or maintenance activities?	2				
3	Are periodic city cleaning/ urban environment enhancemet drives carried out?		1			
	TOTAL	16	5	1	0	0
	TOTAL (OUT OF 30)			22		
	TOTAL SCORE (OUT OF 200)			107		

RADHAKRISHNA TEMPLE WARD

Table 2. Walkability Index: Radhakrishna Temple ward

WALKABILITY INDEX- RADHAKRISHNA TEMPLE WARD					
		SCALE			
NEIGHBOURHOOD CHARACTERISTICS	ALWAYS	MOSTLY	SELDOM	NEVER	NOT APPLICABLE
	2 POINTS	1 POINT	0.5 POINTS	0 POINT	0 POINT
A. PHYSICAL FACTORS					
I LANDUSE & AMENITIES					
1 Is there a School within 1.0 km radius ?	2				
2 Is there a Medical facility within 1.0 km radius ?	2				
3 Is there a Grocery/ Convenience store within 1.0 km radius ?	2				
4 Is there a Bus stop/ Metro station/ para transit hub within 1.0 km radius ?	2				
II STREET GEOMETRY					
1 Are the roads meandering ?		1			
2 Are the roads on a flat topography?		1			
3 Are the streets continuous?	2				
III STREET INTERSECTIONS					
1 Is there a well marked pedestrain crossing at all intersections?	2				
2 Is there an overhead bridge or an underpass at major intersections?	2				
3 Are there proper medians to separate the traffic?	2				
4 Are there Refuge Islands in High Traffic zones?		1			
5 Are the signal lights in good working condition?	2				
6 Are there traffic calming measures such as speed bumps, etc?		1			
7 Is the signal crossing time enough?		1			

	IV	LANDSCAPE AND OPEN SPACES					
	1	Is there a Neighbourhood park within 1.0 km radius ?	2				
	2	Does the park have a walking or jogging track?	2				
	3	Does the park have a designated tot lot?	2				
	4	Is there provision for seating?	2				
	5	Are these areas shaded?		1			
	6	Are there adequate Public toilets?	2				
	7	Are there Shade trees along the pavement?		1			
	8	Are there planting strips that demarcate pedestrain and vehicular pathways?			0.5		
	9	Are there waiting areas or hangout zones near the side walks?			0.5		
	V	SIDEWALKS					
	1	Are there sidewalks along major roads and minor roads in your neighbourhood?	2				
	2	Are the sidewalks continuous and well maintained ?		1			
	3	Are they well lit ?		1			
	4	Are they wide enough for atleast 2 people to walk side by side?		1			
	5	Are the sidewalks free of any overhanging utilities?		1			
	6	Are the sidewalks free of obstacles?		1			
	7	Are there legible signages on the side walks?		1			
	8	Are the signs prominently placed?		1			
	9	Are the lights glare free?			0.5		
	10	Do they light up the sidewalks without any shadows?			0.5		
	VI	BUILDINGS					
	1	Do the Buildings on the side of the side walk provide shade?		1			
	2	Is the Building Façade on the side of the sidewalk open ?		1			
		TOTAL		30	16	2	0	0
		TOTAL (OUT OF 70)			48			

