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Research Article

The Overall Diversity in Commuters' FLMC Perception Around Esplanade Metro Station Using Factor Analysis

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ABSTRACT

First and last-mile connectivity (FLMC) links the primary public transportation networks and the start and end of an individual's trip. Sustainable Development Goals have emphasized inclusivity through SDGs 3, 5, 9, 10, 11, and 13. Several researches focus on the need for FLMC in different scenarios. This paper aims to identify the variations of responses across parameters for appraising FLMC with respect to gender and age, classify the associated indicators, and finally optimize the indicators in a defined parameter for the study area. Parameters and associated indicators are determined by conducting a systematic literature review and authenticated by the commuters through a primary survey. The interpretation of the data received is analyzed through exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to demonstrate the final weight of the parameters. Thus, an optimized inclusive outline for identifying and analyzing the parameters for a specific area in a developing context with similar socio-economic status is generated.

Keywords: FLMC; EFA; CFA; Gender; Age.

1. Introduction

In the context of urban India, FLMC refers to the connectivity between the trip origin and destination with the nearest public mass transit station points.

The transportation sector is essential to India's economic growth and social development. However, the diverse requirements of its population, particularly concerning the gender and age of the commuters, often remain disregarded. A comprehensive analysis of studies from several pieces of literature reveals the significance of integrating gender and age contemplations into transportation planning and policy-making to enable inclusivity, safety, and accessibility for all sectors of commuters.

Gender-based transportation needs refer to safety concerns, travel patterns and accessibility, affordability and economic constraints, and associated infrastructure and design responsible for inclusivity for all commuters. This can be further elaborated by stating that safety remains a dominant concern for gender-based communication, especially for women utilizing public transportation in India. Several incidents like harassment and violence discourage women from using the common mass public services, often leading to limited mobility and inadequate access to education, employment, and social opportunities in several cases (Anand & Tiwari, 2006; Tiwari, 2022). Women are frequently observed to exhibit distinct travel behaviors compared to men, categorized by trip chaining (taking multiple trips to reach points A to B), combining numerous errands in a single journey, and traveling during off-peak hours. This pattern is primarily due to their dual roles in professional and domestic spheres. Research also indicates that women conceivably use public transportation for short and frequent trips, especially those associated with household responsibilities, such as shopping, child care, and elder care (R. Joshi, 2013). The transportation infrastructure design often overlooks the precise needs of the women commuters. Such issues can be characterized by inadequate lighting, poorly maintained facilities, and lack of amenities like clean restrooms and walkways, ultimately discouraging women from using public transport (Development Bank, 2023; Leather et al., 2011).

Age-based transportation needs highlight the necessity for geriatric-driven policies in India. India's elderly population is growing rapidly due to advances in medical research and advancements, which necessitate age-friendly transportation solutions. Aged adults often experience mobility challenges due to physical limitations, sensory impairments, and health issues. A study highlights that the lack of accessible transportation options leads to social isolation and decreased quality of life among the elderly (Jahangir et al., 2024; Majumdar et al., 2021). Inclusive design is not exclusively age-related; it also necessitates considering the transportation needs of commuters with disabilities, especially when they are old adults.

Incorporating gender and age deliberations while planning for India's transportation is not merely an instance of equity but also improves the overall competence and efficacy of the transportation system. India can move

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towards a more inclusive and sustainable transportation future by addressing the specific requirements of women and the elderly. Thus, the need to undertake this study focusing on FLMC from the Metro Stations/ Mass Rapid Transit System (MRTS) in India's developing scenario based on specific commuters' needs is undeniable.
The authors trust that similar studies are limited and raise the need for an optimized outline to be a prerequisite for FLMC planning in developing countries like India.

2. Literature Review

The transportation sector plays a vital role in economic and social development, and ensuring inclusivity in mobility is essential for sustainable urban planning. Transportation systems in India often ignore the acceptance to accommodate the specific needs of different demographic groups, particularly concerning gender and age.
The literature review is demonstrated by categorizing it into two sections: Listing the parameters and the associated indicators to be considered for the study and the tools and techniques used for the mentioned set of studies.

2.1 FLMC Parameters and the Associated Indicators

FLMC parameters are assessed over FLMC verticals. FLMC verticals are the assisted facilities that assist in transporting to and from the MRTS and the destinations and origin, respectively. They are categorized under four verticals, namely, walking, Non-Motorized Transit (NMT), Multimodal Integration (MMI), and Intermediate Public Transportation (IPT). The observed output has been the assimilation and structuring of the data obtained from literature in the Indian and non-Indian contexts with similar socio-economic or geographical preferences resembling the study undertaken, as indicated in Table 1.

Table 1 Parameters and Associated Indicators to be applied for the study

Sl. No.	Parameter	Indicator	FLMC Vertical	References
01	**Accessibility (Physical)**	1.1 Ease of access from the main road to the walking/ cycling pathway – *curb height/ramp/grade-separated walkway/tactile flooring*	Walk, NMT	(Baobeid et al., 2021; Dion B et al., 2015; Grigolon et al., 2017; Krenn et al., 2015; Leather et al., 2011b; Patel & Patel, 2020; Saelens et al., 2003; United Nations, 2015)
		1.2 Natural terrain condition suitability – *plain surface/ sloped/semi–sloped/ steep/ slippery/ likewise*	Walk, NMT	
		1.3 Distance from MRTS station to parking/ shared mode/ bus stops/ IPT – *distance to and from the parking facility or bicycle-shared points*	Walk, NMT	
		1.4 Number of road crossings between bus stops/ IPT stops stations – *the importance of the barrierless connectivity to and from the MRTS to the next mode for accessing FLMC*	MMI, IPT	
		1.5 Continuity of walkway/ bicycle track – *an uninterrupted pathway for a particular/ specified stretch*	Walk, NMT, MMI, IPT	
		1.6 Adequacy of width of pedestrian/cycling way – *clear width for walking/ cycling without any hindrance during peak demand*	Walk, NMT, MMI, IPT	
		1.7 Encroachment by vending/ similar activities/ parking – *obstructive to the clear width of walking/ cycling*	Walk, NMT, MMI, IPT	
02	**Attractivity and Comfort (desirable)**	2.1 Assisted Street furniture at suitable locations – *ensuring comfort and convenience along with the visual element in the ways of walking/ cycling*	Walk, NMT, MMI, IPT	(Acharjee & Sarkar, 2021; Arellana et al., 2020;

