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ASSESSING POTENTIALLY WALKABLE HERITAGE TRAIL IN JOHOR BAHRU, MALAYSIA USING ANALYTICAL HIERARCHICAL PROCESS AND GEOGRAPHICAL INFORMATION SYSTEM

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Abstract

This study aims to assess walkability on potential heritage trails in Johor Bahru City using AHP and GIS. In this study, MCDA was used to determine the weightage of the criteria used by GIS to assess the potentially walkable heritage trail in Johor Bahru City. Past studies have been used as a reference to determine the criteria for potentially walkable heritage trails. The criteria are all measurable and can be represented as spatial data on the ground to be used in GIS analysis. Then, the weightage was calculated using the Analytical Hierarchy Process (AHP), which is one of the MCDA weighing methods. The weightages were then used in Travelling Salesman Problem (TSP) Analysis to assess the potentially walkable heritage trail. Weightages are added as a cost during TSP analysis by calculating their value in a field script. The script includes the cost and each criteria name for a better understanding of the TSP process. A single heritage trail was produced that connects six different heritage locations while prioritizing criteria in this study when creating the heritage trail. The six heritage locations are the Royal Abu Bakar Museum, Johor Bahru Chinese Heritage Museum, Bangunan Sultan Ibrahim, Johor Ancient Temple, Masjid Al-Attas and Arulmigu Sri Rajakaliamman Glass Temple. The heritage trail has improved in its accessibility and travel time compared to the existing path. This indicates that travelling using potentially walkable heritage trails produced by this study will shorten travel time and be healthier as it focuses on walking rather than passive transportation.

Keywords: Analytical Hierarchical Process, Geographical Information System, Multi-criteria Decision Analysis, Travelling Salesman Problem, Walkable Heritage Trail

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INTRODUCTION

A heritage site serves as a cultural treasure, holding immense value for a country by encapsulating rich cultural elements and reflecting the identity of the local community or people. Essentially, a historical site serves as a continual bridge connecting the past to the present, narrating the societal story (Rostami et al., 2014). Johor Bahru City boasts numerous cultural heritage landmarks, including the over-a-century-old Sultan Abu Bakar Mosque, the Catholic Church of the Immaculate Conception, and the Johor Ancient Temple, hosting a Chingay procession for over 140 years. These cultural gems were integrated into the Majlis Bandaraya Johor Bahru (MBJB) urban development project along the Coronation Avenue, transforming the city into a metropolitan area. However, without proper monitoring and solutions in place, this urban expansion could jeopardize the cultural heritage.

The government urgently required real-time information on urban expansion to formulate effective legislation and policies for land management and protection (Ji et al., 2001). In order to promote walking as a viable travel option for both residents and tourists, a proposed heritage trail was introduced, incorporating walkability criteria as a crucial factor (Ghadzlie et al., 2024; Ruslan et al., 2023). The challenge, however, lies in the absence of studies addressing walkability on a proposed heritage trail. Selecting appropriate walkability criteria was essential and tailored to the specific conditions of Johor Bahru City and the proposed heritage trail. Researchers faced the dilemma of omitting certain variables when choosing criteria or models (Wong et al., 2011). Illustrating the efficacy of the proposed heritage trail using Crime Prevention Through Environmental Design (CPTED), a visual representation of the trail on a map was essential. Creating a cartography map and a dashboard emerged as the preferred method to offer interactive information for end-users and tourists, enhancing the overall experience.

