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Walkability Assessment of LRT Stations in Klang Valley Malaysia using GWI Criteria

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ABSTRACT

The success of any public transport service, particularly for individuals transitioning from car usage, hinges on the crucial ability to walk or bike safely to and from metro stations. This study aims to evaluate, compare, and rank the walkability of various Light Rail Transit (LRT) stations in Kuala Lumpur by utilizing the Global Walkability Index (GWI), with a specific focus on safety, security, comfort, connectivity, and cultural aspects. Using a questionnaire that includes demographic profiling and Likert scale questions aligned with the GWI approach, the study gathered data from 540 respondents through an online survey conducted at the Ampang Line LRT station. A random sampling approach was employed to guarantee representation and diversity. The gathered data underwent an in-depth analysis utilizing the Global Walkability Index (GWI), encompassing 18 variables across five factors. The findings indicated disparities in walkability across various LRT stations, with specific stations showing elevated walkability index values of 3.2, signifying a high level of pedestrian-friendliness. Notably, stations such as Sentul Timur, Titiwangsa, PWTC, Sultan Ismail, Bandaraya, Masjid Jamek, Plaza Rakyat, Hang Tuah, Pudu, Chan Sow Li, Miharaja, Maluri, Pandan Jaya, Pandan Indah, and Cempaka exhibited conditions conducive to walking, reflecting positive strides in establishing a pedestrian-friendly environment. Conversely, stations like Sentul, Cahaya, and Ampang, having walkability index values of 3.1, demonstrate the least favorable walkability levels, underscoring areas that necessitate enhancements to promote better walkability. The results of this study carry substantial implications for urban planners and policymakers, emphasizing the importance of comprehending walkability for well-informed decisions in infrastructure development. Enhancing walkability not only elevates the overall quality of life but also encourages the utilization of public transportation, thereby fostering environmental sustainability and mitigating traffic congestion.

Keywords:
Walkability index, pedestrian friendliness, LRT stations

1. Introduction

Transportation is an important factor in the development of sustainable cities. There is a growing need for sustainable transportation solutions due to increased concerns about energy usage, traffic congestion, and environmental deterioration. Because mass transit systems can accommodate huge

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numbers of passengers, ease traffic congestion, and have a smaller overall carbon footprint, they are becoming more recognized as sustainable modes of transportation. However, providing an acceptable degree of accessibility to stations is a crucial factor in making any feasible means of public transportation successful to attract more users. Several strategies can be used to encourage the use of public transportation, including developing walkability, implementing Transit Oriented Development, and strengthening the development of public transportation systems [1].

In general, high-quality walkable catchments can increase ridership on public transport services. Walkability pertains to the ease and safety of walking in urban areas, particularly for reaching key city attractions such as train stations, public transport stops, schools, shops, and parks. Possessing well-designed pedestrian infrastructure has the potential to motivate individuals to walk for their daily necessities. Specifically, enhancing the quality of pedestrian pathways near bus stops and railway stations could enhance the appeal of public transportation, promoting walk-to-transit practices by ensuring users can comfortably and safely cover the initial or final mile on foot [2]. Various elements influence the walkability and general accessibility of public transportation. These factors encompass principles related to Transit-Oriented Development (TOD), the quality of pedestrian infrastructure, the affordability and location of nearby housing, and proximity to workplaces and schools. Collectively, these factors determine the viability of walking commutes. The ease with which the transit stations can be accessed on foot, referred to as walking accessibility, plays a pivotal role in determining the alignment and placement of transit stops [3].

The walkability issues near Light Rail Transit (LRT) stations in Kuala Lumpur have become a noteworthy concern impacting the daily lives of many commuters. This stems from the LRT stations being positioned near major highways or secluded areas, leading to safety concerns and an increased walking distance for commuters. Moreover, adverse local weather conditions and other unfavorable factors further discourage pedestrians from journeying to the LRT stations. Thus, the study aims to determine the critical factors influencing public transport accessibility, scrutinizing the parameters involved in walkability analysis, and pinpointing the key walkability indices relevant to LRT stations. Through such endeavor, the findings from the study provide useful insights that can guide future planning and decision-making, ultimately striving to enhance the walkability and accessibility of LRT stations in Kuala Lumpur.

