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Editors: Lizawati Abdullah, Nor Suzila Lop, Nor Nazihah Chuweni, Suriani Ngah Abdul Wahab, Hasnan Hashim

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WELCOME SPEECH FROM THE CHAIRMAN

RISM 17th International Surveying Conference for Undergraduates (ISCU 2025)

بسم الله الرحمن الرحيم السلام

عليكم ورحمة الله وبركاته

Greetings to all,

It is with great pleasure that I welcome you to the 17th RISM International Surveying Conference for Undergraduates (ISCU 2025), themed *"Embracing Construction Revolution 4.0: Transforming Malaysia's Built Environment."* On behalf of the Royal Institution of Surveyors Malaysia (RISM), I also wish to express our sincere appreciation to Universiti Teknologi MARA (UiTM), Perak Campus, for graciously hosting this significant event.

As we navigate the era of the Fourth Industrial Revolution (IR4.0)—or in our context, Construction Revolution 4.0 (CR4.0)—we are witnessing transformative advancements across the global construction sector. Technologies such as Building Information Modelling (BIM), the Internet of Things (IoT), artificial intelligence (AI), robotics, big data analytics, and cloud computing are redefining the way we build, manage, and interact with our built environment. For Malaysia, embracing CR4.0 is a strategic imperative to achieve our socio-economic and environmental goals.

This conference serves as a vital platform to unite surveying undergraduates from various disciplines, fostering critical dialogue on industry challenges, enhancing professional networking, and preparing a new generation of talent for the rapidly evolving construction landscape. It is also an opportunity for employers to engage with and inspire our future professionals.

I would like to extend my heartfelt thanks to all industry speakers, paper presenters, judges, and participants for their time, contributions, and support in making ISCU 2025 a success. I also commend the organising committee for curating a meaningful and dynamic conference experience.

May the knowledge gained, connections formed, and ideas exchanged during this event inspire all participants to lead and innovate in their future endeavours.

Wishing everyone a productive and memorable conference.

Prof. Ts Sr Dr. Adi Irfan Bin Che Ani'
Chairman, Universities' Partnering Committee
RISM Session 2024/2025
May 2025

WELCOME SPEECH FROM CO-CHAIRMAN

RISM 17th International Surveying Conference for Undergraduates (ISCU 2025)

Bismillahirrahmanirrahim.

السلام عليكم ورحمة الله وبركاته and greetings to all.

It is my great pleasure to welcome everyone to the 17th International Surveyor Conference for Undergraduates (ISCU 2025), proudly hosted by Universiti Teknologi MARA (UiTM) Perak Branch in collaboration with the Royal Institution of Surveyors Malaysia (RISM). This event is a meaningful platform for students in the built environment to share ideas, showcase innovations, and build professional networks. We are honoured by your presence and enthusiastic participation, with 135 accepted papers and 78 poster presentations this year.

UiTM Perak, home to the College of Built Environment, has long been a hub for academic excellence in architecture, planning, and surveying. Our commitment remains strong in nurturing competent graduates who meet industry demands and contribute to nation-building.

While you're here, we invite you to experience the heritage and culture of Perak Tengah from the architectural richness of Rumah Kutai to the historical towns of Pasir Salak, Bota, and Kampung Gajah.

To all presenters and winners, congratulations on your achievements. Let your work today be a catalyst for future success and academic growth. We hope this conference will inspire you to explore new ideas, foster collaboration, and make lasting memories.

My deepest thanks to the Royal Institution of Surveyors Malaysia (RISM) and the organising committee for making this event a success.

We hope your experience here will be rewarding and unforgettable.

Thank you. Selamat datang dan selamat berjaya.

Associates Professor Dr. Nur Hisham Ibrahim, *PMP*
Co-Chairman, Universities' Partnering Committee
RISM Session 2024/2025
May 2025

WELCOME SPEECH FROM THE PROJECT DIRECTOR

RISM 17th International Surveying Conference for Undergraduates 2025

Alhamdulillah, all praise to Allah S.W.T. for His guidance and blessings in making the RISM 17th International Surveying Conference for Undergraduates (ISCU) 2025 a reality.

It is with great honour and gratitude that I welcome all participants, guests, academicians, and industry professionals to this prestigious event, proudly organized under the Royal Institution of Surveyors Malaysia (RISM). This 17th edition of ISCU stands as a proud testament to our collective dedication toward academic excellence, professional collaboration, and youth empowerment in the field of surveying.