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Sl. No.	Parameter	Indicator	FLMC Vertical	References
		2.2 The character of the abutting-built form creating pleasant views/ vistas – *enabling and attracting users to walk and cycle in the area*	Walk, NMT	Lakhotia et al., 2020; Patel & Patel, 2020; Sheshadri Nayak, 2013; Wibowo et al., 2015)
		2.3 Presence of commercial and recreational activity in the place without hindering commuters – *to ensure eyes on the street, eliminating discomfort by users, especially females and seniors*	Walk, NMT	
		2.4 Presence of natural landscape as a visual element – *use of any existing trees/ water bodies as an element of attraction and comfort for the users*	Walk, NMT	
		2.5 Presence of trees and vegetation as a shade/ vista - *creating visual balance and comfort in the summer/ sun*	Walk, NMT, MMI, IPT	
		2.6 Paving materials encouraging walking and cycling – *ensuring convenience to walk/ cycle, non-skid, not broken, tactile flooring, and likewise*	Walk, NMT	
		2.7 Presence of shading device (natural/ artificial) in the walkway/ cycle track/ waiting area – *to act as a barrier during the scorching sun/ rain*	Walk, NMT, MMI, IPT	
		2.8 Presence of essential public amenities in the vicinity/ terminus area – *like public toilets, drinking water facilities*	Walk, NMT, MMI, IPT	
03	**Availability of essential support infrastructure**	3.1 Availability of travel modes at the required frequency and Level of Service (LoS) – *readiness of modes like bus/ tram/ cab/ shuttle/ to the required direction/ zone*	MMI, IPT	(Amirtham et al., 2015; Nag et al., 2020; Patel & Patel, 2020)
		3.2 Availability of shared cycle facility/ parking in the MRTS zone – *enabling required options to the users for assessing the FLMC*	NMT	
		3.3 Availability of information/signage to and from the MRTS station and indicating the location map of the vicinity – *assisting in reaching the essential services without loss of time and resource*	Walk, NMT, MMI, IPT	
		3.4 Availability of ticket counter/inquiry/ unified payment system – *assisting to board any suitable mode available without interruption*	MMI, IPT	
		3.5 Availability of IT infrastructure - *Wi-Fi facility, charging stations, ATM, and likewise*	MMI, IPT	
		3.6 Availability of fare and real-time information on modes – *enabling the users to decide on the mode and time management*	MMI, IPT	
		3.7 Availability of inclusive parking/ bays/ boarding/ dropping points – *assisting the different types of users of the spaces to access without hesitation*	MMI, IPT	
04	**Environmental Suitability**	4.1 Noise quotient of the micro-region – *affecting the walking/ cycling users*	Walk, NMT	

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Sl. No.	Parameter	Indicator	FLMC Vertical	References
		4.2 Air quality of the microclimate – *suitable for waiting/ accessing the area*	Walk, NMT	(ITDP, 2025; Tin Tin et al., 2012)
		4.3 Prevalent microclimatic conditions affecting commuters – *rain/ heat/ extreme temperatures/ stormy/* likewise	Walk, NMT	
		4.4 Cleanliness of the pedestrian walkway/ cycling track – *ensuring health status through solid waste management of the area/ pathways*	Walk, NMT	
05	**Safety and Security**	5.1 Presence of abutting-built form/ land use during several hours of the day – *ensuring typology of roadside activities and determining the sense of security on the street*	Walk, NMT, MMI, IPT	(Acharjee & Sarkar, 2021; Adinarayana & Mir, 2020; Archer, 2005; Arellana et al., 2020; Avinash et al., 2019; Bivina et al., 2019, 2020; Jamei et al., 2021; Joo & Oh, 2013; Kumar et al., 2011; Lakhotia et al., 2020; Mittal N, 2010; Patel & Patel, 2020; Replogle Michael, 1992; Sheshadri Nayak, 2013; Wibowo et al., 2015)
		5.2 Presence of designated separated lanes for designated users – *separate lanes/ stretch for separate users (walkways for pedestrians/ cycling tracks for cyclists, roadway for vehicles)*	Walk, NMT, MMI, IPT	
		5.3 Presence of commercial and recreational activity in the place to ensure certain footfall – *ensuring the utility of the way and eyes on the street*	Walk, NMT, MMI, IPT	
		5.4 Presence of natural/ artificial surveillance to ensure perceived safety – *presence of guards/ police at the junctions, installation of CCTV, likewise*	Walk, NMT, MMI, IPT	
		5.5 Traffic speed and volume at the crossings/ junctions and the number of crossings – *presence of zebra crossing/ signals/ subways/ walkable over bridges*	Walk, NMT, MMI, IPT	
		5.6 Use of bollards and railings to ensure the designated space for different users – *if the designated lanes are on the same plane*	Walk, NMT, MMI, IPT	
		5.7 Visual connectivity ensuring the visible range to certain distances – *clear view of the stretch of waking and cycling way to ensure the safety and security of the users*	Walk, NMT, MMI, IPT	
		5.8 Presence of lights during the night hours – *to eliminate any negative actions (robbery, physical harm) and ensuring the safety and security of users*	Walk, NMT, MMI, IPT	

2.2 Tools and Techniques

Several tools and techniques have been used for transportation studies related to the gender and age of commuters while assessing the FLMC. Combining these analytical tools and techniques assists in creating a comprehensive understanding of how to conduct research on gender and age-based transportation needs in India. Integrating qualitative and quantitative methods confirms that transportation policies address the explicit challenges of various demographic groups, leading to more inclusive and sustainable urban transport systems. Table 2 describes the various tools and techniques that are used in these studies:

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Table 2 Tools and Techniques as reported in several literatures

Sl. No.	Tools and Techniques	Studies	References
1	Survey-Based Studies	To assess transportation needs	(Bhattacharyya & Mitra, 2013; Kumar Jain Principal & Kumar Jain, 2015; Replogle Michael, 1992)
2	Geographic Information Systems (GIS)	To understand mobility patterns	(Bivina et al., 2019; Lam et al., 2022; Nogueira, 2012; Tsiompras & Photis, 2017)
3	Statistical and Econometric Models	Multinomial Logit Models: Commuters' Perception Affecting Travel Behaviour. Structural Equation Modeling (SEM): To examine complex interrelationships. Time Series Analysis: To forecast the data series.	(Chauhan et al., 2022; Fresly & Panjaitan, 2015; Kilani et al., 2022; Rajina Rahiman & Naseer, 2022; Sheshadri Nayak, 2013)
4	Big Data and Smart Mobility Analytics	Mobile Phone Data and GPS Tracking: To assess real-time insights into travel patterns. Smart Card Transactions: To examine the demographic variation in transportation. Artificial Intelligence (AI) and Machine Learning (ML): To predict the efficiency of the projected scenario.	(Fresly & Panjaitan, 2015; oğuz, 2019; States Environmental Protection Agency, 2021)
5	Qualitative Research Approaches	Focus Group Discussions: Group-based studies. Narrative Analysis: Story-telling techniques. Participatory GIS: Communities mapping the mobility needs/ demands.	(Kilani et al., 2022; Sumenri Thongam & Y. Arunkumar Singh, 2024; Sunil Gavaskar & Swetha, 2022)