		B. PSYCHOLOGICAL FACTORS					
	I	LEGIBILITY					
	1	Is it easy to find your way around as a local in the city?		1			
	2	Are there urban landmarks present?		1			
	II	SAFETY					
	1	Do motorists stop for pedestrians?		1			
	2	Do you feel safe while crossing busy roads?		1			
	3	Do motorists stay away from foot paths?		1			
	4	Do motorists drive within speed limits?		1			
	5	Is the neighbourhood free of stray animals?			0.5		
	III	SECURITY					
	1	Do tyou feel safe from any perceived threat or crime, while walking in your area?		1			
	2	Do the facades of adjacent buildings have enough windows overlooking the street?	2				
	3	Are the CCTV/ Traffic cameras in working condition?	2				
	4	Do you have immediate access to public transport, in the event of any perceived threat?	2				
	IV	HUMAN SCALE					
	1	Do the width of the roads correspond to aneighbourhood scale (and not a highway) ?	2				
	2	Do you feel connected to your neighbourhood?		1			
	V	IMAGEABILITY					
	1	Do you feel familiar with the existing streetscape and buildings in your locality?		1			
	2	Do you feel nostalgic when you walk in your streets?		1			
	VI	AESTHETIC SURROUNDINGS					
	1	Do you feel appreciative of your beautiful surroundings when you walk?		1			
	2	Are the surroundings interesting?		1			
	VII	TIME DISTANCE FOCI					
	1	Is there visibility to your destination?		1			
	2	Do you feel familiar with the route to your daily and popular destinations?	2				
	3	Is the actual time and perceived time to your destination the same?		1			
		TOTAL		10	14	0.5	0	0
		TOTAL (OUT OF 40)			32.5			

		C. SOCIAL FACTORS				
	I	LIVELY				
	1	Are there street vendors for daily produce?	2			
	2	Are there any street activities?		1		
	II	HETEROGENOUS				
	1	Does the walking population include diverse age groups?	2			
	2	Does the walking population include different genders?	2			
	3	Does the walking population include diverse ethnic groups?	2			
	4	Does the walking population include diverse income groups?	2			
	III	INCLUSIVE				
	1	Does the walking population include ethnic and gender minorities?	2			
	2	Does the walking population include differently abled ?	2			
	IV	SENSE OF PLACE				
	1	Do you feel an integral part of the city?	2			
	2	Do you feel like like calling your neighbourhood your own?	2			
	V	COMMUNITY FEELING				
	1	Is there a religious place of your chosen faith within 1.0 km radius ?	2			
	2	Is there a place for congregation for a common activity (community hall/ library) within 1.0 km radius ?	2			
	VI	ECONOMY OF SCALE				
	1	Is the para transit/ public transpoort affordable?		1		
	2	Do you have to pay for parking?		1		
	3	Is daily produce more affordable on road side carts?	2			
		TOTAL		24	3	0
		TOTAL (OUT OF 30)			27	

D. ENVIRONMENTAL FACTORS

I	CLEAN ENVIRONMENT					
1	Is the foot path free of garbage?		1			
2	Are the drains (if any) near the footpath covered?	2				
3	Are there proper manhole covers?	2				
II	POLLUTION FREE					
1	Does the air feel pure for breathing?		1			
2	Does the air feel dust free?		1			
3	Does the air feel free of any undesirable odours?	2				
4	Is the traffic decibel level bearable?	2				
5	Is the air free of allergens?		1			
III	NATURAL SETTING					
1	Is there any natural scenery (lake/ open spaces/ mountains/ etc.;) along your walking route?				0	
2	Do you feel invigorated walking near this natural setting?				0	
3	Is the natural setting well maintained?				0	
IV	PLEASANT CLIMATE					
1	Does the temperature feel comfortable to walk throughout the year?	2				
2	With minimal weather gear (umbrella/ raincoat/ etc) , are you able to access your neighbourhood areas ?	2				
V	PUBLIC HEALTH ENGINEERING					
1	Are the storm water drains well maintained ?	2				
2	Is there an efficient garbage seggregation and coollection system in your neighbourhood?		1			
	TOTAL	14	5	0	0	0
	TOTAL (OUT OF 30)			19		