I extend my heartfelt appreciation to RISM for its unwavering support, to the hardworking ISCU 2025 Organising Committee, and to all 16 partnering universities across Malaysia for their commitment and contributions. Your efforts have shaped this conference into a dynamic platform for knowledge exchange, innovation, and professional growth.

To the academicians and practitioners present, your insights are invaluable in bridging the gap between academic theory and real-world practice. To our undergraduate participants, your passion, curiosity, and commitment are the very foundation of our future. May this conference not only deepen your academic journey but also ignite a spirit of leadership, integrity, and sustainable thinking.

Let this gathering serve as more than an academic milestone. May it foster lifelong networks, inspire transformative ideas, and chart new directions in our shared professional journey.

Wishing everyone a rewarding and inspiring conference experience.

Sr Dr. Nurul Fadzila Zahari
Project Director
RISM 17th ISCU 2025

INTEGRATION OF FUZZY-AHP AND GIS IN MODELLING TRANSIT BIKEABILITY INDEX

Nur Amirah Wahidah Mohd Zahari[1], Nabilah Naharudin[2]*

[1,2]*Faculty of Built Environment, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, MALAYSIA.
Email: nabilahnaharudin1290@uitm.edu.my
*Corresponding Author

ABSTRACT

Transit accessibility is one of the important elements in ensuring that all available facilities are easily accessible. Accessing transit stations would definitely helps in encouraging people to use the services itself. Imagine, if a station is not well-accessible by the demand, how would people use the service? The most important part is the First and Last Mile of the transit journey. The increasing popularity of cycling as a form of transport is due to improvements in bicycle infrastructure. Furthermore, First and Last Mile connectivity when combined with public transport networks has made cycling a practical and viable option for urban commuters. However, are all routes safe for cycling? There are several ways to enhance the accessibility. One of it by measuring them, before a further plan can be taken. Therefore, this study will be conducted to measure the Transit Bikeability Index in Kuala Lumpur City Centre. By considering several factors, including comfort, safety and accessibility, this study will integrate GIS and Fuzzy-AHP to measure the Transit Bikeability Index. First, the suitability of each criterion will be calculated using the Fuzzy-AHP method to address the issue of inconsistency and uncertainty in decision-making derived from assessments by experts in this field. The derived Fuzzy weights will be validated through sensitivity analysis. Then, the Fuzzy weights will be used as parameters in GIS analysis to derive the Transit Bikeability Index. Proximity and spatial join analysis will be used for this purpose where the weightage of parameters existed along a road will be summed to compute the Transit Bikeability Index. To aid in this process, a custom tool was developed using ModelBuilder in ArcGIS Pro, automating data processing, weightage applications and spatial analysis. The results will be visualized as a bikeability map, highlighting roads with high and low suitability for cycling.

Keywords: Cycling, Fuzzy Analytical Hierarchical Process (FAHP), GIS, Multiple-Criteria Decision Analysis (MCDA).

I. INTRODUCTION

Transit accessibility is one of the important elements in ensuring that all available facilities are easily accessible and encourage the use of transit from and to Transit Oriented Development (TOD). This aims to reduce car trips and related traffic difficulties in the TOD sector (Lee & Salih, 2024). Not only that, travelling time could also be reduced and travel becomes easy. Accessing transit stations would help in encouraging people to use the services itself. First and Last Mile (FLM) which are trips form and to transit stations, are important components in determining transit usage (Mohiuddin, 2021). If the FLM is convenient, people may use the service. There are several ways to enhance the accessibility, which is Transit Accessibility Index (TAI), a main metric that could be used to measure accessibility through Multiple-Criteria Decision Analysis (MCDA). The application of MCDA methods in TAI helps in overcoming the complexity of the transit system to accurately analyse the transit accessibility. In addition, the MCDA method also helps planners consider quantitative and qualitative data that can address uncertainty and stakeholder preferences such as perceived safety and proximity to transit. Therefore, this approach helps in identifying specific areas that need improvement.

