

DETERMINING THEMED WALKING TRAILS IN BANDAR HILIR MALACCA BY USING SPATIAL-MCDA

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ABSTRACT

Themed walking trails are becoming popular these days. It connects different type of destinations and therefore would enhance a better travel experience. The trails which aiming for people to seamlessly exploring an area should not be limited to have short travelling time and distance only. Many factors need to also be considered such as safety, accessibility, infrastructure, and facilities. With that, the trails could offer a diverse range of experiences to the end-users. Hence, this study was conducted to determine the themed walking trails with an increased focus on the criteria. The objectives of this study are; (i) to identify suitable criteria for finding the themed walking trails, (ii) to identify the themed walking trails by using Spatial-MCDA, and (iii) to create a map visualizing themed walking trails. This study utilized Spatial-MCDA to determine themed walking trails which took public preferences into consideration in finding the potential routes by using GIS. In this study, three (3) themed walking trails connecting popular attractions in Bandar Hilir, Malacca, were determined which are (a) Eateries Trail, (b) Shopping Trail, and (c) Heritage Trail.

1. INTRODUCTION

Trails are a type of linear attraction that directs the visitor's experience, by providing several routes that have a purpose, and are interpreted. It has become increasingly popular in the previous three decades (Nemanja, 2016). It can also be found in rural areas, cities, and even on the beach, as well as underwater areas and themed tours. It is accessible by foot or other means of transportation. Trails can range from a very local to an international scale, and various stories and themes can be interpreted. It is very attractive to be used as a used tourism product. This is because, it is very beneficial to the destination manager in managing visitors, providing opportunities for interpretation as well as the creation of a strong place image. With the concept of a 'nested hierarchy of trails as well as experience elements on the trails and even formed by various types of trails, scales, and locations, and all of them operate in the wider policy environment and more comfortable. By placing the visitor experience at the heart of their model, they emphasize the importance of trails' interpretative function (Boyd, 2014).

The concept of a themed walking trail or route is really not new things, and many of nowadays popular trails are based on the ancient

pilgrim as well as the trade routes and hiking trails. New trails, on the other hand, have been made to satisfy the growing need for diverse place products and to address the demand for more personalized tourism experiences (Boyd, 2014). The more applied components of the trails field have received the most attention, and there is a growing literature on the creation of food and wine routes (Law, 2012), the trails' potential for tourism development Briedenhann & Wickens, 2004), their importance in historical interpretation (Al-Hagla, 2010; Kong, 2021) and trail users of the environmental impacts (Manning, 2001).

A trail is a visible linear route of many types that is visible on the ground and may have an original and historical linear transport or travel function at its roots. A route, on the other hand, is often based on a modern-day conceptualization and classification of a circuit or course that connects related natural or cultural attractions into a thematic linear corridor (Boyd, 2014; Svenson et al., 2021). Scenic routes have become more important since the 1980s. These are routes that pass through scenic natural and cultural areas with high aesthetic value for visitors (Schill & Schill, 1997; Suaib et al., 2020). Scenic routes usually follow natural features such as mountain

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ranges or coastlines, and they can elicit awe or nationalist sentiments due to their emphasis on national symbolism and identity.

Depending on whatever institution or individual is defining it and for what purpose, the term 'trail' has a wide range of definitions (Guthrie, 2006). The National Recreation and Park Association in the United States (US) classifies trails as greenway trails, park trails, and connector trails, which connect parks to workplaces and schools (Moore & Shafer, 2001). Trails are defined as all natural or man-made linear corridors in rural or urban areas that are designated as trails, paths, or routes for the purpose of recreationists, tourists, or travellers, regardless of their mode of transportation.

Walking trails can be developed or planned for various purposes. Thus, it named, themed walking trails. They could be for exploring nature or scenic area, historic sites, urban tourist attractions, and more. This is to satisfy the need of the people who are visiting the area to maximize their experience in exploring the area. Many countries offered this type of trails for tourist. For example, Switzerland which is rich in nature and is known to have many panoramic trails that tourist can walk through such as Panoramic Trail between Mannlichen and Kleine Scheidegg. The countries even provided map of the walking trails both static and interactive web map that tourist can refer to if they want to explore the region by walking. One of the web maps is known as Switzerland Mobility which can be accessed at this URL: <https://map.wanderland.ch/>.

