Journal of Research in Mathematics Trends and Technology
Journal homepage: https://talenta.usu.ac.id/jormtt

Integration of AHP and VIKOR Method to Select the Optimum Destination Route

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ARTICLE INFO

Article history:
Received: 8 January 2024
Revised: 11 February 2024
Accepted: 29 March 2024
Available online: 30 March 2024

E-ISSN: 2656-1514
P-ISSN:

How to cite:
Gultom, P., Miranda., Nababan, E.S.M., Mardiningsih., Suyanto, "Integration of AHP and VIKOR Method to Select the Optimum Destination Route," Journal of Research in Mathematics Trends and Technology, vol. V6, no. 1, Mar. 2024,
doi: 10.32734/jormtt.v6i1.17717

ABSTRACT

Using a variety of criteria, group decision-making is a popular method for rating possibilities. Here, we assess each choice based on the same standards. AHP and VIKOR techniques have been proposed to address the problem of creating detours to the historical tourism attractions of Medan City. This study modifies the VIKOR technique to identify a feasible solution while evaluating options with both narrow and broad requirements. This study provides numerical examples based on case studies to illustrate the application of the proposed model and assess the effectiveness of this approach modification. The results show that the updated strategy is effective and realistic.

Keyword: AHP, VIKOR, network analysis, transportation historical destinations

1. Introduction

By changing the criteria used in the decision-making process, Multi-Criteria Decision-Making (MCDM) is a method of decision-making that assists in identifying superior alternatives. Decision-making systems employ the Analytic Hierarchy Process (AHP) and Visekriterijumsko Kompromisno Rangiranje (VIKOR) as two techniques to handle a variety of problems, including waste management and resource allocation[1]–[3]. While VIKOR is a multicriteria optimization and compromise solution approach used to optimize solutions and establish a compromise that meets several criteria, AHP is a decision-making system developed by Saaty and its team. By integrating different criteria and alternatives into decision-making processes, the combination of AHP and VIKOR in decision-making systems enables decision-making to obtain optimal and compromise solutions by taking into account a variety of aspects and perspectives[4]–[6]. AHP and VIKOR have been employed in some research in a variety of settings, including train systems, resource allocation, and hybrid LiFi/WiFi access. In transportation planning, network analysis is a technique used to assess the viability of alternate routes[7]. The best route can be found using a technique called network analysis, which takes into account factors like time. For instance, in the case of Medan's mass passenger transportation, the optimal route with the least amount of time needed was determined using the Network Analysis approach[8], [9]. When using this strategy, datasets with pertinent properties are utilized for analysis.

One of Indonesia's largest cities, Medan is well-known for its cosmopolitan population and promise in a number of areas, such as economics, human resources, and agriculture[10], [11]. The purpose of the study is to determine how more people visiting Medan's tourism destinations such as its museums, art galleries, and educational institutions will affect those places. The study will concentrate on how the growth of Medan's tourism infrastructure and the city's economy are affected by an increase in visitors. Through an examination of the many influences on the city's economy, the study seeks to offer important information for upcoming planning and development initiatives.

2. Method

The steps of this research are shown in Figure1:

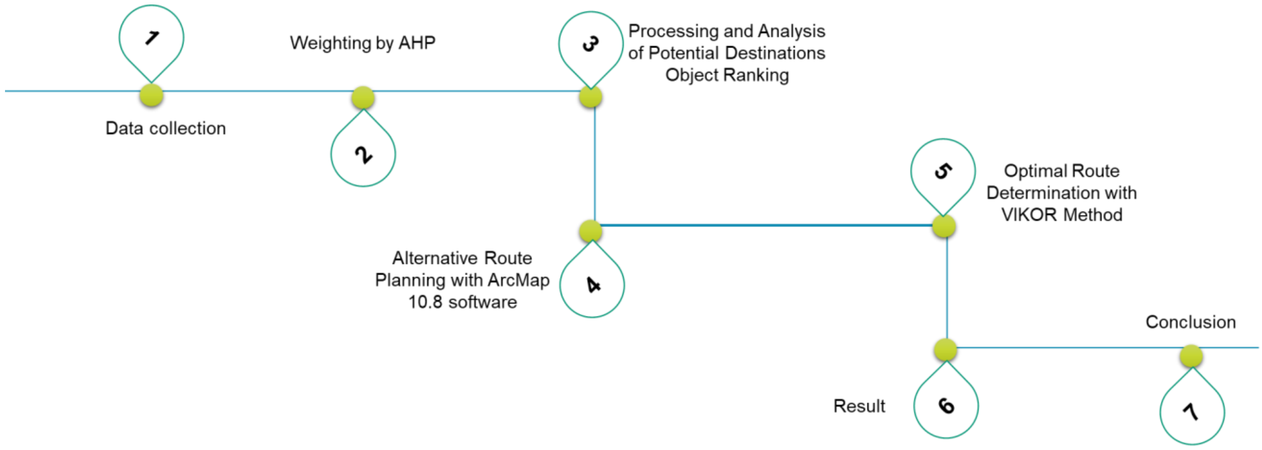

Figure 1. Research Method Diagram

The study employed AHP pairwise comparison questionnaires, which were based on expert assessments and included respondents from related agencies. Additionally, shapefiles of Medan City administrative boundaries, transportation roads, public facilities distribution, and historical destination objects distribution were utilized[12], [13]. Additionally, statistical data was collected on the number of visitors to Medan City historical destination objects in 2023, as well as data on the reputation of these objects based on public questionnaire distribution. Finally, quantitative data was collected on the number of attraction facilities in Medan City historical destination objects in 2023.

3. Result and Discussion

Ranking Historical Destinations Using Weighting and Sub-Criteria

Based on the responses supplied by the three expert respondents on the AHP questionnaire, computations were made to determine the weights of each criterion and sub-criteria from the parameters. Table 1 shows the weights of the three criteria, including accessibility, amenities, and attractions. Table 2 shows the weights of the accessibility sub-criteria[14], [15]. Table 3 shows the weight values of the amenities sub-criteria. Table 4 shows the weights of each attraction sub-criteria.

Table 1. Weight of Expert Respondent Assessment Criteria

Criteria	Code	Weight
Accessibility	A1	0.153
Amenities	A2	0.562
Attractions	A3	0.285

Table 2. Weight of Accessibility Sub-Criteria Assessment of Expert Respondents

Sub-Criteria	Code	Weight
Main Road Access	B1	0.192
Public Facility Access	B2	0.365

Information & Guidance	B3	0.443

Table 3. Weight of Amenities Sub-Criteria Assessment of Expert Respondents

Sub-Criteria	Code	Weight
Public Facilities	C1	0.397
Destination Reputation	C2	0.5
Supporting Facilities	C3	0.103

Table 4. Weight of Attractions Sub-Criteria Assessment of Expert Respondents

Sub-Criteria	Code	Weight
Number of Visitors	D1	0.796
Number of Attractions	D2	0.102
Cultural & Historical Value	D3	0.102

The weight can be employed to evaluate historical tourist objects through the weighted overlay approach, as the comparison matrix is deemed appropriate when the inconsistency ratio value is less than 0.1.

Processing Standards for Sorting Supposed Historical Travel Destinations

1. Accessibility Criteria

Using ArcMap 10.8 software, data is processed for accessibility criteria using Euclidean Distance and then categorized using the weighted overlay approach. Fig. 2 displays the outcomes of the processing. The distance between each location is shown by the color used to represent the accessibility criteria. As said in class 1, the regions that are nearest to public amenities and major roads are those with the lightest blue color (class 1), whereas the areas that are furthest from these sites are those with the darkest blue color (class 5). The places in Fig. 2 have the following classes and distances:

- Class 1: 0 to 346.39 meters
- Class 2: 346.39 to 692.77 meters
- Class 3: 692.77 to 1,039.16 meters
- Class 4: 1,039.16 to 1,385.54 meters
- Class 5: 1,385.54 to 1,731.93 meters