TAI is closely related to TOD which focuses on travelling half-mile radius around a station by walking and cycling. Thus, the questions is, is it possible to walk or ride a bike from the transit to the destination? This is where Transit Bikeability Index (TBI) came into the picture. TBI is a tool used to see how conducive an area is to cycling that considers factors that directly affect the safety, convenience and overall experience of cyclists (Kellstedt at al., 2021). The most common factor used to build this TBI is through comfort and safety (Arellana et al. 2020). If the TBI is high, it means that cycling is viable and can make it easier for people to rely less on cars, reduce their environmental impact and promote a healthier lifestyle.

In Malaysia, Kuala Lumpur City Hall (DBKL) has planned the Kuala Lumpur Pedestrian and Cycling Master Plan 2019-2028 which aims to encourage residents to use bicycles to go to public transit stations, then take the MRT or LRT to their next destination (DEWAN BANDARAYA KUALA LUMPUR, 2019). The public's acceptance and rejection of this matter is also taken into consideration to emphasize the need for better FLM infrastructure, especially protected cycling lanes, as raised by stakeholders in media reports (Malay Mail, 2023).

Figure 12.0 News from malaymail

These days, we could see more people use bike. It is interesting if bike is also use as mean of transportation to commute to workplace as people in Japan and Holland do because the city council had prepared the city for cycling. The question is, will people use it? Is it safe? Thus, this study will be conducted for measuring the bikeability to transit stations in KL City Centre. In this study, criteria in bikeability will be determined and MCDA methods will be used to measure the TBI. The criteria are necessary in knowing the cycling index which is formed into a score that makes it easier to understand in a consistent assessment and to address the gap. Therefore, this study will be conducted to solve three (3) research questions which are; (i) What are the criteria influencing TBI?, (ii) How can TBI be measured?, and (iii) How to evaluate suitable MCDA methods to measure TBI?

VII. LITERATURE REVIEW

A. Criteria Influencing Transit Bikeability Index

Table 1.0 Criteria influencing TBI

Author(s)	Safety				Comfort		Accessibility			
	Road Surface	Lighting	Speed Limit	Traffic	Road Width	Slope	Bike Road/ Lane	Parking	Connectivity/ Facilities	Shared/ Dedicated Bike Lanes
(Schmid-Querg et al., 2021)			√	√		√	√	√		
(Codina et al., 2022a)				√		√	√	√	√	√
(Chondrogianni et al., 2023a)			√		√		√			√
(Weikl & Mayer, 2023)		√	√			√	√	√		√
(Litman & Litman, 2024)			√						√	
(Ito & Biljecki, 2021)		√	√	√	√	√	√	√	√	√
(Dai et al., 2023)						√			√	
(Ros-McDonnell et al., 2020)		√		√			√	√	√	√
(Karolemeas et al., 2022)			√	√		√			√	
(Paulusová & Sharmeen, 2024)					√	√		√		√
(Hardinghaus et al., 2021)	√		√	√		√	√			
(Arellana et al., 2020)		√	√	√			√	√		
(Tran et al., 2020)					√	√		√		
(Santos et al., 2022)				√	√	√		√	√	√
(Fazio et al., 2021)				√				√	√	

Transit is a mode of transportation that helps in reducing car dependency and helps promote health especially during the COVID-19 pandemic by supporting social distancing (Shamshiripour et al., 2020) and improve the quality of life especially for residents who rely on transit for their transportation needs (Jin et al., 2022). The evaluation of criteria in calculating the TBI is based on expert knowledge from academics taken from a literature review. As stated in Table 1.0, it shows the criteria and the authors who evaluated them in their studies. Speed limit, traffic, road width, slope, bike lane, parking, connectivity and shared or dedicated bike lanes are criteria that are commonly chosen by several researchers.

Factors such as road surface, lighting, speed limits and traffic volume are often considered in terms of safety because of their direct influence on cyclists' risk exposure. The road width and slope are assessed to ensure the comfort of cyclists, where a wide road makes it easier for them to pedal and allows for smoother movement, while the presence of a slope will make it more difficult for them to cycle. In creating a cycling-friendly area, bike paths are an important criterion for assessing connectivity to destinations such as public transit, workplaces and other facilities. Therefore, bicycle parking is also prioritized because without it, cyclists may face difficulty in storing their bicycles, which will prevent them from riding. Accessibility to shared and dedicated bike lanes plays a key role in improving the overall cycling experience and connectivity. Usually, shared bike lanes are in constrained spaces, which can be uncomfortably and even dangerous. In contrast to designated bike lanes, they are isolated from motorised traffic or pedestrian walkways, which enhances the safety of other road users and gives cyclists a sense of priority. All these criteria are considered in analyzing the transit bikeability, ensuring a comprehensive assessment of safety, comfort, and accessibility.