LITERATURE REVIEW

Heritage trail is a trail that has been developed or designed based on history as its theme with the aim of acting as a connecting journey to link sites, attractions, and other businesses by providing interactive or factual and fictional information such as legend or myth along the way (Timothy and Boyd, 2015). Every government aims to provide a walkable environment, such as a safe path to downtown, a pleasant experience for elders, women, children, people with disabilities, and reduced automobile dependency. Thus, the concept of a walkable heritage trail combined could be described as a safety trail with an environment perceived as walkable, designed with history as the theme. The walkable heritage trail concept highlighted that each trail had a unique or special theme for its location, visual aesthetic qualities, and safety (Orbasli and Vellinga, 2020). A successful

walkable heritage trail possessed strong meaning-making and had been developed through a detailed selection and interpretation process to ensure the trail was "worthy of preservation, visitation, and remembrance" (Cantillon, 2020). Another benefit of a walkable heritage trail was that it enhanced the concept of aesthetics. A proper walkable heritage trail improves a city's view or environment and sense of place. In a sense, a walkable heritage trail provides tourists with an opportunity to immerse themselves in experiencing cultural and historical sites in a more immersive and dynamic way (Miles, 2017).

RESEARCH METHODOLOGY

In this study, the weightage for criteria was obtained based on the ratings provided by experts through interviews. The interviews were conducted with experts in this field, such as architects and people working in the tourism industry. The purpose of this was to ensure that the weightage reflects the actual practices and preferences of the residents and users of paths or roads in Johor Bahru City. The process of obtaining the weightage involved several stages. Firstly, the criteria were identified during the literature review. Then, an Analytical Hierarchical Process (AHP) model was developed, as shown in Figure 1. This model included control criteria and sub-criteria, with arrows indicating the dependencies between them.

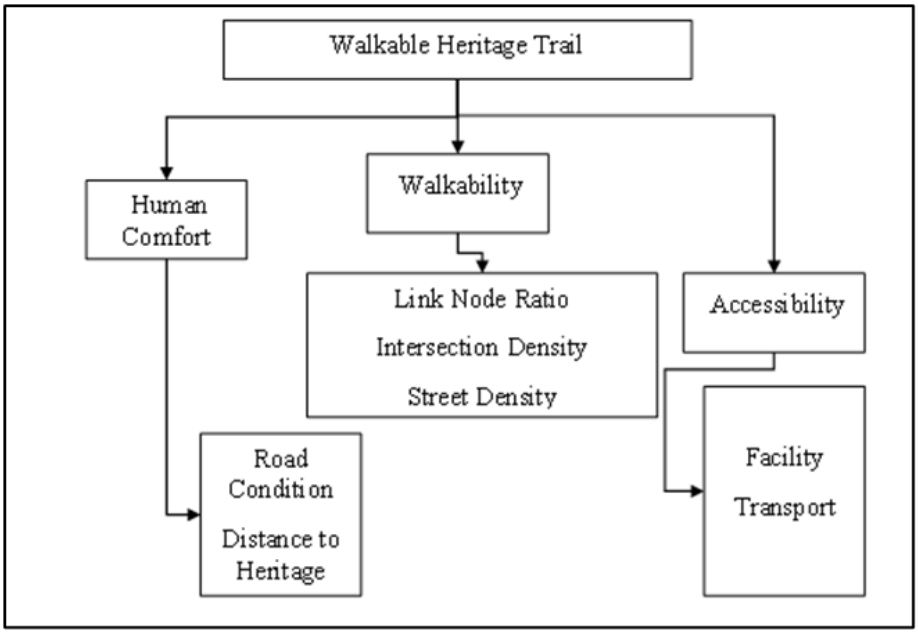

Figure 1. Analytical Hierarchical Process Model
Source: Authors (2024)

The model in Figure 1 consists of three main criteria: walkability, human comfort, and accessibility. Human comfort is further divided into sub-criteria, i.e., road condition and distance to heritage sites. Accessibility includes sub-criteria such as facility and transport. Walkability encompasses intersection density, link node ratio, and street density as its sub-criteria. Next, ratings were obtained from the choices made by experts. Experts were selected based on two conditions: they had to be residents of Johor Bahru City or tourists who had experienced touring the city. Once the ratings were identified, the weightage could be derived and concluded.