E. POLICY SUPPORT

I	FUNDING AND RESOURCES					
1	Is there a municipal budget allocation for developing neighbourhood streets?	2				
2	Is there a municipal budget allocation for developing neighbourhood parks?	2				
3	Are there any NGOs working towards funding for maintenance of streets?	2				
II	ADHERENCE TO URBAN DESIGN GUIDELINES					
1	As per standards, is there adequate width for foot path?		1			
2	Is the open area ratio maintained?		1			
3	Does the CMP include pedestrian concerns?	2				
III	PEDESTRIAN SAFETY LAWS					
1	Are there any laws to protect pedestrian rights?	2				
2	Do pedestrian accidents get suffciently compensated?		1			
3	Are there any laws against drunken driving?	2				
4	Are there any laws agains jay walking?	2				
IV	PEDESTRIAN RIGHTS					
1	Do pedestrians have right of way in busy intersections?		1			
2	Are there any one way streets?		1			
V	CIVIC AWARENESS					
1	Is your neighbourhood community responsible towards maintaining cleanliness as a civic duty?	2				
2	Are there any local help groups or local support groups that organising street cleaning or maintenance activities?	2				
3	Are periodic city cleaning/ urban environment enhancemet drives carried out?		1			
	TOTAL	18	6	0	0	0
	TOTAL (OUT OF 30)			24		
	TOTAL SCORE (OUT 0F 200)			150.5		

Result

Walkability Index for each of the wards was carried out and key issues with lowest scores were identified. The critical factors affecting walkability in each of the wards under different subheadings may be listed and analyzed as follows:

Table 3. Comparative analysis of the walkability index of the wards

WARD NAME:		SHIVAJINAGAR	RADHAKRISHNA TEMPLE
WARD NUMBER:		92	18
TOTAL SCORE (out of 200)		107	150.5
PHYSICAL FACTORS	Score (out of 70)	32.5	48
	REMARKS	Street intersections and sidewalk quality scored lowest in most of the parameters.	No hangout zones and no demarcation for pedestrians
PSYCHOLOGICAL FACTORS	Score (out of 40)	19.5	32.5
	REMARKS	Road safety, accident hazard, aesthetic quality need to be addressed.	Road safety is an issue. Aesthetic quality addressed only in HIG areas
SOCIAL FACTORS	Score (out of 30)	24	27
	REMARKS	Heterogenous and inclusive community seem to exist.	Social factors scored high
ENVIRONMENTAL FACTORS	Score (out of 30)	9	19
	REMARKS	Unclean surroundings, pollution and public health engineering scored least	Clean surroundings only in HIG areas
POLICY SUPPORT	Score (out of 30)	22	24
	REMARKS	Adherence to Urban design guidelines and pedestrian safety laws scored least.	Budget allotted seems to be spent on HIG areas only

Among the factors related to the physical, psychological, social, environmental and policy support factors, the following have been identified as most critical as they scored lowest in all wards:

1.   Street intersections and sidewalk quality scored lowest in most of the parameters.

2.   Road safety, accident hazard, aesthetic quality needs to be addressed.

3.   Unclean surroundings, pollution and public health engineering scored least.

4.   Adherence to Urban design guidelines and pedestrian safety laws scored least.

Conclusion

Studies show that improving walkability in cities can provide sustainable transport solutions to rapidly growing urban settlements. However, walkability is influenced by multidimensional factors and in order to enhance walkability in cities, it is essential to identify critical factors that need to be addressed as a priority. A walkability index that has been formulated incorporating all the influencing factors was formulated and 2 wards in Bengaluru city were assessed through the same. The research showed that this walkability index has held identify issues such as sidewalk quality, road safety, unclean surroundings and civic awareness as the key issues, that need to be addressed at the earliest. Such an endeavour can help transform Bengaluru city into a more pedestrian friendly urban environment.

References

[1]   Accelerating Bangalore's Mobility Transition. (2020). Insights from the Bangalore Urban Mobility Lab.

[2]   Ahmed, K.G. and Alipour, S.M.H. (2021). More dense but less walkable: The impact of macro scale walkability indicators on recent designs of Emirati neighborhoods. City, Territory and Architecture. 8:12

[3]   Alves, F., Cruz,S., Ribeiro,A., Silva,A.B., Martins, J.andCunha,I. (2020).Walkability Index for Elderly Health: A Proposal. Sustainability.