2. Literature Review

Many approaches have been suggested by literature to measure transit accessibility that reflects the modelling objectives. Transit accessibility measuring models are grouped into three categories: system-facilitated accessibility, physical access to transit stops, and access to destinations [4]. System accessibility models concentrate on utilizing various forms of transportation to gain physical access such as walking to public transportation stops, terminals, or stations. System-facilitated accessibility measures quantify the number of travelers able to reach a specific destination within a set time or distance using public transportation [5]. Access to destinations or integral accessibility measures the overall ease of reaching essential activity locations within a reasonable travel time using public transport [6].

Van Wee & Mouter [7] states that walkability represents the pedestrian-friendly conditions for walking that measure the quality of sidewalks, street intersections, land use patterns, and other factors that make walking an attractive mode of transportation. Community health, safety, and livability are improved when walkability is high; car dependence is reduced. As such, walkability to the nearest public transport stations has become a vital metric in addressing urban mobility challenges [8].

Jeffrey *et al*. [9] investigated the walkability of 230 train stations in metropolitan Melbourne, Australia, employing 14 distinct walkability measures. A two-stage cluster analysis was utilized to categorize the train stations based on their levels of walkability. The train station typology was validated using patronage data from different transport modes. The analysis revealed three clusters: train stations in Cluster 1 exhibited higher walkability and were predominantly situated in inner city areas, while those in Cluster 2 were the least walkable and generally located in middle and outer suburban areas. Train stations in Cluster 3 showed the most potential for transit-oriented development (TOD), possessing similar walkability features to those in Cluster 1 but with more parking facilities and local living destinations compared to the less walkable Cluster 2 train stations. The patronage data confirmed the cluster results, showing that cluster 1 train stations, characterized as the most walkable, had the highest percentage of pedestrian entries.

Huang *et al.*, [10] investigated walking behavior among a subgroup of 214 participants residing within one mile of 13 LRT stations, chosen from a sample of residents living in proximity or at a distance from a new LRT line in Seattle. The study revealed that the increase in the proportion of walking in the station areas was inversely related to the participants' distance from home to the nearest LRT station, peaking at distances less than 0.25 miles and decreasing beyond distances greater than 0.75 miles. In addition, the study discovered that factors such as male gender, college education, normal weight status, limited access to cars, and frequent LRT usage were significantly associated with more positive changes in the proportion of walking in station areas. The observed shift in walking behavior to station areas following the completion of the light rail suggests that the local population nearby is drawn to these areas, potentially benefiting both transit usage and economic activity in Transit-Oriented Development (TOD) zones. The residential catchment area for the shift in LRT area walking was within 0.75 miles of the LRT stations.

Ahmad *et al.*, [11] measured the Walkability in Pasir Gudang, Johore. The pedestrian friendliness index was estimated based on the three criteria: 1) residential density (measurement of the population density in each catchment area), 2) population density (measurement of how close a catchment area is to an intersection), and 3) land use diversity (measurement of how diverse the land uses are in each catchment area). The study revealed that Kampung Sentosa scored the highest Walkability Index, followed by Taman Bukit Dahlia, Taman Scientex, and Taman Kota Masai.

To assess the walkability of transit stations, various indicators related to physical aspects have been considered, including design [12], transit connectivity [13], density [14], and directness [15]. Previous studies have also examined factors such as proximity to transit stations [16], availability of transit [17], and frequency of transit service [18]. More recent research has incorporated land use-related factors such as residential density [19], density of job locations [20], density of educational facilities [21], density of grocery stores [22], and land use mix [23] into the analysis of walkability.