B. Fuzzy Analytical Hierarchical Process (FAHP)

AHP is a commonly used method, and it is an approach in making multiple criteria decisions where these criteria are arranged in the form of a hierarchy and helps in evaluating criteria against criteria (Tripathi et al., 2022). However, AHP could lead to uncertainty where the comparison made is less than the scale value or more than the scale value. Uncertainty in AHP occurs because this method relies on subjective pairwise comparisons, where decision-makers assign relative importance between criteria using a predetermined scale.

Therefore, FAHP was introduced to solve this uncertainty issue. FAHP is a comparison of two criteria combined with fuzzy logic. It is used to deal with ambiguity and the consideration of priorities in decision making (Ustaoglu and Aydinoglu, 2020). FAHP will be expressed by the Fuzzy Comparison Ratio Scale which one of it is Triangular Fuzzy Number (TFN). The TFN will provide a ratio scale that provides a lower limit, middle value and upper limit based on the AHP scale to eliminate uncertainty and used to produce fuzzy Pairwise Comparison Matrix in FAHP.

The equation for fuzzy PCM for n criteria is shown in (1) (Chang, 1996; Demirel et al., 2008).

$$C = (C_{ij})_{n\times n} = \begin{bmatrix} (1,1,1) & \cdots & (l_{1n}, m_{1n}, u_{1n}) \\ \vdots & (1,1,1) & \vdots \\ (l_{n1}, m_{n1}, u_{n1}) & \cdots & (1,1,1) \end{bmatrix} \quad (1)$$

Where l, m, u, represents the lower, medium and upper of the TFN respectively.

To calculate the fuzzy weighted vector is based on the following (2).

$$W'(A_i) = [\, W'(A_1), W'(A_2), \dots, W'(A_n)]^T \quad (2)$$

Where A_i (i = 1, 2, … n) are the n criteria. For the normal weighted vector is calculated using the normalization procedure which is in (3).

$$W(A_i) = [\, W(A_1), W(A_2), \dots, W(A_n)]^T \quad (3)$$

C. GIS Modelling With MCDA

Developing a TBI to assess urban cycling infrastructure can be used through GIS models. According to Chang, (2016), GIS models are a process that uses GIS tools to represent, analyze, simulate, and integrate different data sources such as maps, digital elevation models (DEMs), GPS data, images, and tables. The integration of GIS and binary models in GIS help simplify spatial decisions using logic-based classifications 1 (true) and 0 (false), while index models provide a more nuanced evaluation by scoring areas on a continuous scale. To build this binary model, the selection of criteria is the most important step and is usually achieved by conducting a thorough literature review. Both indices involve multicriteria evaluation and rely on overlay operations for data processing (Malczewski, 2006).

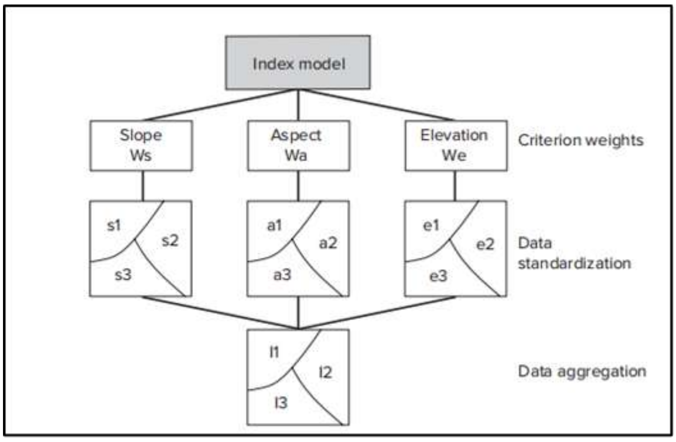

Figure 2.0 Flowchart of Index Model (Chang, 2019)

To calculate this index value, the commonly used method is to use weighted linear combination (Saaty, 1980). Different criteria are given weights based on their relative importance and then aggregated to form a composite score as shown in the flowchart in Figure 2.0. This process is aligned with MCDA, ensuring systematic normalization and integration of diverse criteria for composite scoring.