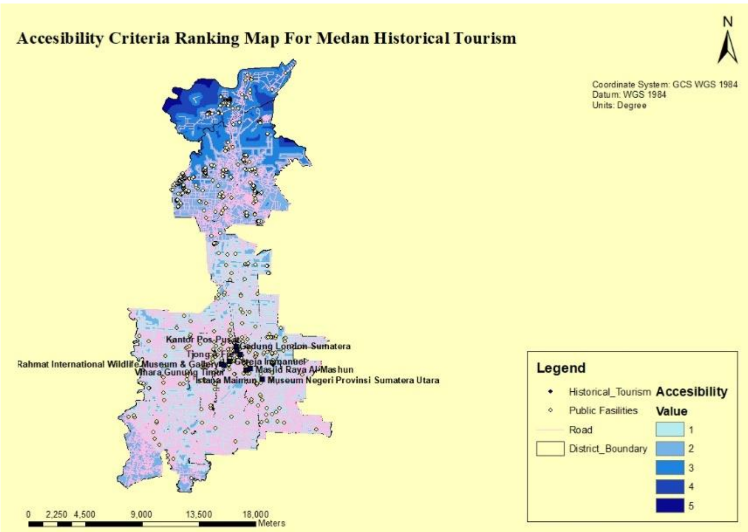

Figure 2. Accessibility Criteria Ranking Map For Medan Historical Tourism

2. Amenities Criteria

The nine historical tourist sites were ranked in order of preference using the weighted overlay findings. There are three sections to the rating. The highest-ranked historical tourism is shown in blue, while the lowest-ranked educational tourism is shown in yellow, based on the amenities criteria. Fig. 4 displays the rating of educational tourism according to amenities.