A Geographic Information System (GIS) allows for the integration of geographic and attribute data, as well as the creation of an action plan and developmental plan for long-term sustainability. It has the ability store, retrieve, analyze, display data related to land use, land cover, urbanization, and environment. High-resolution satellite images are now a useful resource on land use and land cover information. Land suitability index maps can be easily created and used to identify suitable zones for land development in many disciplines using remotely sensed data and radar data, such as Landsat; Shuttle Radar Topography Mission (SRTM) digital elevation model; meteorological data and various land use information, integrated with GIS software capabilities. On the other hand, some expansion modules propose integrating a powerful decision support system with analytical tools, such as multi-criteria optimization methods, spatial analysis, and statistical tools. This development is known as Multi-Criteria Decision Analysis (MCDA), which is a useful tool for making decisions based on multiple criteria (Alabi et al., 2012).

MCDA has several methods that can be used to derive the weightage of criteria which were be used in the decision analysis (Malczweski & Rinner, 2015). One of it was Analytical Hierarchical Process (AHP) that helps as a decision-making framework and was deals with integrated GIS spatial analysis for the relative suitability of land. An integrated GIS-based MCDA method was now widely used in spatial analysis for suitable site selection (Mohit & Ali, 2006). GIS and MCDA were played an important role in site selection when a sustainable land-use planning approach is used. In addition, in land suitability, AHP was a widely used technique in the MCDA method

for urban planning and management. Currently, the development of GIS has a significant impact on the dynamic nature of urban and regional development. The GIS provides an integrated land-use assessment for urban development planning and monitoring. The ArcGIS spatial analysis function allows for the identification and collection of spatial data, as well as weighting with AHP.

The AHP was a pair-wise comparisons approach eigenvalue technique. It was provided a numerical fundamental scale ranging from 1 to 9 for calibrating the quantitative and qualitative performance of priorities. Furthermore, the AHP is effective in ensuring group decision-making involvement. The hierarchy enables evaluation of the contribution made by individual criterion at lower levels to criterion at higher levels of the hierarchy (Saaty, 2008). The AHP's general purpose was to assist decision-makers in selecting the best alternative from the various possible choice alternatives when multiple priorities are present. The analytic hierarchy process was a multiple criteria decision-making tool that combines GIS spatial analysis functions in land suitability analysis to produce suitability maps. One of the most important AHP methods is one that was integrated with various GIS data layers. It was generated suitability models in any type of decision-making analysis for evaluating land-use suitability (Chandio et al., 2011).

GIS provides a framework for collecting, managing, and analysing data. GIS is defined as information that is geographically referenced to the earth and displayed on a map. GIS is a collection of tools and software that were used to store, access, map, and analyse geographic data. Apart from that, GIS also was be defined as a data framework that consists of a number of procedures that are carried out on raw data to produce data that is useful when making decisions.

GIS had been implemented for various purposes due to its vast capabilities in making analysis be it for raster and vector data. The vector data model was also known as a discrete object model. It uses a discrete object in order to represent a spatial feature on the Earth's surface. In addition, vector data was be produced with three (3) of basic step which is classifies spatial features, structure the properties and spatial relationship and code and stores the vector data into a digital data file. Besides that, vector data model was used the geometric object such as point, line and polygon in order to represent the simple spatial features. For a point, it has a zero dimension and made of a point or also was made of a set of separate points. A polygon is two-dimensional and made of to connected, close and also was to nonintersecting the line segments. In addition, a polygon also was stand alone and not share a boundary with the other polygons. The last geometric objects are a line. A line known to be a one-dimensional and also has two end points such as point A and point B. A point in between used to mark the shape of the line (Chang, 2016).

Thus, this study was conducted in an attempt to determine the themed walking trails by using Analytical Hierarchical Process (AHP) and GIS. The combination of AHP and GIS had been implemented widely in decision making involving multiple criteria. The AHP

was responsible in determining the weightage of the criteria while GIS will use the weightage in making the decision. In this study, AHP will weigh the criteria to be used in planning for walking trails while GIS will find the walking trails using Least Cost Path analysis which will consider the weightage into consideration in determine the themed walking trails.