3. Methodological Framework and Data Collection

The methodological framework is categorized into seven steps, and the schematic representation is organized in Figure 1. The data collection is done in two phases: A pilot survey (to determine the appropriateness of the random sampling technique and the correlations of the attributes/ indicators/ parameters) and a complete survey (to determine the study objectives and outcomes). In the pilot survey, a mere sample size of 30 was considered to determine the collected sample's reliability. In this step, Cronbach's Alpha determines the internal consistency. It ranges between 0 and 1; any point greater than 0.7 is considered acceptable for further exploration (Shrestha, 2021). After the Cronbach's Alpha test is satisfied, a complete survey with a sample size of 200 is conducted for further analysis. The further analysis involves Principal Component Analysis (PCA), which requires a sample size ranging between 136 and 170, and we have considered a sample size of 200.

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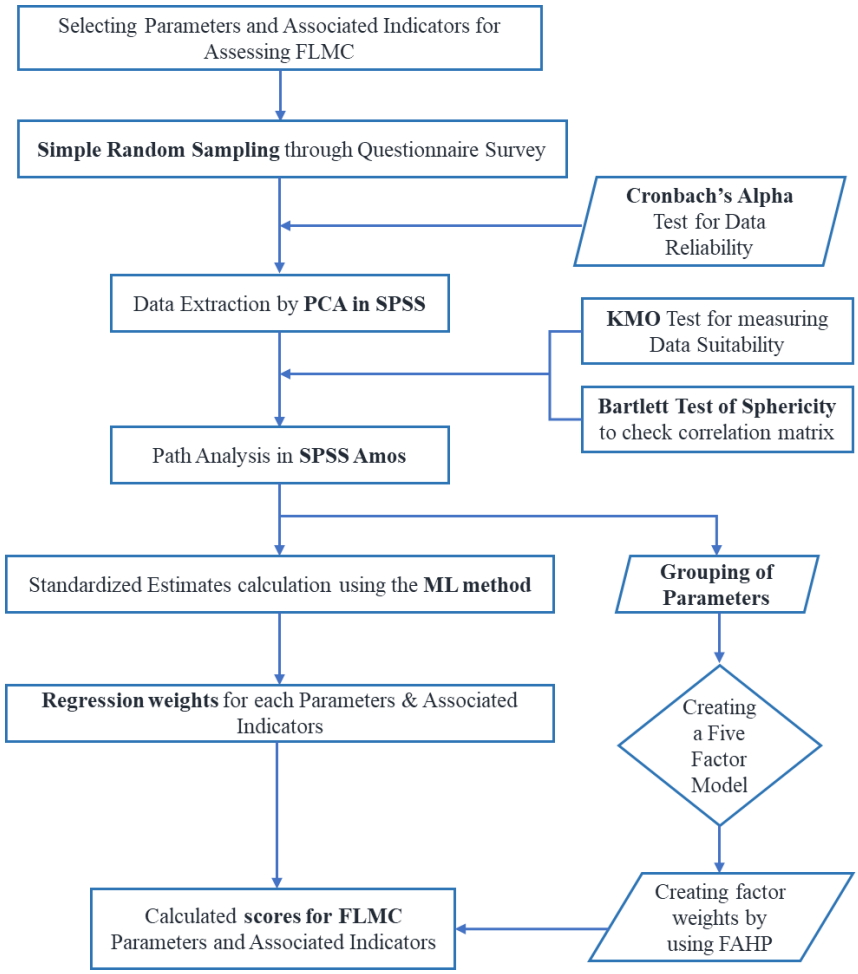

Figure 1 Analytical Framework Representing the Methodology of the Study

SPSS: Statistical Package for the Social Sciences; KMO: Kaiser-Meyer-Olkin; ML: Maximum Likelihood.

4. Study Area and Context

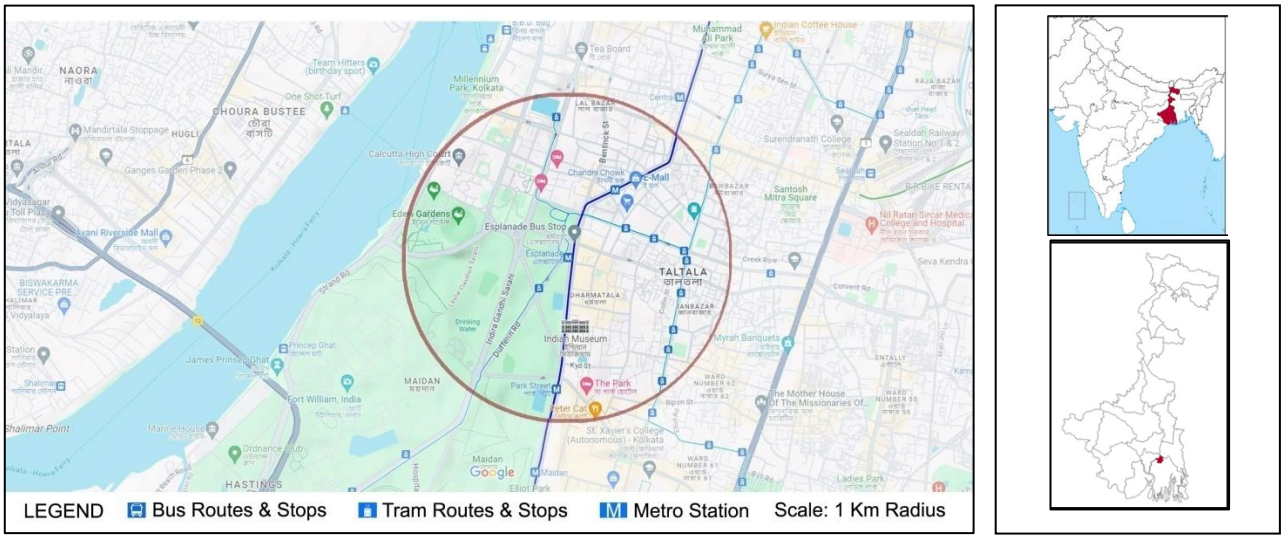

Figure 2a) Delineating the Study Area in a Circle of 1 Kilometre Radius, b) Locating the Study Area in India and the state of West Bengal