[4]   Anne VernezMoudon, C. L., Allen D. Cheadle, Cheza Garvin, D. J., Thomas L. Schmid,& Robert D. Weathers, a. L. L. (2006). Operational Definitions of Walkable Neighborhood: Theoretical and Empirical Insights. Journal of Physical Activity and Health 2006, 3, Suppl 1, S99-S117.

[5]   Almashaqbeh, H. A., Ramachandran, K. K., Guha, S. K., Basha, M., & Nomani, M. Z. M. (2024). The Advancement of Using Internet of Things in Blockchain Applications for Creating Sustainable Environment in the Real Word Scenario. Computer Science Engineering and Emerging Technologies: Proceedings of ICCS 2022, 278

[6]   Baobeid, A., Koc, M. and Al-Ghamdi, S.G. (2021). Walkability and its relationships with health, sustainability and livability: Elements of physical environment and evaluation frameworks. Frontiers in built environment. Volume 7

[7]   Ben-Joseph, E. (nd). Residential Street Standards &Neighborhood Traffic Control: A Survey of Cities' Practices and Public Officials' Attitudes.

[8]   Bharucha, J.P. (2017). An investigation into the walkability problem in Indian cities. Safer Communities. 16(2), pp.77-86

[9]   Bird, M., Datta, G.D., Chinerman, D., Kakinami, L., Mathieu, M., Henderson, M. and Barnett, T.A. (2022). Associations of neighborhood walkability with moderate to vigorous physical activity: An application of compositional data analysis comparing compositional and non-compositional approaches. International Journal of behavioral nutrition and physical activity 19: 55

[10]   BleˇciˊC.I., Congiu.T., Fancello.G., Trunfio. G.A. (2020). Planning and Design Support Tools for Walkability: A Guide for Urban Analysts. Sustainability 2020, 12.

[11]   Chidambaranath, P. and Bitossi,T. (2017). Walkability in Urban India Designing Cool pockets for pedestrian thermal comfort.Transsolar Academy. Final Project Summary

[12]   Choi, E. (2012).Walkability as an Urban Design Problem: Understanding the activity of walking in the urban environment. Licentiate Thesis, KTH Royal Institute of Technology Architecture and the Built Environment School of Architecture, Stockholm Sweden

[13]   Comi, A., Cirianni, F.M.M. and Luongo, A.S. (2022). A sustainable approach for planning of urban pedestrian routes and footpaths in a pandemic scenario. Journal of land use mobility and environment : The city challenges and external agents. methods tools and best practices. TeMA 1 (2022)125-140

[14]   Comprehensive Mobility Plan for Bengaluru (2019) Infrastructure Development Corporation (Karnataka) limited

[15]   Dawra, A., Ramachandran, K. K., Mohanty, D., Gowrabhathini, J., Goswami, B., Ross, D. S., & Mahabub Basha, S. (2024). 12Enhancing Business

Development, Ethics, and Governance with the Adoption of Distributed Systems. Meta Heuristic Algorithms for Advanced Distributed Systems, 193-209.

[16] Dobesova, Z., and Palacký, T.K. (2012). Walkability Index in the Urban Planning: A Case Study in Olomouc City. Advances in Spatial Planning. University in Olomouc Czech Republic Chapter. DOI: 10.5772/36587 ·

[17] Ewing, R., & Cervero, R. (2010). Travel and the Built Environment. Journal of the American Planning Association, 76(3), 265-294. doi:10.1080/01944361003766766

[18] Ewing, R., Park, K. (2020) Basic Quantitative Research Methods for Urban Planners. ISBN: 978-0-367-34325-5

[19] Fan, P.Y., Chun, P.C., Mijic, A., Tan, L.M., Liu, S.M. and Yeteman, O. (2022). A framework to evaluate the accessibility visibility and intelligibility off green- blue spaces related to pedestrian movement. Urban forestry and Urban greening 69.

[20] Favreau J.M.,and Kalsron, J. (2022). What are intersections for pedestrian users. Agile: GIScience series, 3,4 2022

[21] Forsyth, A. (2015). What is a walkable place? The walkability debate in urban design. Urban Design International 20, no.4, 274-292.