2. METHOD

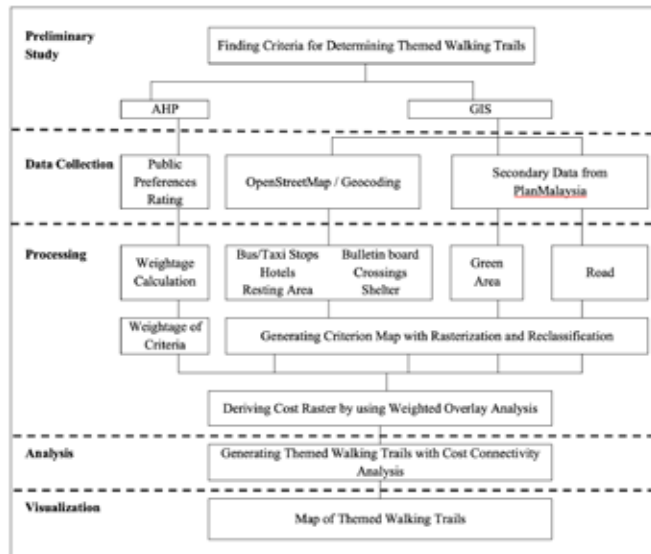


Figure 1: The flowchart of research methodology

This study was conducted in five (5) stages: background Study, Data Acquisition, Data Processing, Data Analysis, and Visualization, as illustrated in Figure 1.

Each stage was provided with its steps. The research methodology section provided a detailed description of the procedure for completing this study as well as the techniques that were used. The literature review relevant to this research was described briefly and in detail in the first stage, which is the background study. In addition, information on the study areas and software that were be used is included. The next stage was data collection. Data acquisition is an important part of the study because it was necessary to determine the data needed for this study, which can come from any source such as open-source or data collected from any relevant agency.

Following that, the data processing section described all of the techniques that were used in this study. Data processing was divided into two (2) parts for this study: AHP and GIS. The results of this data processing were then used to analyse data in the data analysing section. The final stage of this study’s methodology was visualization, where a map visualizing Malacca’s Themed Walking Trails was created.

2.1 Background Study to find Criteria for themed walking trails

The first objective of this study is finding suitable criteria for finding the themed walking trails, which was solved by using the literature review. Many factors impacting the choice of walking trails, according to a previous study had been identified. In determining

themed walking trails, a total of 20 journals were reviewed to find the criteria that were used in this study to determine the themed walking trails.

Previous studies are a source to refer to in finding the criteria used in this study. In the previous study, three (4) criteria were taken to find themed walking trails: safety, Accessibility, Facilities, and Infrastructure. This is because these are the most used criteria in previous studies and are appropriate for use in this study.

Each of the criteria has the sub-criteria representing them on the ground. In the example of the main road, affecting the safety of users in passing through the walking trails can be attributed to the problem statement highlighted for this study. In terms of accessibility, it would be nice if trail users could have a place to stop, such as public transportation stops by the walking trails. Besides that, facilities available on walking trails such as green areas and shelters can provide comfort and convenience to trails user when passing through.

The concept of walking trails is interesting, yet it should be planned carefully to ensure a good walking trail as well as satisfying the trails user needs and requirements. To do so, many criteria or factors need to be considered. Many studies have implemented similar sets of criteria. Mostly, studies in Malaysia uses safety, access, facilities and infrastructure. Meanwhile, other countries’ studies have used all the (4) four characteristics or at least safety, access and infrastructure, as described in Table 1.

Table 1: Previous Studies Mentioning Criteria for Themed Walking Trails

Author(s)	Criteria			
	Safety	Accessibility	Facilities	Infrastructure
(Timothy et al., 2015)	✓		✓	
(WTO, 2019)	✓	✓	✓	✓
(Meyer, 2004)	✓	✓	✓	✓
(Moore et al., 2009)	✓	✓	✓	✓
(James Luke, 2013)	✓	✓		✓
(Niek Bebelaar, 2020)	✓	✓	✓	✓
(Kristan et al., 2017)	✓	✓	✓	✓
(Shuangyu Xu, 2014)	✓	✓	✓	
(Rohit Venkat, 2018)	✓		✓	✓
(Kristin Godtman et al., 2017)	✓		✓	✓
(Roosta et al., 2019)	✓		✓	✓
(Zainul Rijal, 2020)	✓		✓	✓
(Nor Mazlan et al., 2021)	✓	✓		✓
(Mohd Hasrul et al., 2020)	✓	✓		✓

Safety

A walking trail must be safe in terms of pedestrian accidents, traffic accidents, and criminal activity. As we know, the main road is a busy road with any vehicle. Therefore, we need to avoid a main road along the walking trail to make it easier for tourists to use the walking trail without having to feel uncomfortable with the density of vehicles

passing there. To keep the walking trail in a safe environment, we were able to provide a traffic light come with a crossing walk. It can help tourists to go through the walking trail without any worries especially when wanting to cross the road.