D. Applications Of GIS-MCDA For Measuring Bikeability And Accessibility

Assessment in bikeability and accessibility based on GIS-MCDA has been increasingly used because of its ability to combine GIS spatial analysis with decision making from FAHP. For example, the modeling of bicycle paths in Beijing uses GIS-MCDA with a FAHP approach (Ma et al., 2021). The weighting factors used are distance to transit, air quality and accident risk to identify safety and accessibility. In Munich, Germany, the development of a GIS-MCDA was used to examine the state of a practical by using raster data and weighted overlays, incorporating local cyclist input to identify low bikeability zones (Schmid-Querg et al., 2021). Next, in Barcelona, bikeability was mapped based on traffic, infrastructure, connectivity, parking spaces and topography (Codina et al., 2022). Similarly, in Nashville, GIS-MCDA produced an index map to measure the accessibility of a transit for five important service categories that can be accessed based on spatiotemporal transit calculations that provide results on which transit supply level is higher to access the services of food stores, healthcare facilities, childcare facilities, schools and parks (Guo & Brakewood, 2024).

VIII. METHODOLOGY

The methodology flow chart used in this study is shown in Figure 3.0. This study was conducted through five (5) stages. The first stage is the selection of criteria based on a literature review of previous studies to measure the TBI which has been discussed as in Section II. In the second stage, which is data collection, criteria are arranged based on hierarchical structure and identify experts for FAHP as well as spatial data collection. Once the criteria are selected, weights will be calculated using the FAHP methods and data editing will also be carried out. The results will then be verified by experts' verification and site verification to assess the robustness of the results and finally produce a map of TBI.

The first stage is Background Study where ten (10) key factors were identified through a comprehensive literature review to assess the TBI. These factors encompass various elements influencing bikeability, which are Road Surface, Lighting, Speed Limit, Traffic, Road Width, Slope, Bike Road/ Lane, Parking, Connectivity/ Facilities and Shared/ Dedicated Bike Lanes which are then classified under three (3) main criteria Safety, Comfort and Accessibility. The evaluation of these factors helps in understanding how well a given area supports bicycle-friendly transit connections.

In the second stage, spatial data representing the criteria on the ground will be acquired to support the analysis. This study relies on secondary data sources from open-source providers, specifically OpenStreetMap, which offer extensive and accessible geospatial datasets. Simultaneously, data for the FAHP will be collected from five experts using an Experts' Choice Form. This process involves obtaining pairwise comparisons from the experts to assess the relative importance of each criterion. The collected responses will then be used to derive the weight for each criterion, ensuring a structured and data-driven evaluation framework.