Criteria for this study were derived using the AHP formula. If public opinion implied that road condition is preferable to distance to the heritage site, the value was put under the road condition column. As for the calculation, each column over one was totalled. Then, the criteria value in each row for that column was sum. The total sum of the row was multiplied by the number of criteria over one. The general formula can be defined by the equation below. Alternative n is the number of criteria of the same level; if it is the main criteria, l is the number of main criteria (l = 1, 2, ..., p). According to (Malczewski and Rinner, 2015), alternative wk(l) is the weight assigned to the kth attribute associated with the lth objective. Then, the v(aik) is the value function. The sub-criteria will also use the same equation, but the value acquired was multiplied by the value of the main criteria. Refer to Equation 1 for the criteria formula calculation with the general alternative.

$$V(A_{\mathrm{i}}) = \sum_{k=1}^{n} w_l w_{k(l)}\, v(a_{ik}) \qquad (1)$$

Next, assess the walkable heritage trail using the Travelling Salesman Problem (TSP) available in ArcGIS. The input or data needed in TSP is network data and point data acquired by converting building data. In this study, a criterion attribute field will be prepared to provide a cost or barrier during TSP analysis according to the criteria of this study. Figure 2 presents the procedure for determining a walkable heritage trail using TSP analysis.

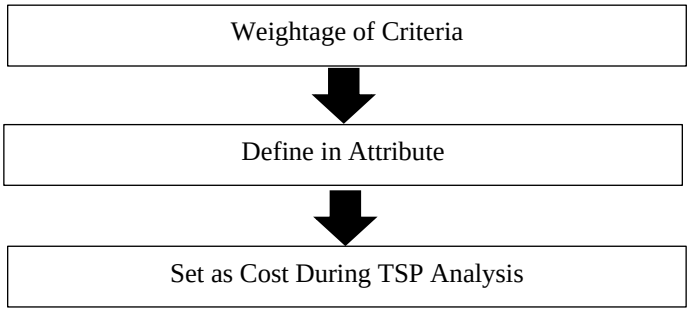

Figure 2. Procedure of Determining Walkable Heritage Trail using TSP Analysis
Source: Authors (2024)

The process involved three fundamental steps. Firstly, the weightage of each criterion was obtained through AHP based on expert opinions. Secondly, the attribute field was defined by assigning the weightage values to each criterion. For example, if road condition was given a higher weightage compared to the distance to heritage sites, the weightage attribute field for road conditions would have a higher value compared to the distance to heritage sites. Finally, in the TSP analysis, there was an option to set the cost as the weightage for analysis. In this step, the attribute field with the weightage value of the criteria was set as the cost attribute. Figure 3 presents the field script for the cost attribute in the attribute field during the TSP analysis. The cost for each criterion was obtained from the AHP analysis conducted using the Superdecision software.

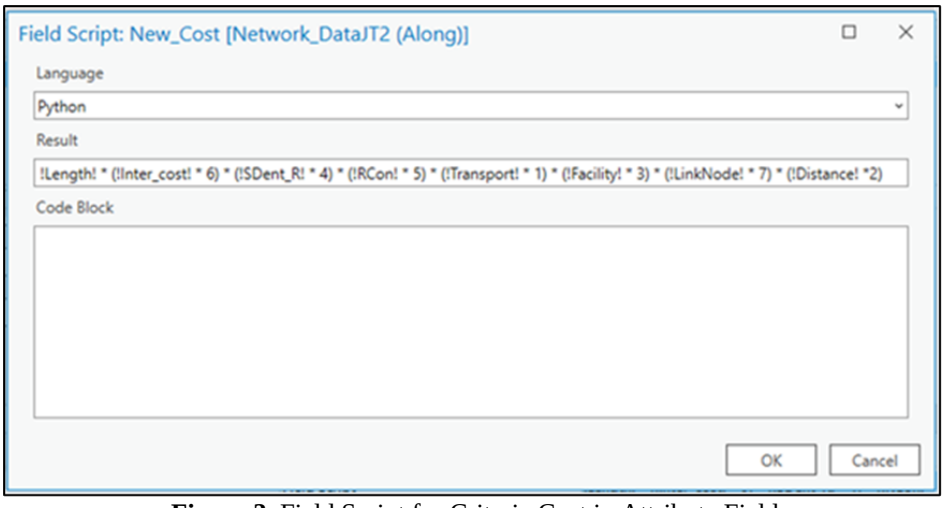

Figure 3. Field Script for Criteria Cost in Attribute Field
Source: Authors (2024)

