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Evaluating factors Influencing Active Transportation in Developing Metropolises

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Abstract

Urban transportation is facing challenges of heavy traffic of two-wheeler, cars, and trucks due to motorized transport. In order to sustain the environment as well as stop environmental degradation, active mobility was introduced as sustainable urban transportation. It indicates any mode of transport that involves physical activity, e.g., cycling, walking, skateboarding, skiing, etc. The study aims to prioritize the factors influencing active mode choices using the FAHP (fuzzy analytical hierarchy process) model, which incorporates expert opinions. To verify the robustness of results, a sensitivity analysis is also performed on the results. The study highlights that major performance indicators belonged to the infrastructure category, with network continuity, width of track, and separate tracks amongst the most influencing factors. To promote active mode choices, it is essential for decision makers and planners to consider factors that matter the most while planning to reduce the impact of transportation on the environment. By prioritizing infrastructure improvements and service provisions that directly address these key factors, cities can encourage a shift toward active mobility, mitigating the negative impacts of transportation on the environment and public health.

Keywords: active mobility; FAHP; Sensitivity; walking; cycling.

1. Introduction

The growing dependence on motorized transportation in developing cities has led to significant environmental degradation. In response, active mobility is increasingly recognized as a crucial component of sustainable urban transportation systems. The shift toward active mobility may help in achieving social sustainability objectives as it offers environmental benefits and contributes to improved public health and an enhanced quality of life (Rainieri G. et al.2024). But in order to effectively promote sustainable transportation practices, a thorough understanding of the factors influencing the adoption of active modes is required (Pisoni et al.,2022).

Active mobility, often referred to as active travel, active transport, or active transportation, is the movement of people via non-motorized means that is based on physical activity on the part of the passengers, which aids in health improvement and environmental benefits (López & Wong, 2017; Vich et al., 2019). The most prime forms of active mobility include walking and cycling (Montoya-Robledo et al., 2020; Pajares et al., 2021; Müllers et al., 2022). Despite some research on active mobility, there is still a significant gap in understanding the relative importance of various contributing factors, especially in the context of developing metropolises. This study aims to address this gap by prioritizing the factors influencing active mode choices, providing valuable insights for policymakers and urban planners.

The primary objective of the study is to review the various aspects of active mobility for sustainable urban transportation. We found a substantial gap in the assessment of factors influencing active mode choice due to a lack of complete understanding of how infrastructure, the physical and built environment, safety, and security influence the choice to walk or cycle. The study emphasizes the necessity for a nuanced approach in policy-making to promote active modes of transportation. This paper assesses these aspects using fuzzy logic and sensitivity analysis to quantify the list of factors affecting active mobility. The fuzzy analytic hierarchy process integrates fuzzy set theory to address the inherent imprecision and subjectivity in human judgments. This approach is particularly beneficial when evaluating criteria that are challenging to quantify precisely, such as "comfort" or "aesthetics" in active transportation (Vaidya & Kumar, 2004). Traditional multi-criteria decision-making methods often struggle with such subjective factors. While the pairwise comparison process can be time-consuming, it can also facilitate a deeper understanding of the trade-offs involved (Tanwar & Agarwal,2024). In contrast, the outputs of methods like TOPSIS, COPRAS, and PROMETHEE provide rankings but may not offer the same level of transparency regarding the relative importance of different criteria.

The Fuzzy Analytic Hierarchy Process can effectively address the challenges associated with subjective and imprecise judgments when evaluating factors influencing active transportation. Its ability to handle linguistic variables and incorporate fuzzy set theory is advantageous for capturing the nuanced perceptions of diverse stakeholders. In contexts where multiple stakeholders with differing perspectives are involved, FAHP can more accurately aggregate preferences by accounting for the inherent fuzziness in individual judgments. Furthermore, when expert opinions are central to transportation planning, as is often the case, FAHP can effectively encapsulate the uncertainty and ambiguity inherent in such expert assessments (Tripathi et al., 2021). The fuzzy sets provide a mechanism to represent the range of plausible interpretations of qualitative factors.

2. Role of factors for active mobility

In recent years, many researchers have actively studied the role of active mobility in sustainable urban transportation (Hackl et al., 2019; Möllers et al., 2022; Pajares et al., 2021; Pisoni et al., 2022). Walking and cycling are the primary modes of transportation that promote active mobility (López & Wong, 2017). Researchers identified mindset and infrastructural facilitation as key supporting attributes for addressing urban mobility issues (Pisoni et al., 2022; Markvica et al., 2020; Vich et al., 2019; Zhang et al., 2018). Although the use of cycling has increased, the availability of bikes tends to discourage walking as an active mobility transportation mode (Scorrano & Danielis, 2021). Gender-based behavior also plays a significant role in the choice of transportation modes for active mobility (Montoya-Robledo et al., 2020). Different statistical models have been implemented for evidence-based decision-making to assess behavioral patterns for walking and cycling to promote active mobility (Hackl et al., 2019).

Adlakha and John (2021) promoted cycling as a means of active mobility for India's urban streets, emphasizing the need for better urban transportation policies. The lack of active mobility in South Asian countries was attributed to government policies favoring motorized transport and the failure of local authorities to develop walking and cycling infrastructure. Poor infrastructure for bicycling and pedestrians was also identified as a prime reason, especially in Indian regions.