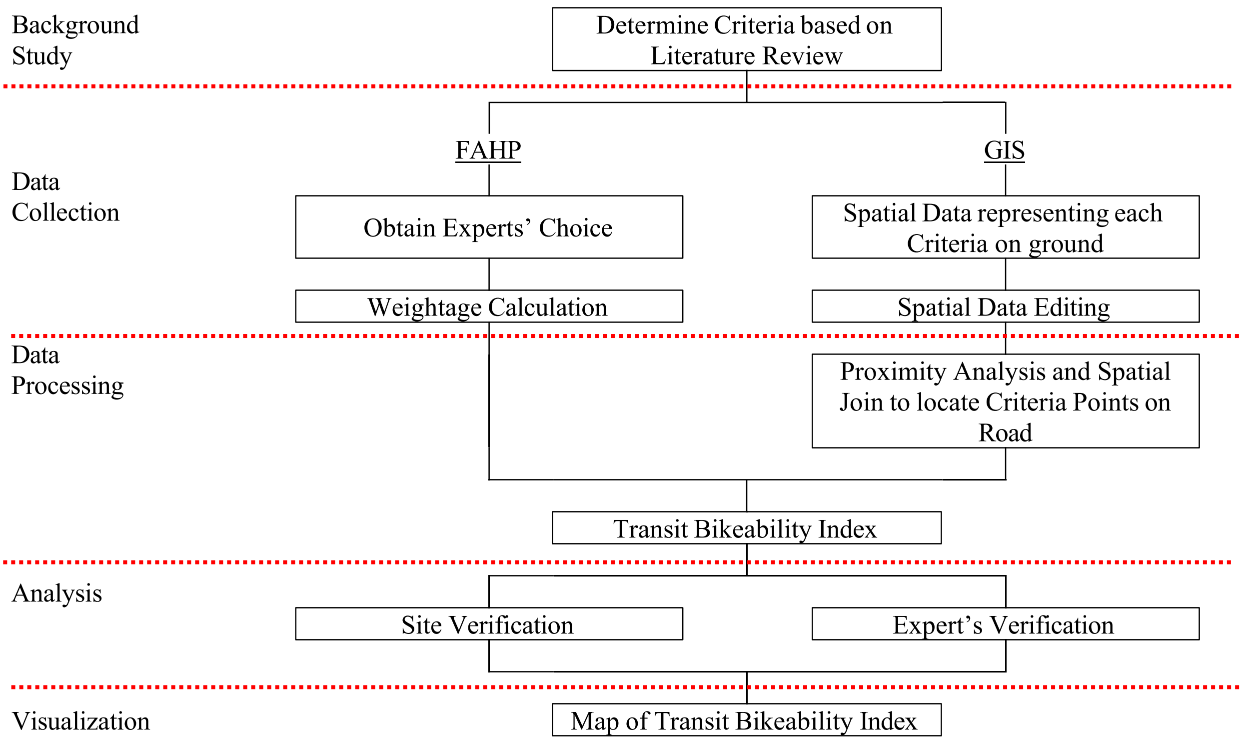

Figure 3.0 Flow Chart of Work

After all the data was collected, spatial data editing and processing were carried out to incorporate criterion weights into the analysis. Various spatial techniques were applied to refine and enhance the dataset, ensuring accuracy and consistency. A spatial join was used to integrate multiple criteria datasets, allowing for seamless combination and analysis. Additionally, proximity analysis was performed to verify that each criterion was correctly assigned within the designated coverage area. This step ensured that the calculated scores at each location accurately reflected the spatial characteristics and relationships of the underlying data, contributing to reliable and meaningful analytical results. To simplify data processing, a model was created in ArcGIS Pro using ModelBuilder to reduce human error when computing the TBI. This model allows users to enter criteria in shapefile format and weights in csv format that have been determined without having to carry out each process manually. This model can also be edited. Therefore, the index calculation process will be more systematic and consistent, thus increasing the reliability of the study results.

To assess the robustness of the results, sensitivity analysis, field validation, and expert validation were performed. Sensitivity analysis is essential to assess the robustness of the results and understand the influence of each criterion on the final index. This analysis systematically varies the weights of the criteria and shows how the values of the variables affect the bikeability scores and rankings of different areas. The field validation method was used to verify the accuracy and usability of the obtained TBI Index by checking whether the model results correspond to real-world conditions. The expert validation method involved consulting experts such as transportation engineers or professional cycling experts to review the TBI.

Finally, the TBI, which are categorized maps, were created to represent the road quality as either low, medium, or high using a three-level color scheme. Therefore, users can easily assess the visual differences using these colors to help highlight critical areas that need improvement, and which routes are easier for them to cycle.

IX. FINDINGS

The findings of this study is a map visualizing the TBI. The map could provide a comprehensive understanding of bicycle friendliness in different areas of the study region. It will highlight which bike paths have zones with various levels of bikeability—low, medium, and high—based on aggregated criteria where lower values indicate poor cycling conditions and higher values reflect well-developed cyclist-friendly infrastructure. With these results, it will identify which areas need good infrastructure, such as bike lanes or improved connections to public transit hubs. This research also helps in promoting cycling as a sustainable and healthy mode of transport as well as reducing traffic congestion.

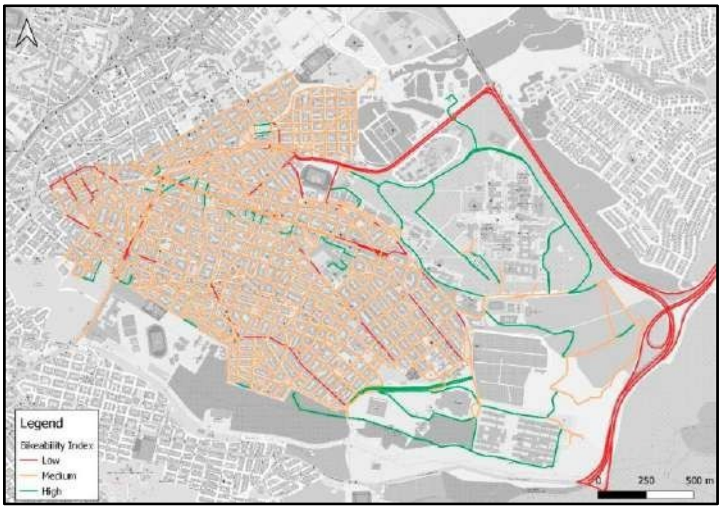

Figure 5.0 Expected Outcome of the Study (Karolemeas et al., 2022)