Accessibility

A route should be easily accessible from tourist centres, which are for tourists, and urban or residential areas, which are for residents. Walking trail that is accessible can improve connectivity with the tourist attraction area thus making it easier for people to visit the area by foot. In addition, for residents, the accessibility of walking trails to their residential area mean that more people will use the trail around their areas, thus could enhance a local economic as well.

In addition, it is important for the walking trails to be accessible by public transportation as well so that people could come to the area by using public transport, then explore the area by foot. For people visiting the area by private vehicles, it is important to have the walking trail accessible to parking areas too. It is also important for walking trails to be accessible to the hotels around the area since when it comes to tourist centres, hotels will definitely be the main focus for tourists from all over the world. Some tourists like to look for accommodation such as hotels located close to tourist areas.

Facilities

Facilities also are one of the criteria that need to be focused. It needs to be consider placing the benches around the trail. For example, Beginner walkers and walkers with special needs may find these benches useful as a rest break. Besides that, we were considered to proximity to the natural attractions such as scenic views, native vegetation, waterfalls, lakes and coastline to attract the tourist to enjoy their walk. Other than that, prepare the presence of existing facilities that may support or facilitate the use of the trail, such as car parks, toilets, picnic facilities, camping sites, tourist information centres, cafés, and tour operators to facilitate tourists.

Infrastructure

Infrastructure should also be emphasized when it comes to walking trails. As we know, tourist areas should provide complete infrastructure to facilitate tourists. By providing a green area in the walking trail area, it helps to make the walking trail more attractive. The green area was provided a peaceful atmosphere to the people around it. As a result, tourists will also have a pleasant time while explore the themed walking trail. Moreover, providing a vending machine can also help the infrastructure of the walking trail become more complete.

2.2 Data Collection

Before data processing can begin, the spatial dataset is necessary to determine themed walking trails. This study required a combination of two (2) types of data, which are from AHP and GIS. This step needs to be taken to get data from the City Council. This process may take a long time due to contact with external parties. Table 2 shows the data required for this study along with the sources of the data.

Table 2: Requirement of Data

Type	Reason(s)	Source
Criteria Rating	To determine the rating of criteria	AHP pairwise comparison
Traffic Light		
Crossings		
Shelter		
Bulletin Board		
Resting Area		Google Earth Pro, Software MapINR
Public Transportation Stops	To represent the criteria on ground	
• Bus Stop		
Accommodation		
• Hotel		
Zoning		PlanMalaysia Malacca
Land Use of Bandar Hilir		
Road Network	To meter the accessibility of the themed walking trail	Open Streets Map (OSM)

Spatial Data Collection.

This study used two (2) data collection methods which are primary data collection and secondary data collection as described in Table 2. Spatial data collected using primary data collection are the Traffic Lights, Crossings, Shelter, Bulletin Board and Resting Area which was obtained using mobile GIS data collection with MAPinr. For Secondary Data Collection, spatial data for Public Transportation Stops, Hotel and roads were obtained from OpenStreetMap and Zoning and Landuse were obtained from PlanMalaysia Malacca.

AHP.

AHP method which is pairwise comparison was one of the methods that had been used in this study. To obtain Public Preferences using the AHP method, several processes have been completed before it is used in the calculation of criterion weights. First and foremost, the Hierarchical Structure was developed after identifying the criteria required for the themed walking trail. Next, the rating of the criteria was obtained by using pairwise comparison technique before the weightage for each can be calculated.



Figure 2: Hierarchical Structure

The rating of the criteria was obtained by using pairwise comparison technique before the weightage for each can be calculated by using the Equation 1.

$$V(A_i) = \sum_{k=1}^n w_1 w_{k(1)} v(a_{ik}) \quad [1]$$

Where;

n = the number of criteria

= criterion weightage of sub-criteria

= value function

2.3 Data processing

After the data to be used has been collected, data processing was taken place. All data used was converted into usable information in the data processing section. As a result, the data processing section for this study was divided into two (2) parts, namely the AHP section and the GIS section.