Therefore, it was recognized that factors influencing active mobility were vital for the proper planning of urban transportation (Hiremath et al., 2013). To maximize the relevance and usefulness of factors, practitioners must take into account the intended aims of these factors (Hiremath et al., 2013; Saleem & Jaiswal.,2024). Table 1 illustrates the various factors and methodologies employed by prior researchers for assessing active mobility in urban transportation.

Table1. Summary of factors and methodology involved in South Asian countries for active mobility

Author	Factors considered	Method
Zhang et al., (2018)	Connectivity, Closeness and Spatial distribution, Comfort, Safety	Form based code
Zahraei et al., (2019)	Demographic factors, travel behavior, transportation technologies, macro factors, global drivers	Environmental scanning, Expert interviews, Technology scanning, Focus group discussions, Drivers of change
Wang & Wong (2020)	Walking behavior, built environment, area wise locations, urban heritage	Mixed methods approach (thematic analysis and contingency table analysis)
Das and Banarjee (2023)	Accessibility to urban space, children's independent mobility and parental perception, Road accidents and child traffic safety	Pilot survey study
Semple & Fountas (2023)	Demographic factors, land use aspect, travel behavior, environmental aspects, economic aspect	Transit oriented development analysis
Chia et al. (2022)	Demographic data, site and nature of the injury, and historical trends	Retrospective chart review of children data; statistical analysis (regression analysis)

Furthermore, there is a need to examine the interplay between various socio-economic and cultural factors influencing active transportation. The factors like individual, physical and built environment, neighborhood design and government policies aimed at promoting active travel impacts differently in varied settings (Winters et al.,2017). This study aims to bridge a crucial gap in the existing knowledge base by thoroughly examining the multifaceted factors that shape active transportation within the context of developing urban centres. Recognizing the complex nature of active travel behaviour, the research at hand centres on three key dimensions: safety and security, services and facilities, and infrastructure. A well-structured questionnaire survey was employed to gather the relevant data (Parishad et al.,2021)

To address the shortcomings of previous research that often overlooked the nuances of developing urban environments, this study employs a robust mixed-methods approach. By systematically gathering and analysing expert opinion, a valuable source of contextualized knowledge, the relative importance of various factors within each dimension is determined. This approach offers crucial insights into valuable insights into the unique challenges and opportunities associated with promoting active transportation in developing metropolises, where infrastructural limitations and socio-cultural norms often differ significantly from those observed in developed cities (Parishad et al.,2023).

3. Methodology

The present study aims to prioritize the factors that enable cities to encourage the use of active modes of travel in order to maintain a balance between their daily commute and health, thereby promoting sustainable transportation practices. This survey aims to capture the nuanced understanding of on-the-ground realities and practical challenges associated with promoting active travel in these contexts. A questionnaire was distributed to a panel of 40 experts. The expert panel comprised practitioners actively involved in urban transportation planning and implementation, researchers, and academicians specializing in transportation studies, urban planning & engineering, and related fields. A structured questionnaire was developed based on the analytical hierarchy process to elicit expert preferences and judgments regarding the relative importance of different criteria in a pairwise comparison matrix; it included sections on infrastructure, services & facilities, safety & security factors. The experts were asked to rate the importance of one element compared to another on a predefined scale (Vaidya & Kumar, 2004). The collected expert opinions are then analyzed using the fuzzy analytical hierarchy process model. This approach allows for the incorporation of inherent uncertainties and ambiguities associated with expert judgments, leading to a more robust and reliable prioritization of factors (Miyamoto & Ximenes.,2021)

The FAHP model also facilitates sensitivity analysis, examining the robustness of the prioritization results under different decision-making scenarios. The major categories of factors were infrastructure, safety, travel behavior, demography, geographical conditions, and weather. Based on literature review we have segregated into three major categories, Infrastructure (I), Services and facilities (S&F) and safety and security (S&S) called the criteria. These categories are further divided into factors. The hierarchic structure adopted for classification is as depicted in figure 1.

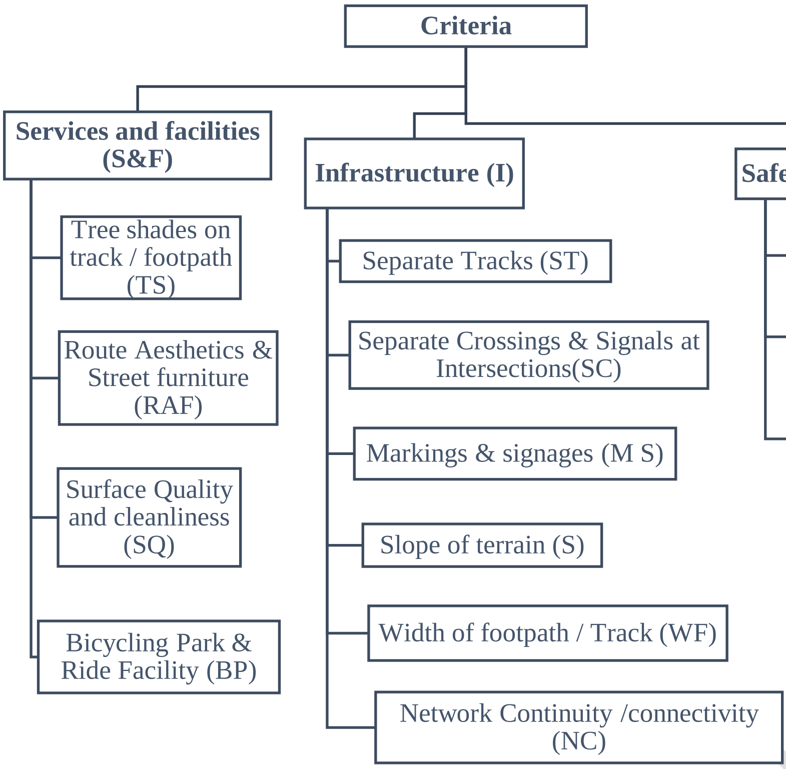

Figure 1: The Hierarchic Structure Adopted for the prioritization of factors

The ranking of factors is determined as discussed in section 8 following a work flow methodology as described in figure 2.