In addition to physical indicators, safety is a crucial consideration for walking to transit stations. Previous studies have explored aspects such as the adequacy of traffic signs and signals [24], as well as road traffic speed [25], addressing both traffic safety and crime-related safety concerns. Some studies have examined how safety concerns related to crime influence decisions about walkability. For example, Foran [26] discovered that factors such as crime rates in residential areas and the availability of path surveillance [27] considerably affecting walkability. Furthermore, there was a positive correlation between the perceived safety of walking facilities and proximity to transit stations, which enhances walkability [28]. For the data collection, the most pertinent study so far assessing perceived walkability employed a qualitative interview method [29], incorporating The Neighborhood Environment Walkability Scale (NEWS) and a survey questionnaire with 21 indicators rated on a Likert scale (1–5), ranging from 'poor' to 'excellent' [30].

3. Methodology
3.1 Study Area

The data collection was conducted at the Ampang Line LRT station (as shown in Figure 1) in Kuala Lumpur using a Google Form for an online survey. This study used a random sampling strategy, collecting data from 540 respondents across 18 LRT stations. The survey targeted a diverse range of respondents in terms of demographic characteristics and was distributed through various online platforms to ensure randomness.

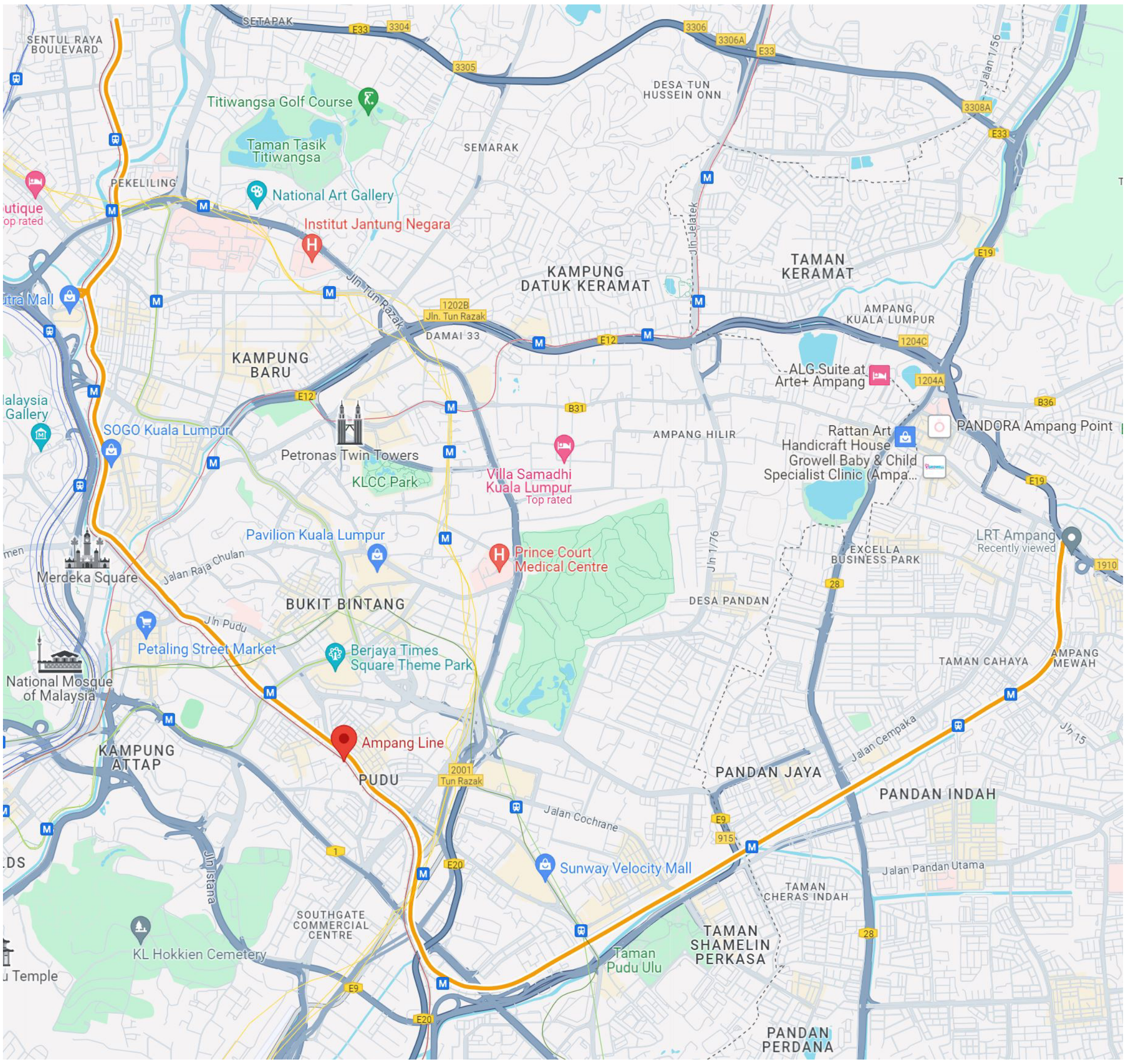

Fig. 1. Ampang LRT Line in Kuala Lumpur

3.2 Data Collection

In this study, the Global Walkability Index (GWI) [31] criterion: safety, security, comfort, connectivity, and cultural were used in the 5 Likert scales survey questionnaire. Each question's response ranges from 1 (strongly disagree) to 5 (strongly agree). The pedestrian perception variables that correspond to the GWI criterion are shown in Table 1.

Table 1
Items for the GWI Criterion

GWI criteria	Pedestrian perception variables	Variable mathematics representative
Safety	Pathway quality	α1
	Percentage of a street with a pathway	α2
	Pedestrian congestion	α3
	Points of conflict between pedestrians and another mode of transport	α4
	Pedestrian crossing facilities	α5
Security	Security from crime	α6
Comfort	Percentage of shaded pathway	α7
	Infrastructure for disabled	α8
	Types of shade	α9
	Signage for pedestrian	α10