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The expanse within a one-kilometer radius from the existing station gate (marked M Esplanade in Figure 2a) of the Esplanade metro-rail station (Kolkata) delineates the study area for the current investigation. The rationale for the study area selection is that the Esplanade metro station is the only intersection of the North-South alignment of Kolkata Metrorail, providing service for the last three decades, and the East-West corridor has been put into operation recently (ISGF, 2017). The daily footfall of Esplanade metro station recorded in 2017 (pre-COVID-19 scenario) was about 85,000 (Japan International Cooperation Agency, 2018) and was about 61608 on 17.03.2024 (Ministry of Railways, 2024) after the partial commencement of the East-West metro line. It is assumed to increase significantly with the commencement of the entire operation of the East-West metro corridor. The existing North-South MRTS corridor connects the old city (in the north) and new city extensions (in the south), and the new East-West corridor connects from Howrah Maidan, passing through one of the major suburban railway terminals (Howrah) to the Esplanade Station and will extend till Sector V, Saltlake (which is the new administrative zone of the metropolitan region). With intrastate and interstate bus depots, one tram depot, retail markets, offices, institutions, organized open spaces, and a host of landmark buildings, Esplanade is a part of the Business District in the central part of Kolkata, which is the largest metro city in the eastern part of India. It has a significant potential for emerging as a multimodal hub. The potential commuters of this zone are varied. Since the area is an interchanging zone with diverse commercial activity happening throughout the day, thus there is a high probability of a variety in the population in the area, ultimately satisfying the criteria of the study's focus or aim.

Besides the metro rail, several modes currently operate in this area, including 2-wheelers, 4-wheelers, buses, bicycles, trams, para-transits, and shuttle cabs. This aligns with the study's focus on a specific gender using multiple modes reported in the literature to be confirmed and validated for the study area. The passenger flow in the Esplanade station indicates two peaks in a typical weekday – morning peak (09:30 – 11:00 a.m.) and evening peak (06:30 - 07:30 p.m.), while an overall peak time of the day is noted in the evening—the peak hour demand accounts for approximately 15% of the day's volume. The weekday peak hour volume averages about 7819 passengers, with 43% outgoing and 57% incomings. This implies that around 125 passengers leave or enter the station every minute during peak hours, seeking FLMC. Analysis of the incoming and outgoing station access mode composition in the Esplanade station (Table 3) reveals the FLMC demand in the station area. Whereas, accessing the trip diary, 38.4% of passengers choose paratransit, 15.3% choose buses, 7.9% choose bicycles, 7.7% choose other motorized vehicles before using the metro rail, followed by 30.7% walking from their origin. 23.3% of passengers choose paratransit, 15.3% choose buses, 23% choose other motorized vehicles before using the metro rail, followed by 38.4% walking to their destination. The composition of gender and age distribution of the trip diary is described in Tables 4 and 5.

Table 3 Incoming and outgoing station access modes composition in Esplanade Station (Primary Survey, 2022).

	Motorized vehicle (%)				**Non-motorized vehicle (%)**		
	Bus	**Tram**	**Cab service (Ola/Uber)**	**Taxi**	**Rickshaw**	**Bicycle**	**Pedestrian**
Incoming	56	2	12	9	N.A.	N.A.	21
Outgoing	44	0	7	16	N.A.	N.A.	33

Table 4 Modal Split from the trip diary of the outgoing commuters

Modes	**% Distribution**	**Male** (In Years)		**Female** (in Years)		**Gender & Age Distribution**
		18-39	**40-65**	**18-39**	**40-65**	
Paratransit	38.40%	48	32	52	68	**Modal Split in percentage %**
Bus	15.30%	53	58	47	42	
Bicycle	7.90%	97	100	3	0	
Others	7.70%	49	43	51	57	
Walk	30.70%	57	64	43	36	

Table 5 Modal Split from the trip diary of the incoming commuters

Modes	**% Distribution**	**Male** (In Years)		**Female** (in Years)		**Gender & Age Distribution**
		18-39	**40-65**	**18-39**	**40-65**	
Paratransit	23.30%	46	38	54	62	

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Bus	15.30%	44	53	56	47	**Modal Split in percentage %**
Bicycle	-	-	-	-	-	
Others	23.00%	54	45	46	55	
Walk	38.40%	17	52	83	48	

5. Analysis and Results

The respondents are requested to rate each associated indicator on a five-point Likert scale (Batterton & Hale, 2017; A. Joshi et al., 2015) based on its importance in the respective FLMC parameter using the following set of linguistic variables comprising five elements, namely 'very high' (5), 'high' (4), 'medium' (3), 'low' (2), and 'negligible' (1). The respondents are categorized as the daily commuters representing the working-age population and selected based on simple random sampling.
After collecting 30 samples, the reliability of the data is confirmed using Cronbach's Alpha. The data set for male and female respondents are checked simultaneously to understand the associative and dissociative factors.

Reliability Statistics

Cronbach's Alpha	N of Items
.721	34

Reliability Statistics

Cronbach's Alpha	N of Items
.787	34

Figure 3 Cronbach's Alpha for Males and Females

Cronbach's Alpha for the Male and Female datasets are 0.721 and 0.787 and, thus, can be considered acceptable to be used in the study for further exploration towards the main focus (Shrestha, 2021).
It is observed that the dataset is suitable for the study, and thus, the survey continued to a sample size of 200. The total sample was assessed with the Kaiser-Meyer-Olkin (KMO) test (Reddy & Kulshrestha, 2019; Shrestha, 2021) for the sampling adequacy in the Statistical Package for Social Sciences (SPSS) statistical tool. Similarly, Barlett's test of Sphericity (Reddy & Kulshrestha, 2019; Shrestha, 2021) was computed to assess the appropriateness of the dataset to perform PCA. PCA is considered the suitable technique for dimension reduction after conducting the KMO and Bartlett's test of sphericity with values of greater than 0.5 and less than 0.05, respectively.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.603
Bartlett's Test of Sphericity	Approx. Chi-Square	2604.657
	df	561
	Sig.	.000

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.645
Bartlett's Test of Sphericity	Approx. Chi-Square	2660.016
	df	561
	Sig.	.000

Figure 4 KMO and Bartlett's Test for Males and Females

It is observed that the captured dataset is suitable for PCA as it satisfies the KMO and Bartlett's Test. The dataset is applied to perform Exploratory Factor Analysis, where indicators in the dataset are detected and assessed through factor analysis and, based on the Eigenvalues greater than 1 in the scree plot, are categorized under the identified parameter with factor loadings greater than 0.7. The factor loadings of less than 0.7 are eliminated, and the elimination is based on the sample size (Field & Alex's Solutions Task, 2014). Further, this dataset is calibrated on Amos 23 to obtain the weights of the indicators categorized under the five-factor parameters.