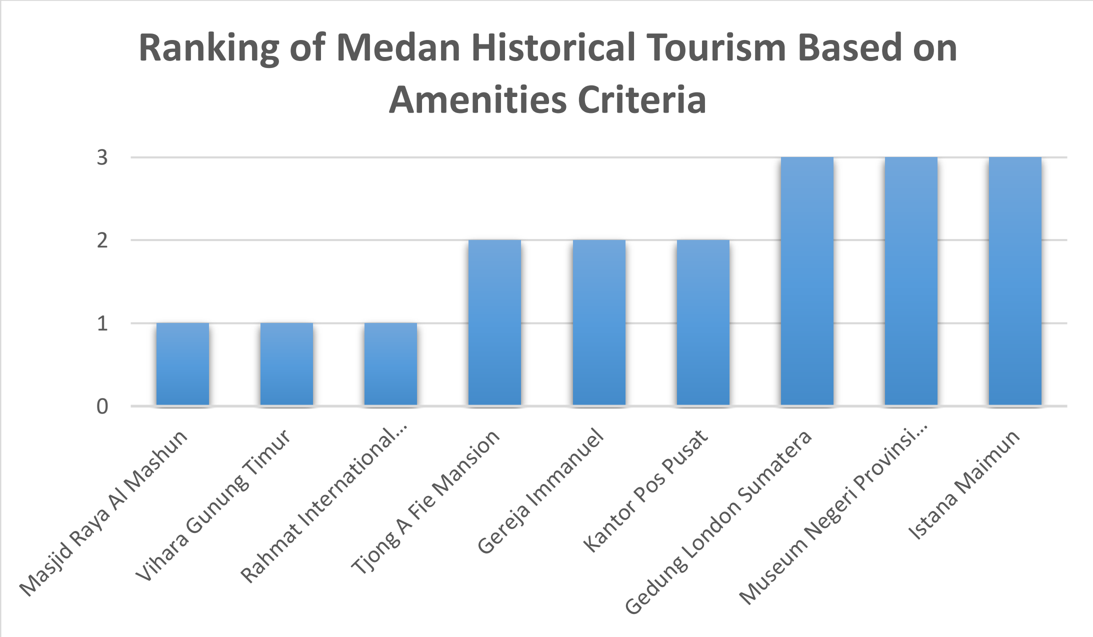

Figure 3. Ranking of Medan Historical Tourism Based on Amenities Criteria

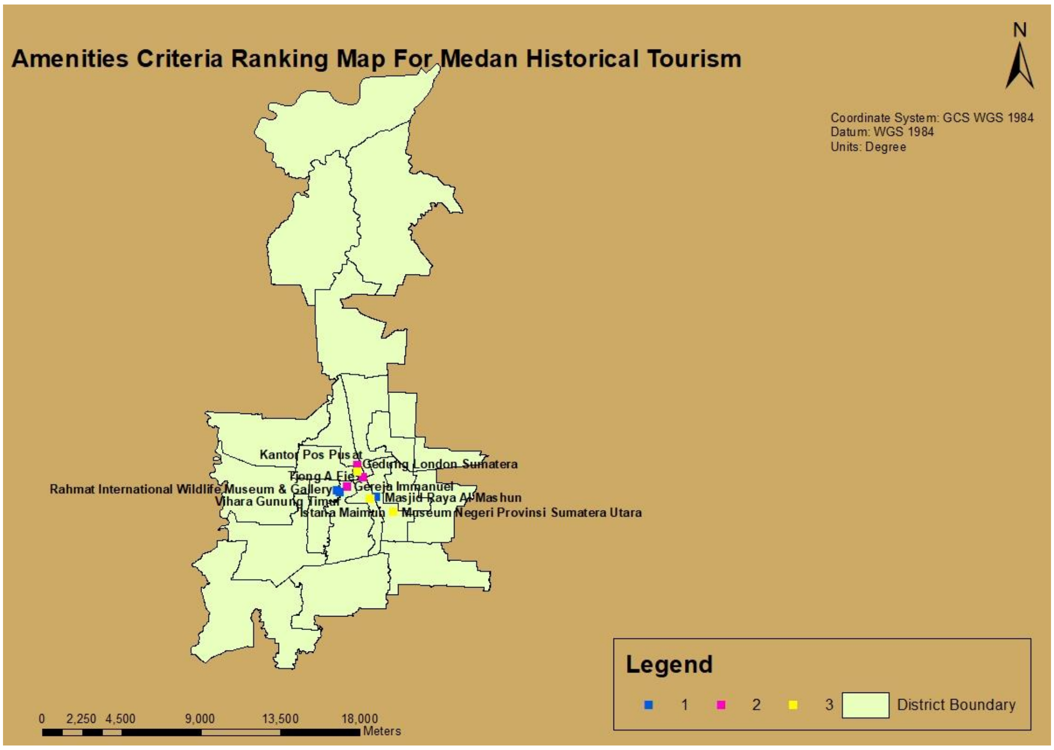

Figure 4. Amenities Criteria Ranking Map For Medan Historical Tourism

3. Attractions Criteria

The weighted overlay results of the attractions criteria, which are based on the weights from the AHP calculation, are then shown in Fig. 5.

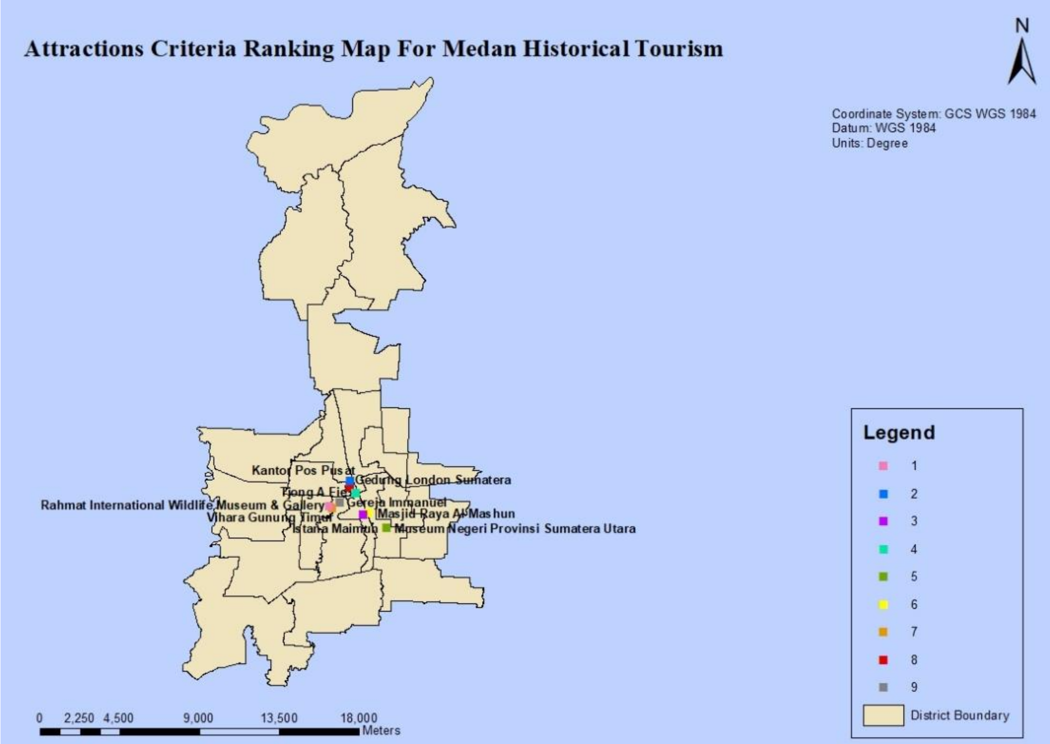

Figure 5. Attractions Criteria Ranking Map For Medan Historical Tourism

The highest-ranked historical tourism is shown by the pink hue, and the lowest-ranked historical tourism is indicated by the gray color. Fig. 6 displays the thorough rating of historical tourism based on the attractions criteria.