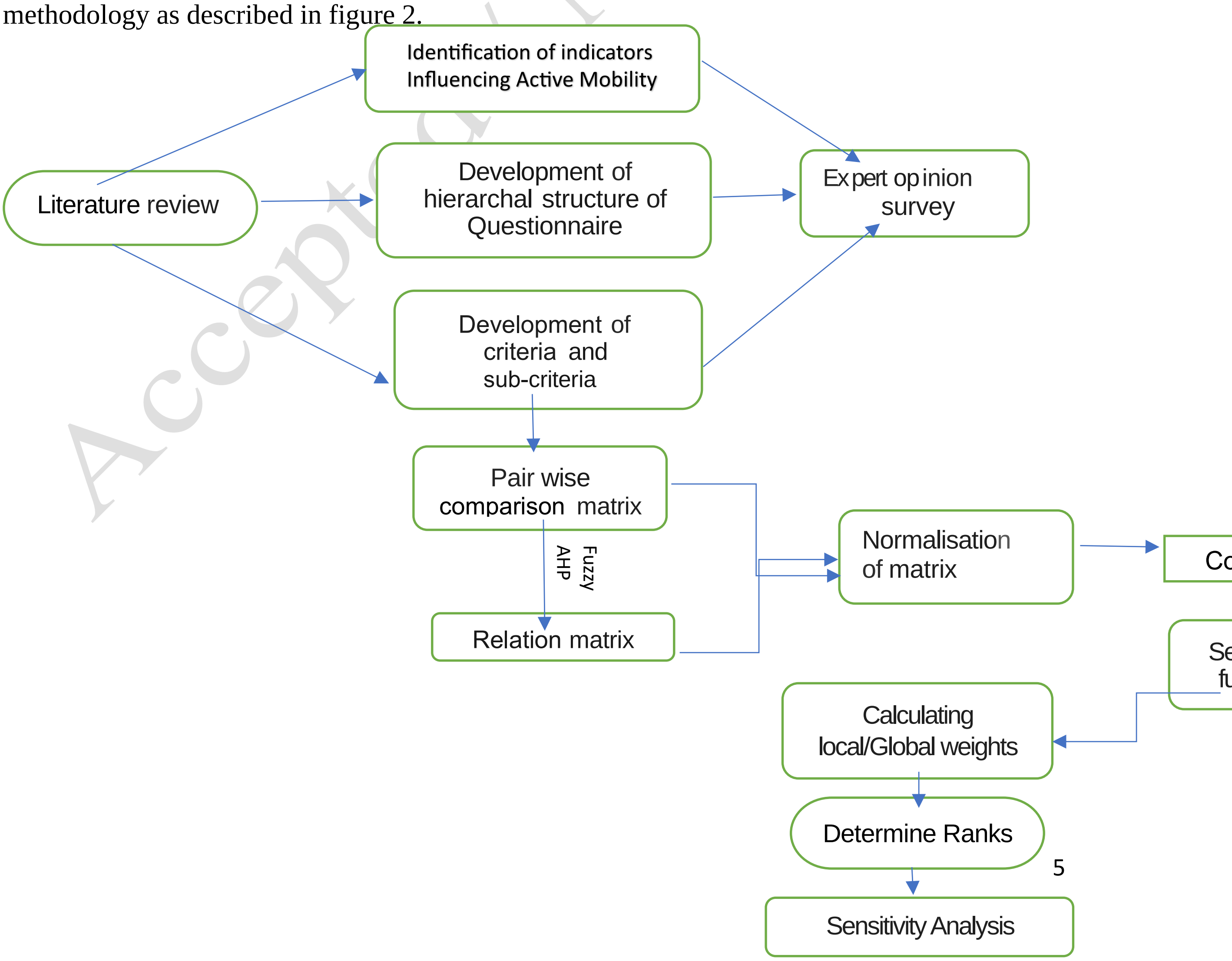

Figure 2: The work flow process for prioritization of factors for active mobility

The reliability of a questionnaire is measured by Cronbach's alpha (α) value (Eq1) and generally a questionnaire with a α value of 0.8 is considered reliable. A value between 0.70 and 0.90 is considerable (Tavakol & Dennick, 2011). The reliability of the designed questionnaire was found to be 0.826 which satisfied the minimum criteria.it shows that the rankings are consistent. Here N = 13 equal the number of study attributes, c = 0.30 corresponds to the average inter-item covariance between items, and v = 0.812 corresponds to average variance.

$$\alpha = \frac{NC}{v+(N-1)C} \qquad \text{Eq 1}$$

In order to evaluate the level of agreement among specialists, Kendall's W coefficient, commonly known as the coefficient of concordance, was also examined (Eq 2). Finally, the result is 0.78. Strong levels of unanimity are indicated when the Kendall's coefficient W > 0.7.

$$w = \frac{12R}{m^2(k^3-k)} \qquad \text{Eq 2}$$

Here total k= 13 attributes, m = 38 judges and R = 1.61*105 is sum of squared deviations and W is Kendall's coefficient.