[22] Groat, L.N. and Wang, D. Architectural Research Methods (2013). Architectural Research Methods. ISBN: 978-0-470-90855-6

[23] Guidelines for planning & implementation of pedestrian infrastructure (2014). Directorate of Urban Land Transport.

[24] Han, H., Nguyen, T. V. T., &Sahito, N. (2019). Sidewalk Zoom-In: A Spatial–Temporal Negotiation and Self-Organization within a Sociable Space. Sustainability, 11(22). doi:10.3390/su11226241

[25] How walkable is your neighbourhood? Health by Design-Creating built environments to foster Healthy Living. An Alliance for Health promotion initiative.

[26] Jardim and de Castro Nito (2022). Walkability indicators in the aftermath of the COVID-19 pandemic: A systematic review. Sustainability 2022, 14, 10933

[27] Janani, S., Sivarathinabala, M., Anand, R., Ahamad, S., Usmani, M. A., & Basha, S. M. (2023, February). Machine Learning Analysis on Predicting Credit Card Forgery. In International Conference On Innovative Computing And Communication (pp. 137-148). Singapore: Springer Nature Singapore.

[28] Joh. K., Nguyen.M.T. and Boarnet. M.G. (2012). Can Built and Social Environmental Factors Encourage Walking among Individuals with Negative WalkingAttitudes? Journal of Planning Education and Research, 32(2), 219–236

[29] Joshi, R., Joseph, Y., Patel, K., Darji, V. (2017). Transit -Oriented Development: Lessons from Indian Experiences. Working Paper 36 : Urban Equity (CUE) CEPT University

[30] Kabade, B., Nagaraja, K.T., Ramanathan, S., Veeraraghavan, A. and Reashma, P.S. Improvement to pedestrian walkway facilities to enhance pedestrian safety initiatives in India. (2018). World Academy of Science, Engineering and Technology. International Journal of transport and vehicle engineering. Vol :12, No. 3

[31] Kalyan, N. B., Ahmad, K., Rahi, F., Shelke, C., & Basha, S. M. (2023, September). Application of Internet of Things and Machine learning in improving supply chain financial risk management System. In 2023 IEEE 2nd International Conference on Industrial Electronics: Developments & Applications (ICIDeA) (pp. 211-216). IEEE.

[32] Koohsari, M.J., Owen,N., Cerin, E., Giles-Corti,B. and Sugiyama,T. (2016) . Walkability and walking for transport: Characterizing the built environment using space syntax. International Journal of Behavioral Nutrition and Physical Activity. DOI 10.1186/s12966-016-0448-9

[33] Kotharkar, R., Bahadure, P.and Sarda, N. (2014) Measuring Compact Urban Form: A Case of Nagpur City, India. Sustainability.6, 4246-4272

[34] Kotti, J., Ganesh, C. N., Naveenan, R. V., Gorde, S. G., Basha, M., Pramanik, S., & Gupta, A. (2024). Utilizing Big Data Technology for Online Financial Risk Management. In Artificial Intelligence Approaches to Sustainable Accounting (pp. 135-148). IGI Global.

[35] Krambeck H.V. (2006).The Global Walkability Index. Submitted to the Department of Urban Studies and Planning and the Department of Civil and Environmental Engineering in Partial Fulfilment of the Requirements for the Degrees of Master in City Planning and Master of Science in

Transportation at the Massachusetts Institute of Technology, Massachusetts.

[36] Krier, L. The Walkable City. Walkability and Mixed-use: Making valuable and healthy communities. The Prince's Foundation.

[37] Krishna, S. H., Vijayanand, N., Suneetha, A., Basha, S. M., Sekhar, S. C., & Saranya, A. (2022, December). Artificial Intelligence Application for Effective Customer Relationship Management. In 2022 5th International Conference on Contemporary Computing and Informatics (IC3I) (pp. 2019-2023). IEEE.