	Temporary obstructions	α11
	Permanent obstructions	α12
	Street lighting	α13
	Cleanliness	α14
Connectivity	Pedestrian crossing facilities	α15
	Connectivity	α16
Cultural	The culture of Using LRT	α17
	Trend of LRT	α18

3.3 Analysis

The data analysis includes examining respondents' demographic information, evaluating the walkability of stations, and comparing the pedestrian-friendliness of stations using the Global Walkability Index (GWI). The average scores of each variable were calculated, summed, and then divided by the total number of variables. The Global Walkability Index was calculated using the following equation:

$$\text{GWI} = (\alpha1 + \alpha2 + \alpha3 + \alpha4 + \alpha5 + \alpha6 + \alpha7 + \alpha8 + \alpha9 + \alpha10 + \alpha11 + \alpha12 + \alpha13 + \alpha14 + \alpha15 + \alpha16 + \alpha17 + \alpha18 \times (1/18) \quad (1)$$

where, α1, α2, α3, ..., = average score of 1st variable, 2nd variable, 3rd variable of all the surveyed roads around the catchment area of the station.

4. Results and Discussion

4.1 Respondents Demographic Profile

From the perspective of the participants in the study, the findings of this research indicate a slight dominance of male users (62.6%) compared to female users (37.4%). The Malay ethnic group is the most prominently represented, accounting for 43.5% of the participants. The largest age group consists of riders aged 18–24 years, making up 51.1% of the respondents. A majority of participants are employed in the educational sector, and a significant proportion (92.8%) report a monthly income within the RM1000 range. Notably, 74.4% of respondents possess a driving license, suggesting potential access to private transport, while 50.9% express a preference for private transport over rail transit.

4.2 Evaluation of LRT Stations Walkability Index

Table 2 presents the results from the data analysis. For the safety across the stations, Stations 3 (Titiwangsa), 6 (Bandaraya), 14 (Pandan Jaya), 15 (Pandan Indah), and 16 (Cempaka) have attained the highest score of 2.5, indicating a heightened level of satisfaction with the quality of walking paths. Conversely, Station 2 (Sentul) registers the lowest safety score of 2.2, signaling the need for improvements in both path quality and safety features. Implementing measures like guard rails and addressing traffic conflicts can substantially enhance the overall safety of the commuting experience.