4. Fuzzy Analytic Hierarchy Process (FAHP)

The fuzzy logic theory was used to build the FAHP approach. It allows for the consideration of multiple criteria and sub criteria providing a comprehensive analysis of various factors influencing the process. Herein the analytic hierarchy process (AHP) scale is converted into fuzzy triangular numbers (FTN) scale to access the priority. This is due to the inability of AHP to handle the randomness in pairwise comparisons (Saaty,2016). Chang (1996) employed the fuzzy AHP to address this uncertainty in AHP methodology. Formation of fuzzy-relative importance matrices for each level of criteria using TFN are illustrated in tables 3,4 and 5. The ranks of individual sub-criteria are also calculated for better understanding of priority of factors. The number of elements should be kept to nine in order to provide adequate consistency when determining priority from paired comparisons. AHP tolerates inconsistency but gives each set of judgments a measure of it. The consistency ratio (CR), stated in Equation 3, can be used to determine the consistency of the judging matrix.

$$CR = CI / RI \qquad Eq\ 3$$

Where CI is consistency index and RI is Random index. In addition, Saaty (2008) provided average consistencies (RI values) of randomly generated matrices. CI for a matrix of order n is defined in Equation 4 as:

$$CI = \frac{\lambda_{max} - n}{n-1} \qquad Eq\ 4$$

CR less than equal to 0.1 is acceptable. If the value is greater, the judgements may be untrustworthy and should be generated again. Table 2 illustrates that value of all the criteria are in acceptable range.

Table 2: The Average Consistencies of Random Matrices

Criteria	Infrastructure	Services and facility	Safety and security
CR	0.09	0.06	0.01

4.1 Determination of the local and global weights for prioritizing the factors

The geometric mean approach was used to calculate the local and global weights of the factors at each level. Equation 5 can be used to find the geometric mean of the i^th^ row (GM_i) of a crisp matrix of a corresponding row indicator.

$$GM_i = \left[\prod_{j=1}^{M} b_{ij}\right]^{\frac{1}{M}} \qquad \text{Eq 5}$$

$$w_i = \frac{GM_i}{\sum_{i=1}^{n} GM_i} \qquad \text{Eq 6}$$

Equation 6 can be used to find the local weights, where b_{ij} in the equation 5 is the value found in the crisp comparison matrix's ith row and j^{th} column. The crisp comparison matrix has M parameters total. The variable's local weight can be estimated by utilizing equation 6. Having established the local weights, Equation 7 can be used to calculate the fuzzy global weights (G_k) from the local weight of the kth level and the global weights of the $(k\text{-}1)^{th}$ level.

$$G_k = w_k G_{k-1} \qquad \text{Eq 7}$$

The pairwise comparison matrix for the three criteria based on these equations are as shown in table 3, 4 and 5.

Table 3: Pairwise comparison matrix for Infrastructure Factors

Criteria	Separate Tracks (ST)			Separate Crossings & Signals at Intersections(SC)			Markings & signages (M S)			Slope of terrain (S)			Width of footpath / Track (WF)			Network Continuity /connectivity (NC)		
Separate Tracks (ST)	1.00	1.00	1.01	1.13	1.19	1.82	2.08	2.33	1.00	1.13	1.30	0.70	0.75	0.81	0.72	0.73	0.75	0.00
Separate Crossings & Signals at Intersections(SC)	0.89	0.97	1.00	1.00	1.00	0.87	0.94	1.05	0.84	1.00	1.22	0.45	0.50	0.55	0.45	0.56	0.69	0.00
Markings & signages (M S)	0.48	0.55	0.96	1.06	1.15	1.00	1.00	1.00	1.24	1.34	1.42	0.26	0.30	0.35	0.38	0.39	0.39	0.00
Slope of terrain (S)	0.88	1.00	0.82	1.00	1.19	0.70	0.75	0.80	1.00	1.00	1.00	0.61	0.67	0.72	0.53	0.56	0.59	0.00
Width of footpath / Track (WF)	1.33	1.42	1.82	2.01	2.22	2.83	3.36	3.90	1.40	1.50	1.63	1.00	1.00	1.00	0.82	0.89	0.97	0.00
Network Continuity /connectivity (NC)	1.36	1.40	1.44	1.78	2.22	2.54	2.58	2.62	1.70	1.79	1.90	1.03	1.13	1.22	1.00	1.00	1.00	0.00

Table 4: Pairwise comparison matrix for Services and facilities

Criteria	Bicycling Park & Ride Facility(BP)			Surface Quality and cleanliness			Route Aesthetics & Street furniture			Tree shades on track / footpath		
Bicycling Park & Ride Facility(BP)	1	1	1	0.29	0.34	0.39	0.69	0.74	0.78	0.96	1.07	1.17
Surface Quality and cleanliness (SQ)	2.5	2.92	3.409	1	1	1	1.84	2.16	2.47	1.99	2.2	2.39
Route Aesthetics & Street furniture (RAF)	1.3	1.35	1.442	0.4	0.46	0.54	1	1	1	1.79	2.01	2.19
Tree shades on track / footpath (TS)	0.9	0.94	1.046	0.42	0.45	0.5	0.46	0.5	0.56	1	1	1