[38] Lam M.L., Wang, Z., Vaartjes, I., Karssenberg, D., Ettema , D., Helbich, M., Timmermans, E.J., Frank, L.D., den Braver , N.R., Wagtendonk, A.J., Beulens, J.W.J. and Lakerveld, J.(2022). Development of and objectively measured walkability index for the Netherlands. International Journal of behavioral nutrition and physical activity. 19:50

[39] Lee.S., Talen.B. (2104). Measuring Walkability: A Note on Auditing Methods. Journal of Urban Design.19(3), 368–388.

[40] Loukaitou-Sideris, A., Liggett, R., & Sung, H. G. (2007). Death on the Crosswalk: A Study of Pedestrian-Automobile Collisions in Los Angeles. Journal of Planning Education and Research, 26(3), 338-351. doi:10.1177/0739456x06297008

[41] Maghelal, P.K., Capp, C.J. (2011). Walkability: A review of Existing Pedestrian Indices. URISA Journal. 23 (2).

[42] Martino, N., Girling, C. and Trigueiro, E. (2019). Exploring Urban Walkability Models and Pedestrian Movement Trends in a Vancouver Neighbourhood. Sim AUD 2019 April 07-09 Atlanta, Georgia

[43] Meyer, D.M. (2016). Transportation planning handbook. Institute of Transportation Engineers.

[44] Minhas, P. and Poddar, A. (2017). Walkability index by global Walkability Index method. International Research Journal of Engineering and Technology.4(7)

[45] Motomura, M.C.N., Fontoura, L. C. da, Kanashiro, M. (2018). Understanding walkable areas: applicability and analysis of a walkability index in a Brazilian city. AmbienteConstruído,PortoAlegre,v. 18,n. 4,p. 413-425,out./dez.2018.ISSN 1678-8621 Associação Nacional de Tecnologia do AmbienteConstruído.

http://dx.doi.org/10.1590/s1678-86212018000400313

[46] Mouzas, A.J., Iannou, B and Fokaides, P. (2022). The establishment of an intermodal walkability index for use in car oriented urban environments: the case of Nicosia. Frontiers in environmental science. 10: 3389

[47] National Walkability Index Methodology and User Guide. (2021). United States Environmental Protection Agency.

[48] New York City Department of Transportation. (2010). The New York City pedestrian safety study and action plan.

[49] NMT design proposal (2013). Directorate of Urban Land Transport

[50] Pedestrian facilities guidebook: Incorporating pedestrians into Washington's transportation system.

[51] Pojani, D., & Stead, D. (Eds.). (2017). The Urban Transport Crisis in Emerging Economies.

[52] Pucher, J., Korattyswaropam, N., Mittal, N., &Ittyerah, N. (2005). Urban transport crisis in India. Transport Policy, 12(3), 185-198. doi: 10.1016/j.tranpol.2005.02.008

[53] Ralph, K. M., Smart, M. J., Noland, R. B., Wang, S., & Cintron, L. (2020). Is it really too far? Overestimating walk time and distance reduces walking. Transportation Research Part F: Traffic Psychology and Behaviour, 74, 522-535. doi: 10.1016/j.trf.2020.09.009

[54] Rashid, M., Akram, W., and Tarry, S.R. (2017)The Study of Walkability Index: A Case Study atJalandhar City in India. International Journal of Engineering Research & Technology (IJERT). 6 (4)

[55] Reagean, A. (2018). Measuring walkability in Gainesville's urban areas: a case study of Millhopper and Downtown. Thesis presented to the Graduate School of the University of Florida in partial fulfillment of the requirements for the degree of Master of Arts in Urban and Regional Planning.

[56] Ribeiro, A.I. and Hoffimann, E . (2018). Development of a Neighbourhood Walkability Index for Porto Metropolitan Area. How Strongly Is Walkability Associated with Walking for Transport? International Journal of Environmental Research and Public Health. .