The field script could be selected in the network dataset properties, specifically under the travel attributes tab, and then the cost tab could be chosen. In this study, a new cost attribute was created for the network dataset using a Python script, as illustrated in Figure 3.8. The script included various components, such as length, inter_cost, RCon, transport, facility, Linknode, and distance, each multiplied by their respective weightage values. For instance, length represented the length of the road in meters, inter_cost denoted the intersection density multiplied by six, RCon indicated the road condition multiplied by five, transport referred to the transport dataset acquired from Google Maps multiplied by one, facility represented the facility dataset acquired from MBJB multiplied by three, Linknode represented the link node value acquired from processing the network dataset multiplied by seven, and distance represented the distance to the heritage site multiplied by two.

ANALYSIS AND DISCUSSION

Criteria for Potentially Walkable Heritage Trail in Johor Bahru City

In this study, the weightage of each criterion for the potentially walkable heritage trail was determined to prioritize the criteria during the network analysis process. The Analytical Hierarchical Process (AHP) method was used to calculate the weightage values. In order to determine the relative importance of each criterion, pairwise comparison techniques were employed to gather expert choice preferences. Pairwise comparison methods involve ranking or assessing the competence level of a set number of choices (Kułakowski, 2018). The questionnaire used for pairwise comparison included all main and sub-criteria, divided into four sections. The questionnaire was administered to three expert respondents with knowledge and experience in tourism, heritage, and town planning. One respondent worked in the tourism industry, another was an academician with previous experience in tourism, and the third respondent was an architect.

Weightage of Potentially Walkable Heritage Trail in Johor Bahru City

Weightage is important in AHP since it shows which criteria should be prioritized during network processing. Weightage shows which criteria should be ranked above the other criteria, and the ranking is used to decide which path is taken to provide the best potential walkable heritage trail according to this study's needs. Since weightage acquired in this study was from multiple individuals, the concept of group judgement and geometric mean calculation was done to finalize the weightage value.

The concept of group judgment in reorganizing the ranking of weightage involves a collaborative approach to reassessing and adjusting the importance or priority of criteria in a ranking system. When the initial ranking of

weightage does not adequately reflect the group's collective judgment or new insights arise, the group comes together to reevaluate and reorganize the weights assigned to each criterion. Almost all methods to determine group judgement are based on the assumption that there are no actual ties in this judgement between each individual (Bury and Wagner, 2008).

Table 1. First Respondent Weightage Result

Criteria	Weightage
Distance to Heritage Trail	0.146129
Facility	0.020933
Intersection Density	0.00712
Link Node Ratio	0.019644
Road Condition	0.584516
Street Density	0.054197
Transport	0.167461

Source: Authors (2024)

Table 1 shows the result of weightage acquired from the first respondent of this study questionnaire. The weightage of criteria with the highest value is road condition. According to the first respondent, road conditions are extremely important for assessing a potentially walkable heritage trail in Johor Bahru City. Meanwhile, the lowest criterion weightage is intersection density. This may happen because the respondent considered that places with more intersections are a hassle, or it preferred to walk through a route or path with single road making.

Table 2. Second Respondent Weightage Result

Criteria	Weightage
Distance to Heritage Trail	0.247960
Facility	0.072124
Intersection Density	0.020064
Link Node Ratio	0.005174
Road Condition	0.030995
Street Density	0.046689
Transport	0.576994

Source: Authors (2024)

Table 2 shows the second respondent weightage result acquired from the AHP questionnaire. The second respondent or expert has a different approach to determining the priority of each criterion because, from the three available experts, only the second respondent has a different value of the most important criteria for the walkable heritage trail in Johor Bahru City. This showed the importance of group judgement as different people or experts provided different judgements. The second respondent considered transport extremely important for

potentially walkable heritage trails in Johor Bahru City. Meanwhile, the link node ratio is valued as the least important for potentially walkable heritage trail criteria.