Table 5: Pairwise comparison matrix for safety and security

Criteria	Road user safety (vehicular conflict) (RS)			traffic calming measures (TC)			Bicycle theft (BT)		
Road user safety (vehicular conflict) (RS)	1	1	1.01	1.1	1.2	1.8	2.1	2.3	1
traffic calming measures (TC)	0.9	0.97	1	1	1	0.9	0.9	1	0.8
Bicycle theft (BT)	0.5	0.6	0.96	1.1	1.2	1	1	1	1.2

5. Sensitivity Analysis (SA)

Sensitivity analysis is used to account for uncertainties in input data, processing, criterion selection, and external factors beyond the decision maker's control (Nyimbili & Erden, 2020). SA was done after FAHP to ensure that relative weights were kept when projected to data variances, resulting in more accurate decision-making. By adjusting the fuzzification factor, the proposed decision-making model underwent a sensitivity study. By altering one input factor at a time while holding the other factors constant, it was used to monitor the criterion weight sensitivity and analyse the consequences on the model outputs (Saltelli et al., 2006). Equation 9.1 shows how the weight of the other criteria, w_j, would change if the weight of the i^{th} (criterion/study attribute) was altered from w_i^0 to w_i.

$$w_J = \frac{(1-w_i)}{(1-w_i^0)} w_j^0 \qquad \text{Eq 8}$$

where w_J is the new weight value of the other (criterion) to be changed; w_i^0 and w_j^0 were the initial weight values of the criteria before being subjected to SA. Table shows an analysis of the model output for six sets (0, 0.2, 0.4, 0.6, 0.8 and 1) and the relative importance of the attributes was monitored shown Table 6.

Table 6: Sensitivity Analysis for factors

Criteria	Factors	Orignal	Set-1	Set-2	Set-3	Set-4	Set-5
Infrastructure (I)	(ST)	0.1217	0.1133	0.1049	0.0965	0.1301	0.1217
	(SC)	0.0903	0.0841	0.0779	0.0717	0.0966	0.0903
	(M S)	0.0750	0.0699	0.0647	0.0595	0.0802	0.0750
	(S)	0.0905	0.0842	0.0780	0.0718	0.0967	0.0905
	(WF)	0.1731	0.1612	0.1492	0.1373	0.1850	0.1731
	(NC)	0.1749	0.1628	0.1508	0.1387	0.1869	0.1749
Services and facilities (SF)	(BP)	0.0291	0.0332	0.0373	0.0414	0.0250	0.0291
	(SQ)	0.0782	0.0892	0.1001	0.1111	0.0672	0.0782
	(RAF)	0.0429	0.0490	0.0550	0.0610	0.0369	0.0429
	(TS)	0.0277	0.0315	0.0354	0.0393	0.0238	0.0277
Safety & Security (SS)	(RS)	0.0571	0.0719	0.0867	0.1015	0.0424	0.0571
	(TC)	0.0248	0.0312	0.0376	0.0440	0.0184	0.0248
	(BT)	0.0147	0.0185	0.0223	0.0261	0.0109	0.0147

For every set of categories and factors, separate fuzzification factors were used to produce the fuzzy pair-wise comparison matrices. Based on global weights, an indicator's rank is determined. The rank or priority increases with the global weight of the indicator. Figure 3 highlights the sensitivity of the decision-making outcomes for all other factors.

Table 7: Sensitivity analysis for indicator criteria

Criteria	Original Set of Weights	Set-1	Set-2	Set-3	Set-4	Set-5
(I)	72.55%	67.55%	62.55%	57.55%	77.55%	72.55%
(SF)	17.78%	20.28%	22.78%	25.28%	15.28%	17.78%
(SS)	9.67%	12.17%	14.67%	17.17%	7.17%	9.67%

	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table 7 indicates the prioritization of the factor's weights through different scenarios. The variations in weight across different factors demonstrated the sensitivity of the decision model to change in the relative importance of factors. Infrastructure is of highest priority as the variations in weights did not alter the position of the indicator followed by Services and facilities.