Table 2
GWI Performance for the LRT Stations

Station	Safety	Security	Comfort	Connectivity
Sentul Timur	2.3	1.0	**3.6**	2.9
Sentul	2.2	**1.4**	3.5	3.0
Titiwangsa	**2.5**	**1.4**	3.5	**3.1**
PWTC	2.3	**1.4**	3.5	**3.1**
Sultan Ismail	2.4	1.2	3.5	**3.1**
Bandaraya	**2.5**	1.2	3.5	**3.1**
Masjid Jamek	2.4	1.2	3.5	**3.1**
Plaza Rakyat	2.4	1.2	**3.6**	**3.1**
Hang Tuah	2.3	1.2	**3.6**	3.0
Pudu	2.4	**1.4**	3.5	3.0
Chan Sow Li	2.4	**1.4**	**3.6**	3.0
Miharaja	**2.5**	1.3	3.5	3.0
Maluri	2.4	1.3	**3.6**	3.0
Pandan Jaya	**2.5**	1.2	3.5	2.9
Pandan Indah	**2.5**	1.3	3.5	3.0
Cempaka	**2.5**	1.2	3.5	2.9
Cahaya	2.4	1.3	3.5	2.9
Ampang	2.3	1.3	3.5	2.8
Average	**2.4**	**1.3**	**3.5**	**3.0**

In terms of security, Stations 2 (Sentul), 3 (Titiwangsa), 4 (PWTC), 10 (Pudu), and 11 (Chan Sow Li) have achieved the highest rating of 1.4, indicating notable security features such as CCTV surveillance and sufficient lighting. Conversely, Station 1 (Sentul Timur) earns the lowest security rating of 1.0, underscoring the necessity for more robust security measures. Strengthening security protocols, including enhanced surveillance, improved lighting, and increased visibility of security personnel, can instill a greater sense of security among commuters.

Regarding comfort, Stations 1 (Sentul Timur), 8 (Plaza Rakyat), 9 (Hang Tuah), 11 (Chan Sow Li), and 13 (Maluri) boast the highest comfort score of 3.6. This score reflects a high degree of satisfaction with comfort-related features such as covered pathways and sufficient signage. All other stations included in the study received a score of 3.5, indicating a generally favorable level of comfort provision. This suggests the need to address issues like vendors conducting business on walkways and permanent obstructions. Enhancing amenities, ensuring accessibility, and maintaining cleanliness can contribute to an overall improvement in the comfort of public transportation stations.

On Connectivity, Stations 3 (Titiwangsa), 4 (PWTC), 5 (Sultan Ismail), 6 (Bandaraya), 7 (Masjid Jamek), and 8 (Plaza Rakyat) garner the highest score for connectivity at 3.1. This indicates the presence of safe pedestrian crossing facilities and satisfactory pathway continuity. Conversely, Station 18 (Ampang) records the lowest score at 2.8, underscoring the need for enhanced pedestrian connectivity. Improving pedestrian facilities, optimizing traffic signals, and providing well-connected pathways can significantly enhance overall connectivity and streamline the commuting process.

For cultural aspect, Station 1 (Sentul Timur) attains the top score of 5, indicating a pronounced preference for public transportation driven by environmental concerns. In contrast, Stations 12 (Miharaja), 17 (Cahaya), and 18 (Ampang) receive the lowest score of 4.6, suggesting a slightly lesser cultural inclination toward utilizing public transportation. Encouraging campaigns that raise environmental awareness, promoting the advantages of public transportation, and implementing eco-friendly initiatives can contribute to fostering a positive cultural shift towards sustainable commuting.

The findings suggest a notable variation in the perceived walkability performance of LRT stations, concerning the GWI criterion. Despite a high cultural score indicating robust environmental consciousness and a proclivity for public transportation, there remains an opportunity for further enhancements in promoting sustainable commuting practices. The lower scores in security underscore the imperative for transit authorities to invest in advanced security measures to align with commuters' expectations and needs.

4.3 GWI for the LRT Stations

The average scores for the station’s walkability index are presented in Table 3.