CONCLUSION

This study was developed to identify the TBI by integrating FAHP and GIS, which provides a structured framework for assessing cycling accessibility in urban areas. Through FAHP, it significantly improved the accuracy and reliability of the decision-making process by addressing uncertainty in expert judgment due to the incorporation of fuzzy logic to reduce inconsistencies in weighting. The development of the tool using ModelBuilder in ArcGIS Pro has proven to be a significant advancement, enabling automated data processing and spatial analysis that further streamlines and streamlines processes, minimizes human error, and increases data processing efficiency making this tool important due to its capabilities.

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REFERENCES

Arellana, J., Saltarín, M., Larrañaga, A.M., González, V.I., Henao, C.A. (2020). Developing an urban bikeability index for diferent types of cyclists as a tool to prioritise bicycle infrastructure investments. Transp. Res.Part A Policy Pract. 139, 310–334. https://doi.org/10.1016/j.tra.2020.07.010

Chang, D. Y. (1996). Applications of the extent analysis method on fuzzy AHP. European Journal of Operational Research, 95(3), 649–655. https://doi.org/10.1016/0377-2217(95)00300-2

Chang, K.-T. (2019). *INTRODUCTION TO GEOGRAPHIC INFORMATION SYSTEMS*. https://lccn.loc.gov/2017049567

Chondrogianni, D., Stephanedes, Y. J., & Fatourou, P. (2023). Assessing Cycling Accessibility in Urban Areas through the Implementation of a New Cycling Scheme. *Sustainability (Switzerland)*, *15*(19). https://doi.org/10.3390/su151914472

Codina, O., Maciejewska, M., Nadal, J., & Marquet, O. (2022). Built environment bikeability as a predictor of cycling frequency: Lessons from Barcelona. *Transportation Research Interdisciplinary Perspectives*, *16*. https://doi.org/10.1016/j.trip.2022.100725

Dai, S., Zhao, W., Wang, Y., Huang, X., Chen, Z., Lei, J., Stein, A., & Jia, P. (2023). Assessing spatiotemporal bikeability using multi-source geospatial big data: A case study of Xiamen, China. In *International Journal of Applied Earth Observation and Geoinformation* (Vol. 125). Elsevier B.V. https://doi.org/10.1016/j.jag.2023.103539

Demirel, T., Demirel, N. C., & Kahraman, C. (2008). Fuzzy analytic hierarchy process and its application. In C. Kahraman (Ed.), Fuzzy multi-criteria decision making. Springer optimization and its applications (1st ed., pp. 53–83). Springer. https://doi.org/10.1007/978-0-387- 76813-7_3

Fazio, M., Giuffrida, N., Pira, M. L., Inturri, G., & Ignaccolo, M. (2020). Bike oriented development: Selecting locations for cycle stations through a spatial approach. *Research in Transportation Business & Management*, *40*, 100576. https://doi.org/10.1016/j.rtbm.2020.100576

Guo, J., & Brakewood, C. (2024). Analysis of spatiotemporal transit accessibility and transit inequity of essential services in low-density cities, a case study of Nashville, TN. *Transportation Research Part A: Policy and Practice*, *179*. https://doi.org/10.1016/j.tra.2023.103931

Hardinghaus, M., Nieland, S., Lehne, M., & Weschke, J. (2021). Article more than bike lanes—a multifactorial index of urban bikeability. *Sustainability (Switzerland)*, *13*(21). https://doi.org/10.3390/su132111584

Ito, K., & Biljecki, F. (2021). Assessing bikeability with street view imagery and computer vision. *Transportation Research Part C: Emerging Technologies*, *132*. https://doi.org/10.1016/j.trc.2021.103371