Spatial Data Preparation for Criteria

Because the majority of the data was obtained through open-source, the quality of the data may not be as high as we would expect. Furthermore, the information was digitized. Errors in digitization are to be expected. In addition, the data set must be topologically edited. Topological editing was a type of editing that restricts coincident geometry and related nodes and edges. In addition, the projection system of each of the data were standardised so that they all have the same projection system.

Weightage Calculation using AHP

AHP was used to calculate all of the weightage criteria that have been listed that were the attributes for the spatial data used to determine the Themed Walking Trail. The calculation of weightage was begun with a rating of the criteria based on the public’s preferences using pairwise comparison. The weightage calculation for the criteria and sub-criteria listed for this study were then take place.

Table 3: Standardize weightage for each of the sub-criteria

Criteria	Weightage	Sub-Criteria	Weightage
Safety	0.43	Crossing	0.06
		Avoid Main Road	0.37
Accessibility	0.18	Public Transportation Stops	0.06
		Hotels	0.12
Infrastructure	0.13	Green Area	0.05
		Shelters	0.08
Facilities	0.26	Resting Area	0.13
		Bulletin Board	0.13

The results of the Public Preferences were then be calculated to determine a set of precedence for the criteria and sub-criteria used as attributes in determining the Themed Walking Trail. Table 3 summarizes the weightage for each sub-criterion for themed walking trails. After inserting weightage for each criterion and sub-criteria’s scores, the model was verified, run, and a visualization map for themed walking trails in Bandar Hilir, Malacca was generated.

Cost Connectivity to Find the Themed Walking Trails.

Cost Connectivity was one of the methods available in GIS

applications. The Cost Connectivity tool is to define the optimal network of least paths, not to create separate paths connecting one region to another. Using the paths, the phenomenon can move from one region to another on the resulting network, possibly traveling through other regions. This technique was used in determining Themed Walking Trails as shown in Figure 3.



Figure 3. Process of Determining Themed Walking Trails

2.4 Analysis

The Themed Walking Trails travel time was analysed. Furthermore, the results of the Themed Walking Trails in Malacca were compared to the existing walking path. The improvement made by the Themed Walking Trails to travel between the same origin and destination with the existing walking path was examined. The time travel is then calculated using the length distance.

2.5 Visualization

Visualization was the final step for this study. ArcGIS software help due to display the final results for this research. As a result, one (1) final output was produced, which was a map of a themed walking trail in Malacca. In addition, the map was showing all of the walking trails and their linked themes. At the end of this study, a map was produced that shows three (3) types of themed walking trails, namely Heritage trails, Shopping trails, and Eateries trails. Each of these themed walking trails were differentiated through the use of different colours for each. For example, heritage trails were used a red line. While eateries trails were used blue line and shopping trails line green. As a result, with this map, all end-users or tourists can use it to guide them through the themed walking trail. This can help them understand the themed walking trail better and provide the best experience possible while accessing the themed walking trail.

3. RESULTS AND DISCUSSION

Based on the weightage obtained by using AHP that has been made, the themed walking trails in Bandar Hilir, Malacca were determined by using the weighted overlay technique. As seen in Figure 4, the weightage of main criteria with the highest index 0.4395 for safety which indicates that the trails users are concerned about their safety and hope that traveling from one location to the next will be safer and easier. Safety has as the highest priority, with a score of 0.4395. While Infrastructure is the lowest priority, obtaining only 0.1291. This factor could be due to the crowded Bandar Hilir area, which is always full of vehicles during the day and night because it is a tourist centre area that is always an attraction for tourists who visit Malacca.