Table 3. Third Respondent Weightage Result

Criteria	Weightage
Distance to Heritage Trail	0.108186
Facility	0.011988
Intersection Density	0.077816
Link Node Ratio	0.020064
Road Condition	0.540932
Street Density	0.181074
Transport	0.059939

Source: Authors (2024)

Table 3 displays the weightage results obtained from the questionnaire completed by the third and final respondent in this study. The criterion with the highest weightage value is road condition, indicating its significant importance in identifying a potentially walkable heritage trail in Johor Bahru City, according to the last respondent's perspective. On the other hand, the criterion with the lowest weightage value is facility. This decision may be attributed to the abundance of facilities already present in Johor Bahru City. Therefore, the respondent considered it less crucial as most routes would likely pass through facilities regardless of the chosen route.

Table 4. Geometric Mean Weightage Results

Criteria	Weightage
Distance to Heritage Trail	0.108186
Facility	0.011988
Intersection Density	0.077816
Link Node Ratio	0.020064
Road Condition	0.540932
Street Density	0.181074
Transport	0.059939

Source: Authors (2024)

Table 4 presents the mean weightage results for all the criteria of potentially walkable heritage trails in Johor Bahru City, calculated using the geometric mean. The mean weightage indicated that road conditions obtained the highest value of 0.21399825, reflecting its significant importance in determining the potentially walkable heritage trail. Conversely, the criterion with the lowest weightage value was the link node ratio, with a value of 0.01268113. This result aligns with the weightage tables from all three respondents, as two tables assigned a higher weightage to road conditions while all three tables assigned a lower

weightage to the link node ratio. Notably, the second respondent's weightage table exhibited the lowest weightage value for the link node ratio criterion.

Potentially Walkable Heritage Trail in Johor Bahru City

This study aimed to provide an output of potentially walkable heritage trails in Johor Bahru City. Considering that visitors often prefer self-guided tours, their experience is a key concern (Hayes and Macleod, 2008). Therefore, this study focused on analyzing and identifying potentially walkable heritage trails in Johor Bahru City that are safe and comfortable for self-guided tours. The study specifically centered around heritage sites in Johor Bahru city as destinations. Criteria such as road conditions, distance to each heritage site, facilities, and transport were determined based on a center-to-edge approach, with the heritage sites serving as the central focus. This allowed the study to prioritize particularly significant criteria for this research.

Map of Potentially Walkable Heritage Trail in Johor Bahru City

Figure 5 below shows the potentially walkable heritage map of Johor Bahru city. Maps include a route path that should be taken to discover some of the most historical and aesthetic in the city while walking on a trail with pedestrian walkways, pedestrian overpasses, passing through local food restaurants and facilities such as public toilets, hotels, and nearby bus stops.

The title of this map is "Johor Bahru Heritage Trail Map", and "Welcome to Johor Bahru" as its introduction. The map includes walking duration with an estimated time of two hours, and information on each heritage building in Johor Bahru city is shown on the map. Information about the heritage building includes the date or year of establishment, the influential person who launched the inauguration of the building if available, and any achievements the heritage building might have had during its glory days. The trail starts from building number one until building number six respectively. The information on the left side of the map for each building uses the same numbering shown in the heritage trail. The trails started from the Royal Abu Bakar Museum, Johor Bahru Chinese Heritage Museum, Bangunan Sultan Ibrahim, Johor Ancient Temple, Masjid Al-Attas and Arulmigu Sri Rajakaliamman Glass Temple, respectively.

Figure 5. Potentially Walkable Heritage Map of Johor Bahru City
Source: Authors (2024)

Table 5. Attribute Table for Potentially Walkable Heritage Trail in Johor Bahru City

Lane	Length (m)	Time Travel (h)	Time Travel (hour, minute, second)
1	2531	0.843667	0 hours, 50 minutes, 37 seconds

Source: Authors (2024)

Table 5 shows the results acquired from TSP processing. This study only produces one heritage trail as the TSP method is a method to visit each set of locations while assessing the shortest distance for such a trip (Rexhepi et al., 2013). As defined by Rexhepi in its research study, the output of TSP method analysis is one single route traverses through all heritage sites. The total length from Royal Abu Bakar Museum to Arulmigu Sri Rajakaliamman Glass Temple is 2531 meters or 2.531 kilometers, and the total time travel is 0.843667 hours or 50 minutes and 37 seconds.