Jin, T., Cheng, L., Wang, K., Cao, J., Huang, H., Witlox, F. (2022). Examining equity in accessibility to multi-tier healthcare services across different income households using estimated travel time. Transport Policy 121, 1–13. https://doi.org/10.1016/j.tranpol.2022.03.014

Karolemeas, C., Vassi, A., Tsigdinos, S., & Bakogiannis, D. E. (2022). Measure the ability of cities to be biked via weighted parameters, using GIS tools. the case study of Zografou in Greece. *Transportation Research Procedia*, *62*, 59–66. https://doi.org/10.1016/j.trpro.2022.02.008

Kellstedt, D.K., Spengler, J.O., Foster, M. *et al.* (2021). A Scoping Review of Bikeability Assessment Methods. *J Community Health* 46, 211–224. https://doi.org/10.1007/s10900-020-00846-4

Lee, J. (Brian), & Salih, S. H. (2024). Passive transit accessibility: Modelling and application for transit gap analysis and station area assessment. *Journal of Transport Geography*, *114*. https://doi.org/10.1016/j.jtrangeo.2023.103757

Litman, T. A., & Litman, T. (2024). *Evaluating Accessibility for Transport Planning Evaluating Accessibility for Transportation Planning*. www.vtpi.org

Malczewski, J. (2006). GIS-based multicriteria decision analysis: a survey of the literature. *International journal of geographical information science*, *20*(7), 703-726

Mohiuddin, H. (2021). Planning for the first and last mile: A review of practices at selected transit agencies in the united states. *Sustainability (Switzerland)*, *13*(4), 1–19. https://doi.org/10.3390/su13042222

Paulusová, I., & Sharmeen, F. (2024). School bikeability–what is it, and why is it important? An overview of key indicators and measurement. *Transport Reviews*. https://doi.org/10.1080/01441647.2024.2405218

Ros-McDonnell, L., de-La-Fuente, M. V., Ros-McDonnell, D., & Cardós, M. (2020). Development of a biking index for measuring Mediterranean cities mobility. *International Journal of Production Management and Engineering*, *8*(1), 21–29. https://doi.org/10.4995/ijpme.2020.10834

Saaty, T. L. (1980). *The Analytic Hierarchy Process.* New York: McGraw-Hill.

Saaty T. L., Ozdemir M. S. (2003). Why the magic number seven plus or minus two. *Mathematical and Computer Modelling:* 38(3–4),233–244. https://doi.org/10.1016/S0895-7177(03)90083-5

Santos, B., Passos, S., Gonçalves, J., & Matias, I. (2022). Spatial Multi-Criteria Analysis for Road Segment Cycling Suitability Assessment. *Sustainability (Switzerland)*, *14*(16). https://doi.org/10.3390/su14169928

Schmid-Querg, J., Keler, A., & Grigoropoulos, G. (2021). The munich bikeability index: A practical approach for measuring urban bikeability. *Sustainability (Switzerland)*, *13*(1), 1–14. https://doi.org/10.3390/su13010428

Shamshiripour, A., Rahimi, E., Shabanpour, R., Mohammadian, A. (2020). How is COVID-19 reshaping activity-travel behavior? Evidence from a comprehensive survey in Chicago. Transportation Research Interdisciplinary Perspectives, 7, 100216. https://doi.org/10.1016/j.trip.2020.100216

Tran, P. T., Zhao, M., Yamamoto, K., Minet, L., Nguyen, T., & Balasubramanian, R. (2020). Cyclists' personal exposure to traffic-related air pollution and its influence on bikeability. *Transportation Research Part D Transport and Environment*, *88*, 102563. https://doi.org/10.1016/j.trd.2020.102563

Tripathi, A. K., Agrawal, S., & Gupta, R. D. (2022). Comparison of GIS-based AHP and fuzzy AHP methods for hospital site selection: a case study for Prayagraj City, India. *GeoJournal*, *87*(5), 3507–3528. https://doi.org/10.1007/s10708-021-10445-y

Ustaoglu, E., & Aydınoglu, A. (2020). Suitability evaluation of urban construction land in Pendik district of Istanbul, Turkey. *Land Use Policy*, *99*, 104783. https://doi.org/10.1016/j.landusepol.2020.104783

Weikl, S., & Mayer, P. (2023). Data-driven quality assessment of cycling networks. *Frontiers in Future Transportation*, *4*. https://doi.org/10.3389/ffutr.2023.1127742

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