[57] Schlossberg, M., Rowell, J., Amos, D., & Sanford, K. (2013). Rethinking Streets: Evidence based

guide to 25 complete street transformations: University of Oregon.

[58] Sharma, B. R. (2008). Road traffic injuries: a major global public health crisis. Public Health, 122(12), 1399-1406. doi: 10.1016/j.puhe.2008.06.009

[59] Shaik, M. (2023). Impact of artificial intelligence on marketing. East Asian Journal of Multidisciplinary Research, 2(3), 993-1004.

[60] Singhal, M. (2019). Towards Pedestrian- Friendly Neighbourhoods. ISBN: 978-93-83419-79-1

[61] Soltani, A., Hossein Pour, M., Sholeh, M. &Zare, P. (2018). The development of a walkability audit. Based on Iranian cities pedestrian environment. TeMA - Journal of Land Use, Mobility and Environment · Special Issue 1: 95-108. DOI: 10.6092/1970-9870/546

[62] Singh, A., Krishna, S. H., Tadamarla, A., Gupta, S., Mane, A., & Basha, M. (2023, December). Design and Implementation of Blockchain Based Technology for Supply Chain Quality Management: Challenges and Opportunities. In 2023 4th International Conference on Computation, Automation and Knowledge Management (ICCAKM) (pp. 01-06). IEEE.

[63] Southworth. M. (2005). Designing the Walkable City. Journal of Urban Planning and Development. 131(4): 246-257

[64] Southworth.M. Reclaiming the walkable cities. Frameworks

[65] Telega,A., Telega, I. and Bieda, A. Measuring Walkability with GIS—Methods Overview and New Approach Proposal. Sustainability2020. DOI:10.3390/su12187360

[66] The National Urban Transport Policy (2006). Government of India

[67] The Pedestrian Environmental Quality Index (PEQI): An assessment of the physical condition of streets and intersections DRAFT Methods Report .(2008). Program on Health, Equity and Sustainability Environmental Health Section. San Francisco Department of Public Health.

[68] Thwaites, K., Porta, S., Romice, O. and Greaves, M. (2007). Urban sustainability through environmental design. ISBN 10: 0-415-39547-X

[69] Tumlin, J. (2012). Sustainable Transport planning. ISBN: 978-0-470-54093-0

[70] UN-Habitat. (2013). Streets as Public Spaces and Drivers of Urban Prosperity.

[71] US Department of Transportation. (2004). A Review of Pedestrian Safety Research in the United States and Abroad.

[72] U.S. Department of Transportation. Pedestrian and Bicycle Information Center. Walkability Checklist: How walkable is your community? Partnership for a Walkable America.

[73] Vanderslice, E. (2001). The Art of Walking: Seven Improvisations on a Theme. Australia: Walking the 21st Century.

[74] Yang, J., Deng, W., Wang, J., Li, Q., & Wang, Z. (2006). Modeling pedestrians' road crossing behavior in traffic system micro-simulation in China. Transportation Research Part A: Policy and Practice, 40(3), 280-290. doi: 10.1016/j.tra.2005.08.001

[75] Zaleckis, K., Chmielewski, S., Kamicaityte, J., Grazuleviciute-Vileniske, I. and Lipinska, H. (2022). Walkability compass- a space syntax solution for comparative studies. Sustainability 2022, 14, 2033

[76] Zhou, R., Horrey, W. J., & Yu, R. (2009). The effect of conformity tendency on pedestrians' road-crossing intentions in China: an application of the theory of planned behavior. Accid Anal Prev, 41(3), 491-497. doi:10.1016/j.aap.2009.01.007

[77] Zieff, S. G., Musselman, E. A., Sarmiento, O. L., Gonzalez, S. A., Aguilar-Farias, N., Winter, S. J., King, A. C. (2018). Talking the Walk: Perceptions of Neighborhood Characteristics from Users of Open Streets Programs in Latin America and the USA. J Urban Health, 95(6), 899-912. doi:10.1007/s11524-018-0262