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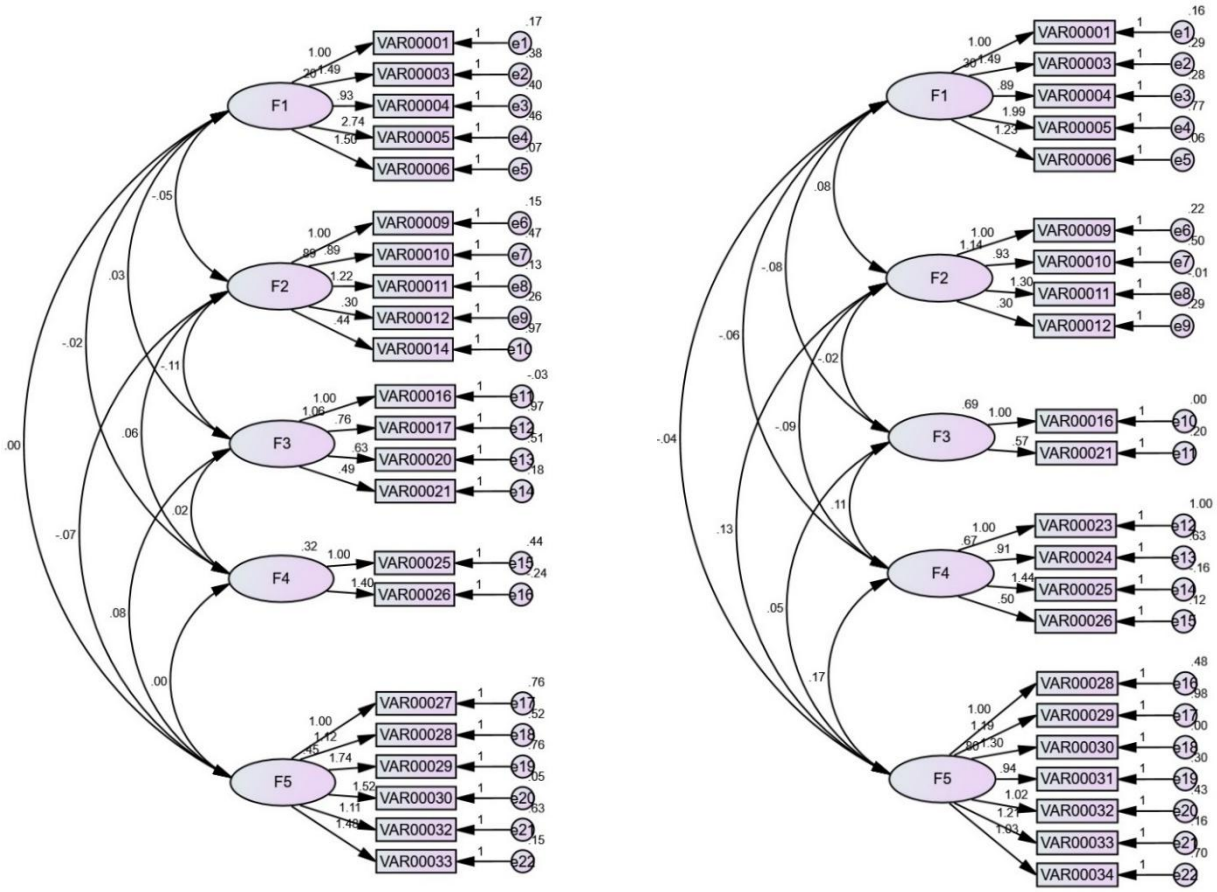

Figure 5 Path Analysis Diagram with factor loadings for Males and Females

The five factors are Accessibility, Attractivity and Comfort, Availability, Environment Suitability, and Safety and Security, as named F1, F2, F3, F4, and F5, respectively, in Figure 5. These calibrated weights are standardized using the Multi-Criteria Decision Making (MCDM) weighted sum method with the factor loading obtained while running Exploratory Factor Loadings (Table 6).

Table 6 Factor Loadings for the Indicators as obtained through PCA

Sl. No.	Parameter	Indicator	Factor Loading		FLMC Vertical
			Male	Female	
01	Accessibility (Physical)	1.1 Ease of access from the main road to the walking/ cycling pathway	**0.17**	**0.16**	Walk, NMT
		1.3 Distance from MRTS station to parking/ shared mode/ bus stops/ IPT	**0.38**	**0.29**	Walk, NMT
		1.4 Number of road crossings between bus stops/ IPT	**0.40**	**0.28**	MMI, IPT
		1.5 Continuity of walkway/ bicycle track	**0.46**	**0.77**	Walk, NMT, MMI, IPT
		1.6 Adequacy of width of pedestrian/ cycling way	**0.07**	**0.06**	Walk, NMT, MMI, IPT
02	Attractivity and Comfort (desirable)	2.2 The character of the abutting-built form creating pleasant views/ vistas	**0.15**	**0.22**	Walk, NMT

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Sl. No.	Parameter	Indicator	Factor Loading		FLMC Vertical
			Male	Female	
		2.3 Presence of commercial and recreational activity in the place without hindering commuters	**0.47**	**0.50**	Walk, NMT
		2.4 Presence of natural landscape as a visual element	**0.13**	**0.01**	Walk, NMT
		2.5 Presence of trees and vegetation as a shade/ vista	**0.26**	**0.29**	Walk, NMT, MMI, IPT
		2.7 Presence of shading device (natural/ artificial) in the walkway/ cycle track/ waiting area	**0.97**	**-**	Walk, NMT, MMI, IPT
03	**Availability of essential support infrastructure**	3.2 Availability of shared cycle facility/ parking in the MRTS zone	**- 0.03**	**0.01**	NMT
		3.3 Availability of information/signage to and from the MRTS station and indicating the location map of the vicinity	**0.97**	**-**	Walk, NMT, MMI, IPT
		3.5 Availability of IT infrastructure	**0.51**	**-**	MMI, IPT
		3.6 Availability of fare and real-time information on modes	**0.18**	**0.20**	MMI, IPT
04	**Environmental Suitability**	4.1 Noise quotient of the micro-region	**-**	**1.0**	Walk, NMT
		4.2 Air quality of the microclimate	**-**	**0.63**	Walk, NMT
		4.3 Prevalent microclimatic conditions affecting commuters	**0.44**	**0.16**	Walk, NMT
		4.4 Cleanliness of the pedestrian walkway/ cycling track	**0.24**	**0.12**	Walk, NMT
05	**Safety and Security**	5.1 Presence of abutting-built form/ land use during several hours of the day	**0.76**	**-**	Walk, NMT, MMI, IPT
		5.2 Presence of designated separated lanes for designated users	**0.52**	**0.48**	Walk, NMT, MMI, IPT
		5.3 Presence of commercial and recreational activity in the place to ensure certain footfall	**0.76**	**0.98**	Walk, NMT, MMI, IPT
		5.4 Presence of natural/ artificial surveillance to ensure perceived safety	**0.05**	**0.01**	Walk, NMT, MMI, IPT
		5.5 Traffic speed and volume at the crossings/ junctions and the number of crossings	**-**	**0.30**	Walk, NMT, MMI, IPT
		5.6 Use of bollards and railings to ensure the designated space for different users	**0.63**	**0.43**	Walk, NMT, MMI, IPT
		5.7 Visual connectivity ensuring the look away to certain distances	**0.15**	**0.16**	Walk, NMT, MMI, IPT
		5.8 Presence of lights during the night hours	**-**	**0.70**	Walk, NMT, MMI, IPT