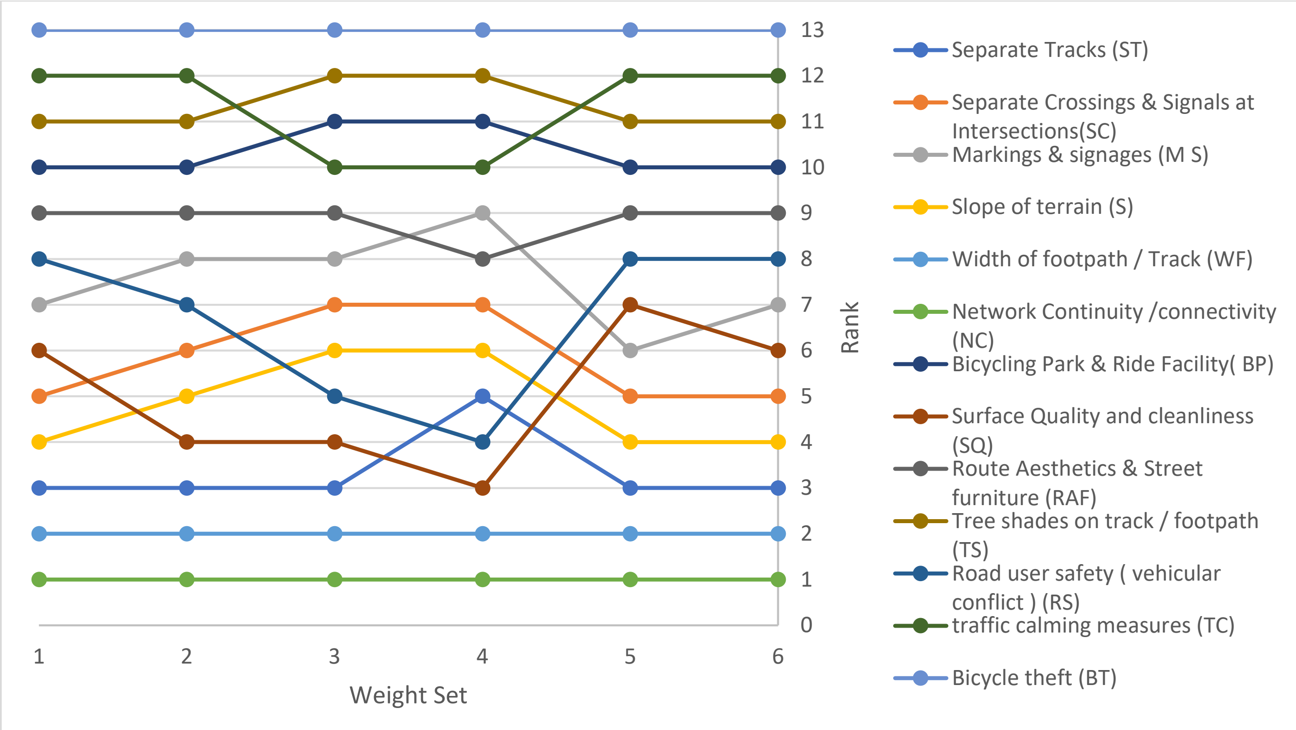

Figure 3: Sensitivity analysis for the factors

6. Results and discussion

Active mobility is a measure to attain sustainability in the transportation system. To achieve this an understanding of its factors and their priority levels is indispensable for planners and policy makers. It will help them prioritize the challenges and demands that needs to be met for promoting sustainable transportation practices. The findings are helpful in assisting with the decision-making process for the creation of an urban bicycle infrastructure plan that incorporates multimodal active transportation infrastructures mechanized pedestrian mobility (Zhang & Zhou, 2023).The analysis provides an insight into factors that may encourage users to switch to active mode of travel. Table 8 Shows the pairwise comparison matrix for indictors of Infrastructure(I), Services and facilities (SF) and Safety and security (SS) respectively.

Table 8 : Pairwise comparison matrix of Criteria

9	I			SF			SS		
I	1	1	1	3.57	4.095	4.58	7.18	7.533	8.12
SF	0.2184	0.244173	0.2804	1	1	1	1.54	1.859	2.16
SS	0.1248	0.13275	0.1437	0.46	0.538	0.65	1	1	1

It was found that the primary factors that affect the mode choice of users depend on infrastructure. Network continuity, width of footpath and separate tracks are the top most priorities under the category of infrastructure as shown in figure 4. As the changes alongside the route networks will influence the travel demand. Surface quality & cleanliness and road safety are next in the list as reflected in the analysis of expert opinion survey criteria wise as depicted in table 9. The safety and infrastructure issue includes concerns about road safety, bike lanes, and connection. (Piatkowski, et al., 2015). The continuity of network is regarded as the top most priority for commuters this reflects that the association between network characteristics and ridership is an indispensable aspect of transportation planning and policy and thus they play a significant role in influencing the commuting behaviour (Beck, et al., 2023).

Under the category of services and facilities, factors such as route aesthetics, street furniture, and surface quality are also major considerations. For instance, greenery and barriers are positively correlated with increased cycling activity while streetlights and signals show a negative correlation with speed and trip density (Wang & Wong, 2020). Safe and secure walking environment are among the priority factors for pedestrians (Bivina & Parida, 2020) As per the research to create walk/bicycle friendly cities and enhance sustainable transportation practices it is essential for planners to understand the relation between various factors.