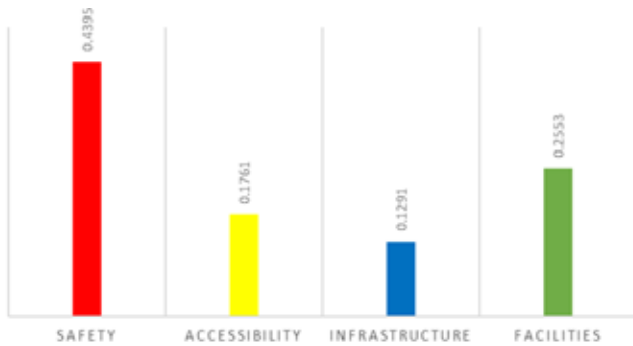


Figure 4: Weightage of main criteria

In this study, the generated themed walking trails in Bandar Hilir, Malacca map is the result of a weighted overlay in which each of the main criteria and sub-criteria are combined into one layer. The relationship between each of the main criterion data that has been processed and has been classified with sub-criteria that have been validated by experts from Malacca Tourism Department.

From the result, many trails are concentrated in the centre of Bandar Hilir, Malacca. This is due to the presence of a tourist centre as well as shopping malls, which are frequently the source of attraction for users of themed trails. As a result, eateries walking trails has the most advantages and attractions out of all the themed walking trails. This is understandable given Malacca’s well-known reputation for its wide and varied food culture. A variety of food and beverages are available in areas that are frequently the focus of the public, making eateries walking trails more appealing.

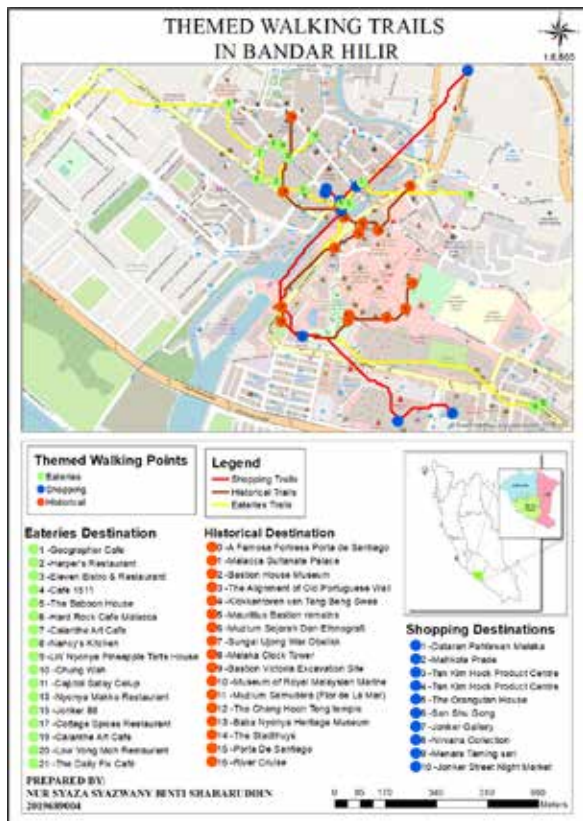


Figure 5: Map of Themed Walking Trails in Bandar Hilir, Malacca

Additionally, results for historical walking trails and shopping walking trails are expected. Both trails have their own set of attractions. It is very beneficial for trail users to continue accessing historical destinations in the study area when using historical walking trails. This is because people are aware that Malacca is a historical state. Malacca is thus known as Malacca Historic City. As a result, it creates space for trail users to enjoy and learn about Malacca’s history.

3.1 The improvement in walking time around Bandar Hilir with Themed Walking Trails

After discovering Themed Walking Trails the travelling time using the existing routes were compared to analyse if there is any improvement can be achieved with the new routes. A time comparison was performed between the proposed new walking trails and the existing walking trails in the study area as shown in Table 4.

Table 4: Comparison of Total Distance of Themed Walking Trails with Existing Trails

Themed Trail	Existing		Proposed		Differences	
	Distance	Time	Distance	Time	Distance	Time
Heritage	3.5km	41 mins 40 secs	1.9km	22 mins 37 secs	1.6km	19 mins 03 secs
Eateries	4.3km	51 mins 11 secs	3.5km	41 mins 40 secs	0.8km	09 mins 31 secs
Shopping	3.5km	41 mins 40 secs	2.0km	23 mins 49 secs	1.5km	17 mins 51 secs



Figure 6: Existing Historical Themed Walking Trails in Bandar Hilir

Figure 6 represents the existing historical-themed walking trails leading to Bandar Hilir’s historical destination. The existing routes that can be used to visit all historical sites is 3.5 km while the proposed new route is only 1.9 km. As a result, the distance between the existing routes and the proposed historical walking trails is 1.6 km. If time travel is used, a leisure pedestrian walking speed of 1.4m/s is imposed. There is a time difference of 19 minutes and 03 seconds between existing routes trails and proposed historical-themed walking trails. This is due to the existing routes travel time of 41 minutes and 40 seconds. While the proposed walking trail takes 22 minutes and 37 seconds. As a result, the new historical-themed walking trail can save time and provide a shorter alternative route than the existing route.