Parameter weights are assessed using FAHP by the stakeholders from each category. Accordingly, the Parameter scores are assessed through the following formulas:

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Indicator Score = Squared Factor Loading / ∑ Factor Loadings (Indicators) n
Parameter Score = ∑ Indicator Score (Parameter) m X Criteria Weight (FAHP) m
Thus, the summarized data is given in Table 7.

Table 7 Summarized data indicating the Criteria weights and Indicator Score

Parameter	Criteria weight (using FAHP)	Squared Factor Loadings		Indicator Score	
		Male	Female	Male	Female
Accessibility (Physical)	0.267	0.03	0.03	0.0056	0.0055
		0.14	0.08	0.0281	0.0182
		0.16	0.08	0.0312	0.0169
		0.21	0.59	0.0412	0.1281
		0.00	0.00	0.0010	0.0008
Attractivity and Comfort (desirable)	0.064	0.02	0.05	0.0044	0.0105
		0.22	0.25	0.0431	0.0540
		0.02	0.00	0.0033	0.0000
		0.07	0.08	0.0132	0.0182
		0.94	-	0.1834	-
Availability of essential support infrastructure	0.166	0.001	0.0001	0.0002	0.00002
		0.94	-	0.1834	-
		0.26	-	0.0507	-
		0.03	0.04	0.0063	0.0086
		-	1.00	-	0.2160
Environmental Suitability	0.101	-	0.40	-	0.0857
		0.19	0.03	0.0377	0.0055
		0.06	0.01	0.0112	0.0031
		0.58		0.1126	0.0000
Safety and Security	0.402	0.27	0.23	0.0527	0.0498
		0.58	0.96	0.1126	0.2074
		0.00	0.00	0.0005	0.0000
			0.09	0.0000	0.0194
		0.40	0.18	0.0774	0.0399

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Parameter	Criteria weight (using FAHP)	Squared Factor Loadings		Indicator Score	
		Male	Female	Male	Female
		-	0.03	-	0.0055
		-	0.49	-	0.1058

Therefore, the overall weights for Male and female indicators and parameters are listed in Table 8.

Table 8 Calculated Parameter and Overall Scores for Males and Females in the study area

Parameter	Parameter Score		Normalized Parameter Score	
	Male	Female	Male	Female
Accessibility (Physical)	0.029	0.045	**12.32**	**17.72**
Attractivity and Comfort (desirable)	0.016	0.005	**6.81**	**2.07**
Availability of essential support infrastructure	0.040	0.001	**17.19**	**0.56**
Environmental Suitability	0.005	0.031	**2.13**	**12.28**
Safety and Security	0.143	0.172	**61.55**	**67.37**

6. Discussion

It can be observed from the analysis that the preferences of male and female respondents vary across the parameters. The preference of males is characterized highest in Safety and Security, followed by Availability, Accessibility, Attractivity and Comfort, and Environment Suitability, whereas the preference of females is characterized highest in Safety and Security, followed by Accessibility, Environment Suitability, Attractivity and Comfort, and Availability. It is observed through responses that women and older commuters are sensitive towards environment suitability compared to availability. It can also be substantiated by their time of travel and purpose of travel apart from the work trips. It is observed that the concentration of the female and older population is generally higher to almost 3 – 4 times that of the male population during the off-peak hours accessing the study area for commercial activities and for boarding the travel mode for long-distance travel from the multimodal hub. Even we can observe that women commuters prioritize the presence of lights at night hours and visual connectivity to a certain distance to ensure perceived safety; women are also observed to be sensitive towards the air quality particulars and noise, which is not observed in the case of males. It is also observed that several other indicators categorized under each parameter behave differently for the different genders, whereas when a comparison across the age group is made, it is also observed that the older population responses tend to be similar to the female responses. Thus, an inclusive response must include both scenarios.

7. Conclusion

This paper presents a data-driven methodological framework to evaluate the weights of the FLMC parameters, an amalgamation of the evidential features of the infrastructure (indicators) and the specific features of the different types of user's perceptions of it. The sample comprises a similar proportion of commuters in the overall population; thus, it can be characterized as the most accurate illustration of simple random sampling

in the study area. The use of FL through FAHP has been fruitful in achieving crisp results affirming the global weights of the parameters.
The study outcome indicates that the commuter preference of the parameters and indicators is sensitive to the commuter's gender and age. Similarly, it can be stated that any optimized indicator indicates its relevance in the area. The finalization of the parameters indicates the intrinsic demand for infrastructure in the area, thus creating a scope of sustainable development approaches for the physical planners.
The study area has been presented as a supportive illustration of the proficiencies of the methodological framework. Thus, the policy implication indicates that it can be considered a tool for investigating the weights of the applicable indicators in any given context. The list of parameters and indicators is confirmed based on the need for a developing scenario structure with similar socio-economic status and urban morphology; it might vary in the case of other contextual demands. The perception of the commuter is dependent on the localized scenario; thus, it impacts the final output. It can also be stated that several pieces of literature focus explicitly on the parameters relating to a particular FLMC vertical (walk, NMT, MMI, and IPT). This study enables the grouping of the FLMC verticals, which can be further explored in future studies and have comprehensive practical implications in any developing context (specifically India).

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Informed Consent
The survey participants have been informed about the use of the data.