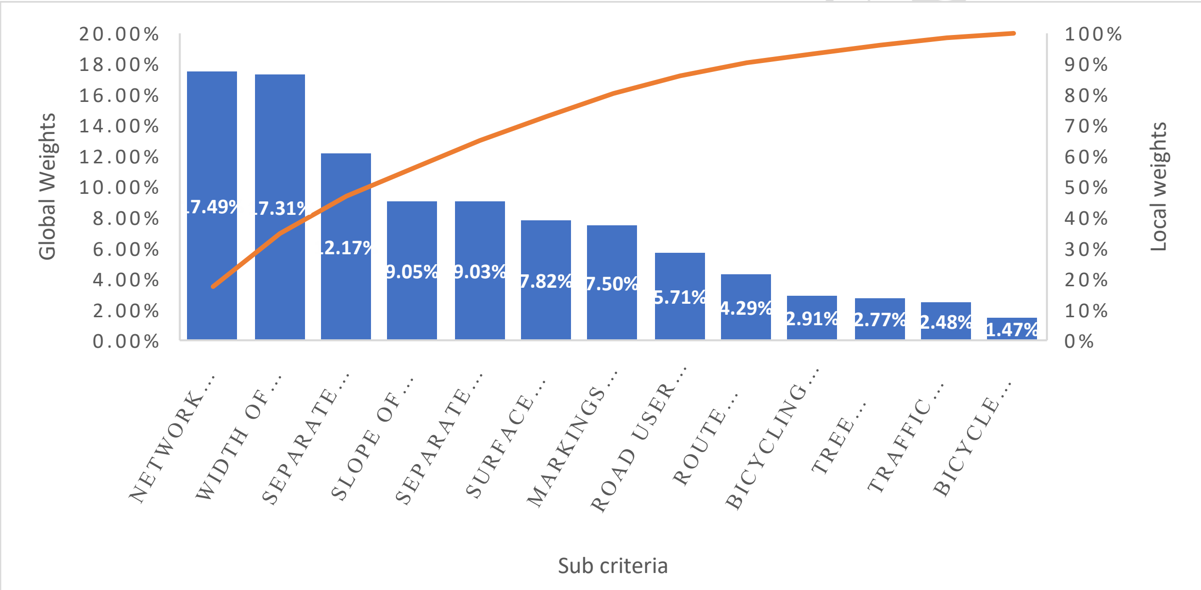

Figure 4: Prioritization of factors influencing active mode choices

Table 9: Sensitivity Analysis and Prioritization of Factors

Ranks	Orignal (1)	Set-1 (2)	Set-2 (3)	Set-3 (4)	Set-4 (5)	Set-5 (6)
Separate Tracks (ST)	3	3	3	5	3	3
Separate Crossings & Signals at Intersections(SC)	5	6	7	7	5	5
Markings & signages (M S)	7	8	8	9	6	7
Slope of terrain (S)	4	5	6	6	4	4
Width of footpath / Track (WF)	2	2	2	2	2	2
Network Continuity /connectivity (NC)	1	1	1	1	1	1
Bicycling Park & Ride Facility(BP)	10	10	11	11	10	10
Surface Quality and cleanliness (SQ)	6	4	4	3	7	6
Route Aesthetics & Street furniture (RAF)	9	9	9	8	9	9
Tree shades on track / footpath (TS)	11	11	12	12	11	11

Road user safety (vehicular conflict) (RS)	8	7	5	4	8	8
traffic calming measures (TC)	12	12	10	10	12	12
Bicycle theft (BT)	13	13	13	13	13	13

In heavily populated places, (Din, et al., 2023) advise giving sustainable transportation policies and solutions top priority. While addressing the issues brought on by population density, policies like encouraging public transportation and electric cars and making investments in infrastructure that facilitates active transportation modes like walking and cycling can help reduce the adverse environmental impacts of transportation. Factors influencing walking and cycling mode vary , with trip characteristics and built environment having the highest impact on active mode use (Ton, et al.,2019) Although The prioritization of factors helps in investment decision and prevents wastage /underutilisation of available resources (Heidari, et al., 2023) but to promote sustainable transportation practices educational interventions are necessary as they will help in changing the mindset and attitude of children and adolescents towards active transportation. This will also help in eliminating the negative mindsets associated with active mode choices (Chanpariyavatevong, et al., 2024)

Semple & Fountas, (2023) recommend that prior to implementation, pedestrianization should be studied locally, city by city, or town by town. This enables plans to be customized to the demands of the community or to the constraints of the current infrastructure. For the majority of instances, exclusive lanes for pedestrians, and their interactions on MFD (Macroscopic Fundamental Diagram) are important. While the particular impact of these variables on a particular network depends on its distinct configuration (Liu, et al., 2024).There isn't a single solution available that addresses all facet of urban and transportation-related problems. Prior until now, combined solutions might appear to be the most appropriate for the future (Sarri, et al., 2024).Cities with similar travel characteristics could be investigated for the effect of land use on travel behaviour and different active travel scenarios could be modelled.

Promoting active transportation in developing metropolises requires a multifaceted approach. Crucial elements include investing in dedicated cycling infrastructure, enhancing connectivity between existing routes, and widening pedestrian walkways. This may involve reallocating road space, creating separated cycling lanes, and improving pedestrian crossings. Additionally, addressing the mobility challenges faced by vulnerable groups, such as the elderly, people with disabilities, and lower-income populations, through inclusive design and targeted interventions is essential.

Manageable slopes are particularly important for active travel, especially for cyclists and individuals with limited mobility. Urban design features, such as street furniture, greenery, and aesthetically pleasing routes, can enhance the overall walking and cycling experience, thereby encouraging greater mode shift towards active transportation. Furthermore, education and awareness campaigns to highlight the benefits of active mobility, coupled with behavioral nudges, can help foster a culture of sustainable transportation. Cities should also prioritize the development of secure bicycle parking near transit stations and plant trees along active transportation routes to provide shade and improve aesthetic appeal. In conclusion, a comprehensive strategy addressing the built environment, transportation infrastructure, inclusive design, and behavioral change is necessary to effectively promote active transportation in developing metropolises.

7.Conclusion

The research emphasizes that urban streets are a major component of the built environment. This research provides a nuanced understanding of the factors influencing active travel choices in developing metropolises, making a unique contribution to the field of sustainable urban transportation. While prior studies have often focused on developed cities, this research delves into the unique challenges and opportunities of developing urban environments. By systematically analyzing expert opinions, this study goes beyond merely identifying relevant factors; it offers a contextualized understanding of their relative importance, providing valuable insights for practitioners and policymakers. This perspective is crucial for developing effective strategies to promote active transportation in developing metropolises, where infrastructural limitations, socio-cultural norms, and travel patterns often differ significantly from developed cities. The findings contribute in advancing our understanding of active travel behavior in understudied contexts and offering actionable insights for creating more sustainable urban environments.