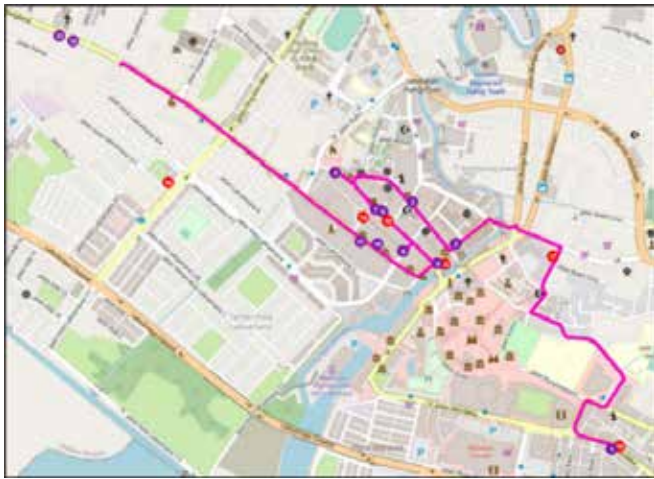


Figure 7: Existing Eateries Themed Walking Trails in Bandar Hilir

Figure 7 depicts the existing routes that can be used in accessing the eateries in Malacca's Bandar Hilir. The distance of the existing routes is 4.3km. The proposed eateries-themed walking trails are 3.5 km. This clearly shows that the distance between the existing routes and the proposed eateries-themed walking trails is 0.8 km. The existing route takes 51 minutes and 11 seconds to complete, while the proposed walking route takes 41 minutes and 40 seconds. Thus, the time difference between the existing routes and the proposed eateries-themed walking trails was 9 minutes and 31 seconds. As a result, it demonstrates that the new eateries-themed walking trails save more time than the existing routes.



Figure 8: Existing Shopping Themed Walking Trails in Bandar Hilir

Figure 8 depicts the existing routes that can be used in visiting the shops around Bandar Hilir, Malacca. Because Bandar Hilir is a popular tourist destination in Malacca, there are numerous shopping options. The existing routes in Bandar Hilir, Malacca, are 3.5km long. However, the proposed shopping-themed walking trails are 2.0km long. Thus, the differences in the distance between the existing routes and the proposed shopping-themed walking trails is 1.5km. Existing routes would take 41 minutes and 40 seconds to complete. However, the proposed shopping-themed walking trails take 23 minutes and 49 seconds to complete. As a result, the time difference

between the existing routes and the proposed shopping-themed walking trail is 17 minutes and 51 seconds. This demonstrates that the new shopping-themed walking trails are more cost-effective in terms of time and distance than the existing routes.

4. CONCLUSION

This study has determined the criteria to be used in determining themed walking trails in Bandar Hilir, Malacca. Among the four (4) criteria are safety, accessibility, facilities, and infrastructure. In conclusion, all of the objectives outlined for this study have been achieved. The findings reflect that all objectives of this study had been achieved. First, the criteria and subcriteria found from previous studies and had been verified by expert were weighed. Their weightage actually in-line with the previous studies as Safety is the most important criteria. This shows, no matter anywhere, safety is the first priority when it comes to active transportation, including pedestrian. With this, the first objective of this study had been achieved. The second objective is about finding the themed walking trails. By using Path Analysis, the trails were found. The trails were also compared with the existing routes to see if it provides any improvement in the walking experience. And yes, they did provide improvement. This may encourage more tourists to visit and take advantage of the themed walking trails.

For future works, Malacca is well-known for being a popular destination for the wider public, especially tourists. However, due to time constraints, not all areas of Malacca can be covered. As a result, only a few areas can be covered for this study, which is Bandar Hilir, the main city of Malacca. There are many identified areas in Bandar Hilir that can be visited. As a result, it is suggested that the study area be expanded so that the themed walking trails can be investigated more thoroughly. The themed walking trails can be studied and evaluated to determine the best route to many destinations.

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