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References

[1] Acharjee, A., & Sarkar, P. P. (2021). Influence of attitude on bicycle users and non-users: A case study of Agartala City, India. *Transportation Research Part D: Transport and Environment*, *97*, 102905. https://doi.org/10.1016/j.trd.2021.102905
[2] Adinarayana, B., & Mir, M. S. (2020). Development of Bicycle Safety Index Models for Safety of Bicycle Flow at 3-Legged Junctions on Urban Roads under Mixed Traffic Conditions. *Transportation Research Procedia*, *48*, 1227–1243. https://doi.org/10.1016/j.trpro.2020.08.145
[3] Amirtham, L. R., Horrison, E., & Rajkumar, S. (2015). *Impact of urban morphology on Microclimatic conditions and outdoor thermal comfort-A study in mixed residential neighbourhood of Chennai, India*.
[4] Anand, A., & Tiwari, G. (2006). A gendered perspective of the shelter-transport-livelihood link: The case of poor women in Delhi. *Transport Reviews*, *26*(1), 63–80. https://doi.org/10.1080/01441640500175615
[5] Archer, J. (2005). *Indicators for traffic safety assessment and prediction and their application in micro-simulation modelling: A study of urban and suburban intersections The Greater Stockholm area defined by accident occurrence (from STRADA)*. KTH.
[6] Arellana, J., Saltarín, M., Larrañaga, A. M., González, V. I., & Henao, C. A. (2020). Developing an urban bikeability index for different types of cyclists as a tool to prioritise bicycle infrastructure investments. *Transportation Research Part A: Policy and Practice*, *139*, 310–334. https://doi.org/10.1016/j.tra.2020.07.010
[7] Avinash, C., Jiten, S., Arkatkar, S., Gaurang, J., & Manoranjan, P. (2019). Evaluation of pedestrian safety margin at mid-block crosswalks in India. *Safety Science*, *119*, 188–198. https://doi.org/10.1016/j.ssci.2018.12.009
[8] Baobeid, A., Koç, M., & Al-Ghamdi, S. G. (2021). Walkability and Its Relationships With Health, Sustainability, and Livability: Elements of Physical Environment and Evaluation Frameworks. In *Frontiers in Built Environment* (Vol. 7). Frontiers Media S.A. https://doi.org/10.3389/fbuil.2021.721218
[9] Batterton, K. A., & Hale, K. N. (2017). Military Operations Research Society The Likert Scale What It Is and How To Use It. *Source: Phalanx*, *50*(2), 32–39. https://doi.org/10.2307/26296382
[10] Bhattacharyya, D. B., & Mitra, S. (2013). Making Siliguri a Walkable City. *Procedia - Social and Behavioral Sciences*, *96*, 2737–2744. https://doi.org/10.1016/j.sbspro.2013.08.307

[11] Bivina, G. R., Gupta, A., & Parida, M. (2019). Influence of microscale environmental factors on perceived walk accessibility to metro stations. *Transportation Research Part D: Transport and Environment*, *67*, 142–155. https://doi.org/10.1016/j.trd.2018.11.007
[12] Bivina, G. R., Gupta, A., & Parida, M. (2020). Walk Accessibility to Metro Stations: An analysis based on Meso- or Micro-scale Built Environment Factors. *Sustainable Cities and Society*, *55*. https://doi.org/10.1016/j.scs.2020.102047
[13] Chauhan, V., Gupta, A., & Parida, M. (2022). Evaluating service quality of Multimodal Transportation Hub (MMTH) in Delhi, India: A gender-based perspective. *Case Studies on Transport Policy*, *10*(2), 1234–1248. https://doi.org/10.1016/j.cstp.2022.04.007
[14] Development Bank, A. (2023). *Enhancing Gender Equality in Infrastructure Development: Theories of Change, Indicators, and Sector Strategies*.
[15] Dion B, Pineda V, & Ginnerup S. (2015). *TOOLKIT: KEY INDICATORS OF ACCESSIBILITY*.
[16] Field, A. P., & Alex's Solutions Task, S. (2014). *DISCOVERING STATISTICS USING SPSS Chapter 17: Exploratory factor analysis*.
[17] Fresly, N., & Panjaitan, W. (2015). *Title Understanding Intermediate Public Transport (IPT) as the Mode of Choice in Jakarta, Indonesia*.
[18] Grigolon, A. B., Van Maarseveen, M. F. A. M., Brussel, M., Hartanto, K., Grigolon, A., & Maarseveen, M. V. (2017). *Developing a bikeability index in the context of transit-oriented development (TOD). Developing a bikeability index in the context of transit-oriented development (TOD)*. https://www.researchgate.net/publication/318792598
[19] ISGF. (2017). *Report_Implementation-Plan-for-Electrification-of-Public-Transportation-in-Kolkata-1*.
[20] ITDP. (2025). *To Combat Extreme Heat, Let's Invest in Better Walking and Cycling Networks - Institute for Transportation and Development Policy*. https://itdp.org/2025/01/29/extreme-heat-invest-in-walking-and-cycling-stmagazine-36/
[21] Jahangir, S., Bailey, A., Hasan, M. U., & Hossain, S. (2024). "We do not go outside, though We want to": Unequal Access to Public Transport and Transport-Related Social Exclusion of Older Adults in Dhaka, Bangladesh. *Journal of Applied Gerontology*, *43*(8), 1165–1176. https://doi.org/10.1177/07334648241231156
[22] Jamei, E., Ahmadi, K., Chau, H. W., Seyedmahmoudian, M., Horan, B., & Stojcevski, A. (2021). Urban design and walkability: Lessons learnt from iranian traditional cities. In *Sustainability (Switzerland)* (Vol. 13, Issue 10). MDPI AG. https://doi.org/10.3390/su13105731
[23] Japan International Cooperation Agency. (2018). *Report on Current Situation Survey at Esplanade Station (Topographical Survey)*.
[24] Joo, S., & Oh, C. (2013). A novel method to monitor bicycling environments. *Transportation Research Part A: Policy and Practice*, *54*, 1–13. https://doi.org/10.1016/j.tra.2013.07.001
[25] Joshi, A., Kale, S., Chandel, S., & Pal, D. (2015). Likert Scale: Explored and Explained. *British Journal of Applied Science & Technology*, *7*(4), 396–403. https://doi.org/10.9734/bjast/2015/14975
[26] Joshi, R. (2013). *PROMOTING LOW-CARBON TRANSPORT IN INDIA Low-Carbon Mobility in India and the Challenges of Social Inclusion Bus Rapid Transit (BRT) Case Studies in India*.
[27] Kilani, M., Diop, N., & De Wolf, D. (2022). A Multimodal Transport Model to Evaluate Transport Policies in the North of France. *Sustainability (Switzerland)*, *14*(3). https://doi.org/10.3390/su14031535
[28] Krenn, P. J., Oja, P., & Titze, S. (2015). Development of a Bikeability Index to Assess the Bicycle-Friendliness of Urban Environments. *Open Journal of Civil Engineering*, *05*(04), 451–459. https://doi.org/10.4236/ojce.2015.54045
[29] Kumar Jain Principal, R., & Kumar Jain, R. (2015). NON-MOTORIZED TRANSPORT AND SUSTAINABLE URBAN PLANNING: A CASE STUDY OF PUNE METROPOLITAN REGION. *Article ID: IJCIET_06_07_009 Journal of Civil Engineering and Technology*, *6*(7), 69–79. http://www.iaeme.com/IJCIET/index.asp69http://www.iaeme.com/IJCIET/issues.asp?JTypeIJCIET&VType=6&IType=7http://www.iaeme.com/IJCIET/issues.asp?JTypeIJCIET&VType=6&IType=7http://www.iaeme.com/IJCIET/index.asp70
[30] Kumar, P., Kulkarni, S. Y., & Parida, M. (2011). Security perceptions of Delhi commuters at Metro-bus interchange in multi modal perspective. *Journal of Transportation Security*, *4*(4), 295–307. https://doi.org/10.1007/s12198-011-0072-5
[31] Lakhotia, S., Lassarre, S., Rao, K. R., & Tiwari, G. (2020). Pedestrian accessibility and safety around bus stops in Delhi. *IATSS Research*, *44*(1), 55–66. https://doi.org/10.1016/j.iatssr.2019.07.001
[32] Lam, T. M., 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., & Lakerveld, J. (2022). Development of