Table 3
Average GWI for the LRT Stations

Station	Average GWI
Station 1: Sentul Timur	3.2
Station 2: Sentul	3.1
Station 3: Titiwangsa	3.2
Station 4: PWTC	3.2
Station 5: Sultan Ismail	3.2
Station 6: Bandaraya	3.2
Station 7: Masjid Jamek	3.2
Station 8: Plaza Rakyat	3.2
Station 9: Hang Tuah	3.2
Station 10: Pudu	3.2
Station 11: Chan Sow Li	3.2
Station 12: Miharaja	3.2
Station13: Maluri	3.2
Station 14: Pandan Jaya	3.2
Station 15: Pandan Indah	3.2
Station 16: Cempaka	3.2
Station 17: Cahaya	3.1
Station 18: Ampang	3.1
Overall Walkability Index	3.2

The walkability index values across each station ranged from 3.1 to 3.2, suggesting an overall moderate to high level of pedestrian-friendliness. However, it's crucial to highlight that the walkability index couldn't attain the maximum value of 5. This limitation primarily stems from the average scores of station walkability performance outlined in Table III. The table demonstrates that specific factors, including safety, security, connectivity, comfort, and culture, garnered scores that contributed to the overall walkability index not reaching its maximum. For instance, certain stations received lower safety scores, indicating a need for improvement in path quality and safety features. Similarly, security scores revealed areas where enhanced security measures are necessary to meet commuters' expectations.

Notwithstanding these limitations, stations with walkability index values of 3.2, namely Sentul Timur, Titiwangsa, PWTC, Sultan Ismail, Bandaraya, Masjid Jamek, Plaza Rakyat, Hang Tuah, Pudu, Chan Sow Li, Miharaja, Maluri, Pandan Jaya, Pandan Indah, and Cempaka, showcase a notably high level of pedestrian-friendliness. These stations offer favorable conditions for walking, reflecting a positive initiative in creating a pedestrian-friendly environment. In contrast, stations such as Sentul, Cahaya, and Ampang with indices of 3.10 demonstrate the lowest level of walkability, indicating areas with potential limitations and requirements for improvements in walkability. With an overall walkability index of 3.2, the LRT stations demonstrate a moderate level of pedestrian-friendliness.

The results regarding the GWI performance of LRT stations provide valuable insights into the pedestrian-friendliness of the evaluated stations. Factors such as sidewalk quality, connectivity, and amenities play a crucial role in shaping the walking experience for commuters. By recognizing and comprehending these factors, urban planners and transportation authorities can prioritize enhancements and interventions aimed at improving the overall walkability of LRT stations. The average GWI scores for LRT stations yield a comprehensive evaluation and comparison, serving as a valuable tool for decision-makers to assess the current state of walkability and identify specific areas for improvement. In enhancing the existing public transport accessibility in the Klang Valley, Khalid & Samsudin [32] revealed that Transit Oriented Development (TOD) stands out as a promising solution to address several challenges faced by Kuala Lumpur residents. TOD can have significant impacts on a city, influencing both planning and land-use regulations. From a planning and legal perspective, TOD has the potential to transform land usage and elevate the value of the surrounding areas.

The study findings carry practical implications for urban planning strategies and policy interventions. Incorporating the identified factors and parameters into planning processes enables city authorities to design urban environments that are more walkable, accessible, and sustainable. This approach has the potential to decrease private vehicle usage, alleviate congestion, and reduce carbon emissions, fostering a transition toward more environmentally friendly and efficient modes of transportation.

5. Conclusion

This study employed GWI questionnaire to evaluate the accessibility of LRT stations in the Klang Valley. The findings of the study indicate that LRT stations in the Klang Valley exhibit a moderate level of pedestrian-friendliness, as reflected by the overall walkability index. The analysis highlights areas for improvement and offers valuable insights for urban planning and transportation policy. By considering the identified factors and utilizing the Walkability Index, policymakers and urban planners can implement targeted interventions to enhance walkability and create more inclusive, sustainable, and pedestrian-friendly environments.

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