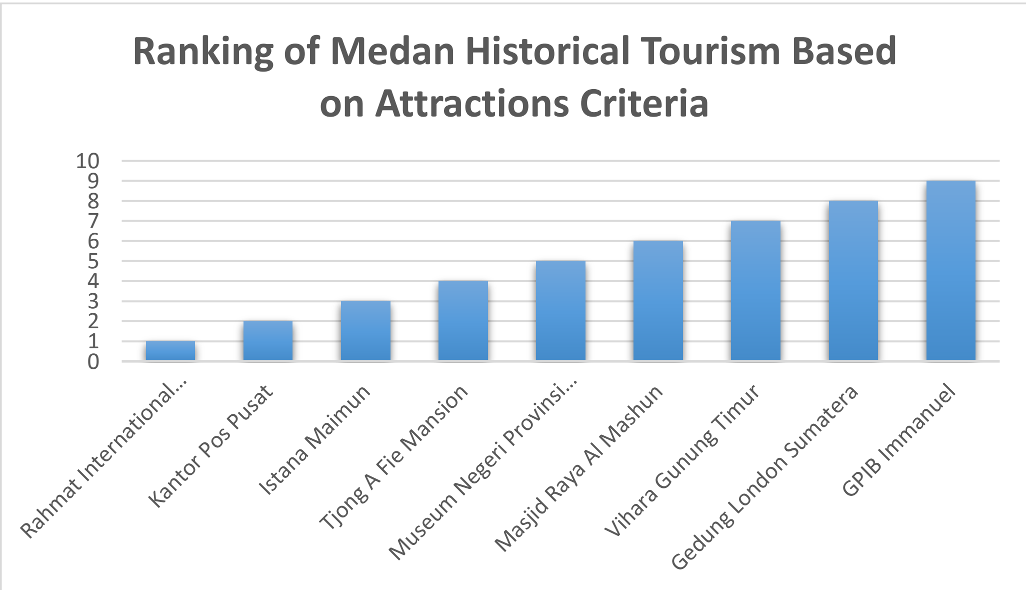

Figure 6. Ranking of Medan Historical Tourism Based on Attractions Criteria

An Evaluation and Ranking of Possible Historical Destination Items

Weighted overlay processing is done using the AHP results for every criterion. Using the weights from the AHP Questionnaire, Figure 7 shows a ranking map of potential historical sites in Medan City based on accessibility, amenities, and attractions.