Site Verification for Walkable Path for Heritage Trail in Johor Bahru City

Verification of walkable heritage trails includes several assessments or evaluations. First is safety assessment, which helps assess potential safety hazards along the route. By inspecting the trail firsthand, one can identify any obstacles, slippery surfaces, steep sections, unstable terrain, or other conditions that may pose a risk to walkers. This information is crucial for ensuring the safety of trail users and implementing appropriate measures to mitigate potential dangers. Since

most of the trails use pedestrian paths, slippery surfaces are invalid or checkout for this assessment.

Figure 6. Terrain and Accessibility Along Walkable Heritage Trail
Source: Authors (2024)

Figure 6 shows the condition of terrain and accessibility in Johor Bahru City during site verification of the study area along the walkable heritage trail. As can be seen in the figure with a tree above, the terrain surface along the Royal Abu Bakar Museum, which is the first destination in this study, was stable terrain and in good condition. Johor Bahru City road condition is good and well-maintained. Because it is a royal city and rich in history, it can be a good reason why the roads in the city are in good condition. Additionally, verifying walkable heritage trails includes accessibility evaluation. Verifying walkable heritage trails allows for evaluating the trail's accessibility for different user groups, including individuals with disabilities, the elderly, or those with limited mobility. By examining the trail's slope, width, surface quality, and the presence of accessible infrastructure such as ramps or handrails, the verification process helps determine if the trail meets accessibility standards or if modifications are necessary to enhance inclusivity.

Heritage Trail in Improving Accessibility in Johor Bahru City

Heritage trails aim to improve accessibility by providing inclusive and engaging experiences for visitors to historical sites and cultural landmarks. These trails are designed to enhance access to heritage sites, ensuring that people of all abilities can explore and appreciate the historical and cultural significance of these locations. By implementing criteria in this study, heritage trails can become more accessible, enabling a wider range of visitors to engage with and appreciate the cultural and historical significance of the trail. Creating an inclusive experience ensures that everyone can participate and enjoy the rich heritage on display.

Travel Time for Potentially Walkable Heritage Trail in Johor Bahru City

Figure 7 shows comparisons between the existing path and heritage trail in Johor Bahru City. The existing path is green, the heritage trail is red, and the line that is in a darker color is the path that is used by both the existing path and the heritage trail. The symbol with the restroom logo is used to show the facilities available in Johor Bahru City, which was acquired from Majlis Bandaraya Johor Bahru (MBJB).