an objectively measured walkability index for the Netherlands. *International Journal of Behavioral Nutrition and Physical Activity*, *19*(1). https://doi.org/10.1186/s12966-022-01270-8

[33] Leather, J., Fabian, H., Gota, S., & Mejia, A. (2011). *Walkability and Pedestrian Facilities in Asian Cities State and Issues ADB Sustainable Development Working Paper Series*. www.adb.org/poverty

[34] Majumdar, B. B., Jayakumar, M., Sahu, P. K., & Potoglou, D. (2021). Identification of key determinants of travel satisfaction for developing policy instrument to improve quality of life: An analysis of commuting in Delhi. *Transport Policy*, *110*, 281–292. https://doi.org/10.1016/j.tranpol.2021.06.012

[35] Ministry of Railways. (2024). *Metro Rail, Kolkata*. https://mtp.indianrailways.gov.in/view_detail.jsp?lang=0&dcd=3944&id=0,4,268

[36] Mittal N. (2010). Pedestrian safety at urban intersections in Delhi, India. *Indian Journal of Transport Management*, *34*(2), 111–125.

[37] Nag, D., Bhaduri, E., Kumar, G. P., & Goswami, A. K. (2020). Assessment of relationships between user satisfaction, physical environment, and user behaviour in pedestrian infrastructure. *Transportation Research Procedia*, *48*, 2343–2363. https://doi.org/10.1016/j.trpro.2020.08.284

[38] Nogueira, Helena. (2012). *Healthy Places, Healthy People Living Environment Factors Associated With Physical Activity in Urban Areas*. IntechOpen.

[39] oğuz, melis. (2019). Paratransit Sistemlerde Güvenlik Algısı: İstanbul'da Minibüs Örneği. *Journal of Planning*. https://doi.org/10.14744/planlama.2019.29981

[40] Patel, S. J., & Patel, C. R. (2020). A stakeholders perspective on improving barriers in implementation of public bicycle sharing system (PBSS). *Transportation Research Part A: Policy and Practice*, *138*, 353–366. https://doi.org/10.1016/j.tra.2020.06.007

[41] Rajina Rahiman, V., & Naseer, M. A. (2022). Walkability to public transport: prioritization of parameters for walkability assessment in the urban areas of Kerala, India. *European Transport - Trasporti Europei*, *89*. https://doi.org/10.48295/ET.2022.89.3

[42] Reddy, L. S., & Kulshrestha, P. (2019). Performing the KMO and Bartlett's Test for Factors Estimating the Warehouse Efficiency, Inventory and Customer Contentment for E-retail Supply Chain. *International Journal for Research in Engineering Application & Management (IJREAM)*, *05*, 2454–9150. https://doi.org/10.35291/2454-9150.2019.0531

[43] Replogle Michael. (1992). *WTP ol1 6 2, Non-Motorized Vehicles in Asian Cities*.

[44] Saelens, B. E., Sallis, J. F., & Frank, L. D. (2003). *Environmental Correlates of Walking and Cycling: Findings From the Transportation, Urban Design, and Planning Literatures*. http://www.cnu.org

[45] Sheshadri Nayak, M. (2013). *BICYCLE LEVEL OF SERVICE IN URBAN INDIAN CONTEXT*.

[46] Shrestha, N. (2021). Factor Analysis as a Tool for Survey Analysis. *American Journal of Applied Mathematics and Statistics*, *9*(1), 4–11. https://doi.org/10.12691/ajams-9-1-2

[47] States Environmental Protection Agency, U. (2021). *National Walkability Index: Methodology and User Guide, June 2021*. www.epa.gov/smartgrowth

[48] Sumenri Thongam, & Y. Arunkumar Singh. (2024). Customer Satisfaction Index (CSI) and Importance Performance Analysis (IPA) Methods for Intermediate Public Transport System in Imphal, Manipur. *International Research Journal on Advanced Engineering Hub (IRJAEH)*, *2*(03), 416–424. https://doi.org/10.47392/irjaeh.2024.0061

[49] Sunil Gavaskar, J., & Swetha, S. (2022). Multimodal Transport Solutions for Smart Cities. *Technoarete Transactions on Advances in Computer Applications*, *1*(1).

[50] Tin Tin, S., Woodward, A., Robinson, E., & Ameratunga, S. (2012). Temporal, seasonal and weather effects on cycle volume: An ecological study. *Environmental Health: A Global Access Science Source*, *11*(1). https://doi.org/10.1186/1476-069X-11-12

[51] Tiwari, G. (2022). *Walking in Indian Cities – A Daily Agony for Millions - The Hindu Centre*. https://www.thehinducentre.com/the-arena/current-issues/walking-in-indian-cities-a-daily-agony-for-millions/article65551959.ece

[52] Tsiompras, A. B., & Photis, Y. N. (2017). What matters when it comes to "walk and the city"? Defining a weighted GIS-based walkability index. *Transportation Research Procedia*, *24*, 523–530. https://doi.org/10.1016/j.trpro.2017.06.001

[53] United Nations. (2015). *Sustainable Development Goals*. https://sdgs.un.org/goals

[54] Wibowo, S. S., Tanan, N., & Tinumbia C, N. (2015). Walkability Measures for City Area in Indonesia (Case Study of Bandung). In *Journal of the Eastern Asia Society for Transportation Studies* (Vol. 11).