The study prioritized the factors that matter for improving the quality of service for active transportation and thus analyzed the sensitivity in decision-making for the justification of robustness in the selection of factors using the FAHP model. It was noted that the rank of the highest priority indicator never alters with a change in the fuzzification factor or the decision altitude. It can be inferred that the rank of these factors follows a similar pattern irrespective of the fuzzification factors. The analysis indicated that infrastructure is a major area of focus for promoting active mobility, followed by services and facilities required for cycling and walking. The investigations reflect that network continuity in the infrastructure category is the most influential of all the criteria for encouraging users to switch to active mobility. The top five factors that majorly influence the active mode choice according to the FAHP model study are network continuity, width of footpath, separate signals at intersections and crossings, and slope of terrain.

There are numerous research possibilities in this area, as very little work has been done, and little of what has been done focused only on providing ramps without understanding user behavior and requirements regarding prioritization of various conditions. Such provision of facilities discourages even the potential users, as they lack safety, comfort, and spatial integration. Therefore, the existing systems need a proper framework with well-marked factors to attain sustainability in the transport sector. Longitudinal studies could also be conducted to track changes in active mobility patterns over time in response to policy intervention and infrastructural developments. Assessing user behavior and preferences regarding mode choices and how different demographics influence the mode choices and perceive the level of services for active modes may help in aiming to achieve sustainability in the transportation sector. This may lower its subsequent impact on the environment and public health. The available analysis of prioritization may help formulate a framework to help the planners and policymakers define the level of service for active transportation and make informed choices about resource allocation and policy implementation.

Data availability

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Conflict of Interest

We hereby declare that the authors have no actual and potential conflict of interest.

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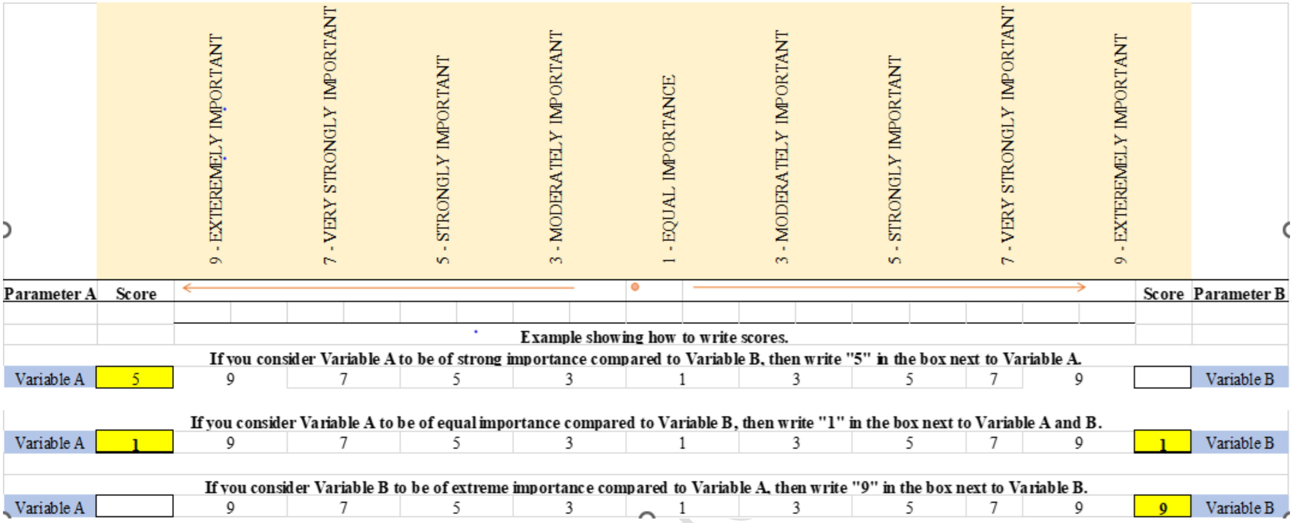
Annexure

The following Annexure highlights the structure of questionnaire survey conducted for this study and the scale of relative importance.

Scale of relative importance

1	Equal importance
3	Moderate Importance
5	Strong Importance
7	Very strong Importance
9	Extremely strong importance
2,4,6,8	Intermediate values

Example for marking



A. Infrastructure

Criteria 1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Criteria 2
Separate Tracks																		Separate Crossings & Signals at Intersections
Separate Tracks																		Markings & signages
Separate Tracks																		Slope of terrain
Separate Tracks																		Width of footpath / Track
Separate Tracks																		Network Continuity /connectivity
Separate Crossings & Signals at Intersections																		Markings & signages
Separate Crossings & Signals at Intersections																		Slope of terrain
Separate Crossings &																		Width of footpath / Track

Signals at Intersections																		
Separate Crossings & Signals at Intersections																		Network Continuity /connectivity
Markings & signages																		Slope of terrain
Markings & signages																		Width of footpath / Track
Markings & signages																		Network Continuity /connectivity
Slope of terrain																		Width of footpath / Track
Slope of terrain																		Network Continuity /connectivity
Width of footpath / Track																		Network Continuity /connectivity

B. Services and facilities

Criteria 1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Criteria 2
Bicycling Park & Ride Facility																		Surface Quality and cleanliness
Bicycling Park & Ride Facility																		Route Aesthetics & Street furniture
Bicycling Park & Ride Facility																		Tree shades on track / footpath
Surface Quality and cleanliness																		Route Aesthetics & Street furniture
Surface Quality and cleanliness																		Tree shades on track / footpath
Tree shades on track / footpath																		Route Aesthetics & Street furniture

C. Safety & Security

Criteria 1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Criteria 2
Road user safety (vehicular conflict)																		Traffic calming measures
Road user safety (vehicular conflict)																		Bicycle theft
Traffic calming measures																		Bicycle theft