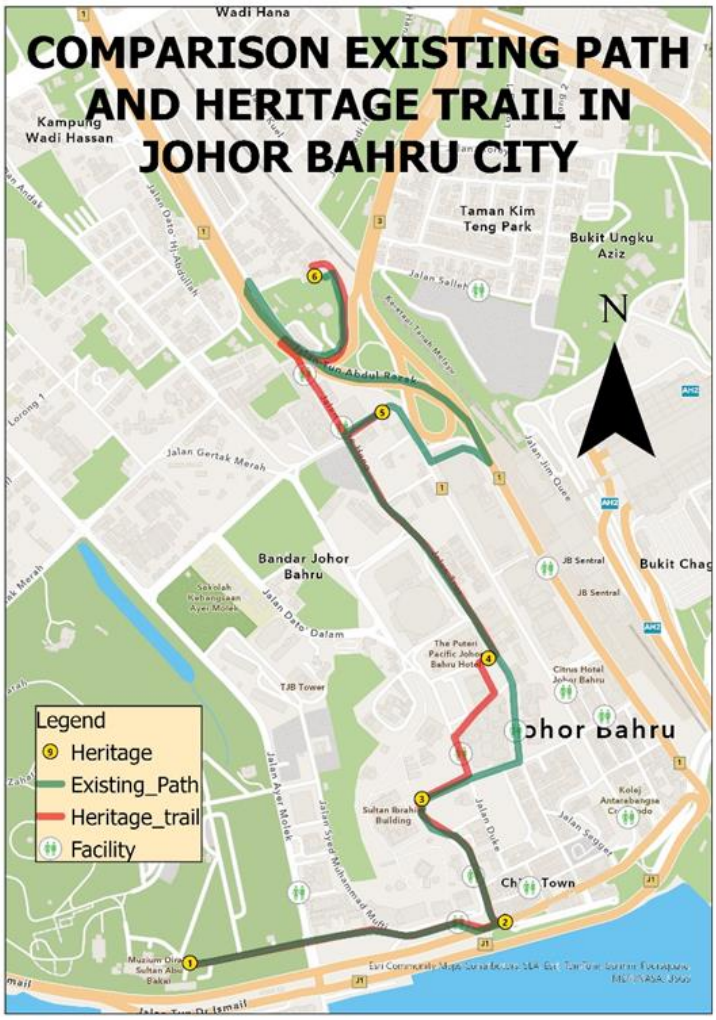

Figure 7. Comparison of existing path and heritage trail in Johor Bahru City
Source: Authors (2024)

As can be seen in Figure 7, the existing path passes through four facilities, while the heritage trail passes through five facilities. The existing path passes through highways or main roads much more frequently than the heritage trail, which focuses on passing through roads with pedestrian paths, which means less vehicle traffic and is suitable for tourists to walk.

Table 6 shows a comparison table for the existing path and potential heritage trail in Johor Bahru City using the TSP method and creating a single path that passes through all heritage locations similar to the heritage trail map. Table 6 has three columns, which are from right for lane, length in meter units, and time travel shown in hours, minutes, and seconds, respectively. The existing path length is 3620 meters or 3.62 kilometers, and the time travel taken to finish it is 1 hour, 12 minutes and 24 seconds. Meanwhile, the heritage trail acquired from this study is only 2531 meters or 2.531 kilometers and takes 50 minutes and 37 seconds.

Table 6. Comparison Table for Existing Path and PotentialHeritage Trail in Johor Bahru City

Lane	Length (m)	Time Travel (hour, minute, second)
Existing	3620	1 hour, 12 minutes, 24 seconds
Heritage	2531	0 hours, 50 minutes, 37 seconds
Difference	1089	0 hours, 21 minutes, 47 seconds

Source: Authors (2024)

Cost attributes bend the result of TSP analysis in producing an optimal road while prioritizing all seven criteria in this study. It is evident, as a result, in Figure 7, that both existing paths without cost attributes overlap with potentially walkable heritage trails with cost attributes. The method of storing and arranging data on travel cost attributes in a geodatabase proves to be an excellent tool used in different types of spatial models (Ursu & Bulai, 2012). Databases have a few benefits, including the ability to model the behavior of geographic objects, the ability to assign rules, and the efficient and reliable administration of relationships across internal datasets (Nicaora & Haidu, 2011).

CONCLUSION

To conclude, this study aimed to identify potential heritage trails in Johor Bahru City using AHP and TSP analyses. The study addresses issues arising from a preliminary background study, emphasizing the significance of heritage sites in preserving culture and stimulating the local economy. The first objective involves determining criteria for assessing walkable heritage trails, drawing from 22 literature sources to establish main criteria such as walkability, human comfort, and accessibility. The second objective focuses on identifying potential heritage trails, employing AHP for weightage determination and TSP analysis to find an

optimal route. The study concludes that TSP analysis offers a single, optimized route through all destinations. The third objective involves visualizing the heritage trail through GIS mapping successfully creating a heritage map for Johor Bahru city. Ultimately, all three objectives are achieved, providing a comprehensive approach to enhancing tourist experiences and preserving cultural heritage in the city.

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