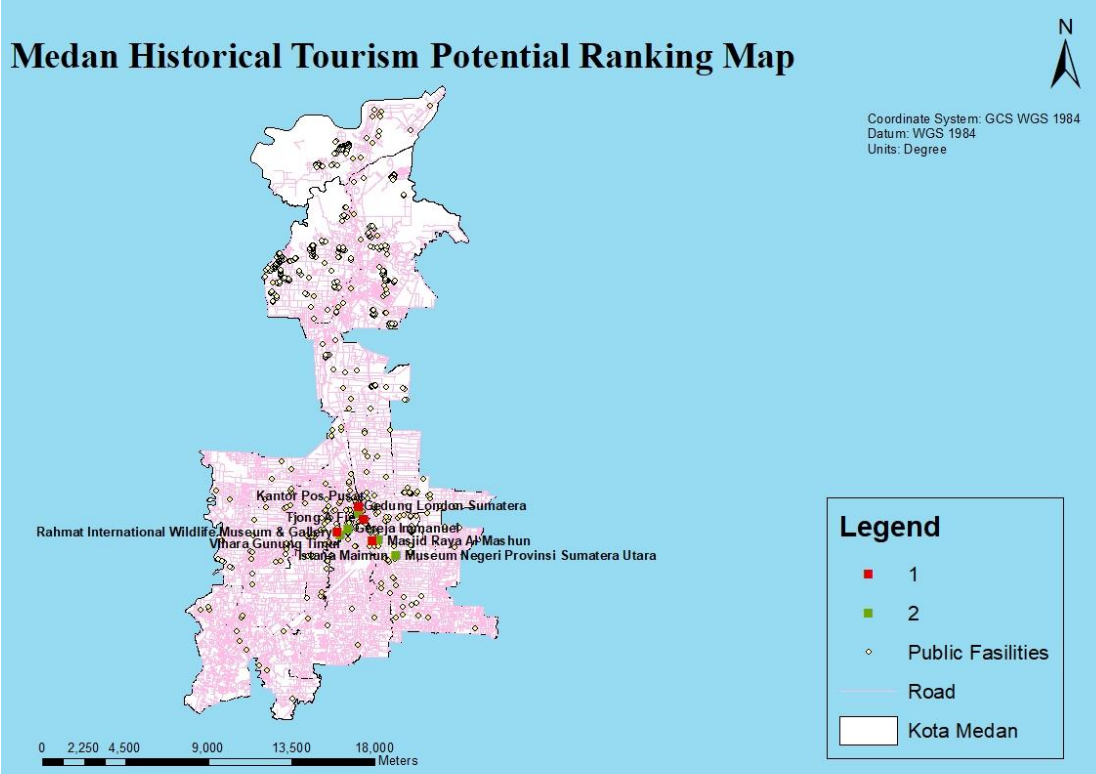

Figure 7. Medan Historical Tourism Potential Ranking Map

The potential rankings for historical destinations are represented by the numbers 1 and 2. Locations with poor potential at rank 2 are shown in green, whereas historical tourism locations with strong potential at rank 1 are shown in red. Fig. 8 presents a detailed rating of historical places based on facilities, attractions, and accessibility.

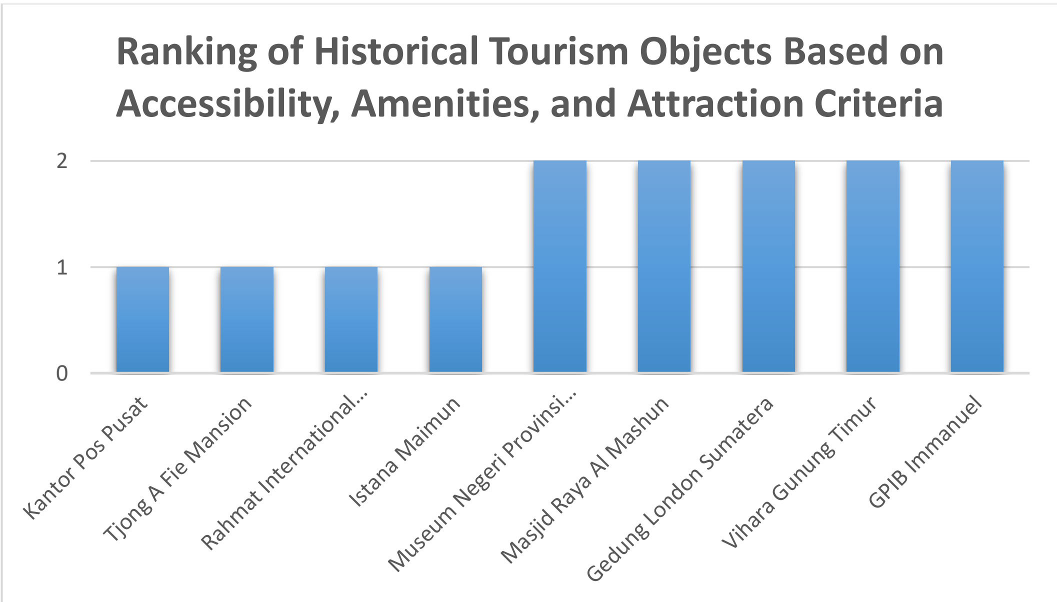

Figure 8. Ranking of Historical Tourism Objects Based on Accessibility, Amenities, and Attraction Criteria

Using Network Analysis to Plan Alternative Tourist Transportation Routes

Three alternate tourist transit routes, each passing through four distinct historical locations with high and low potential ratings, were planned using network analysis in this study.

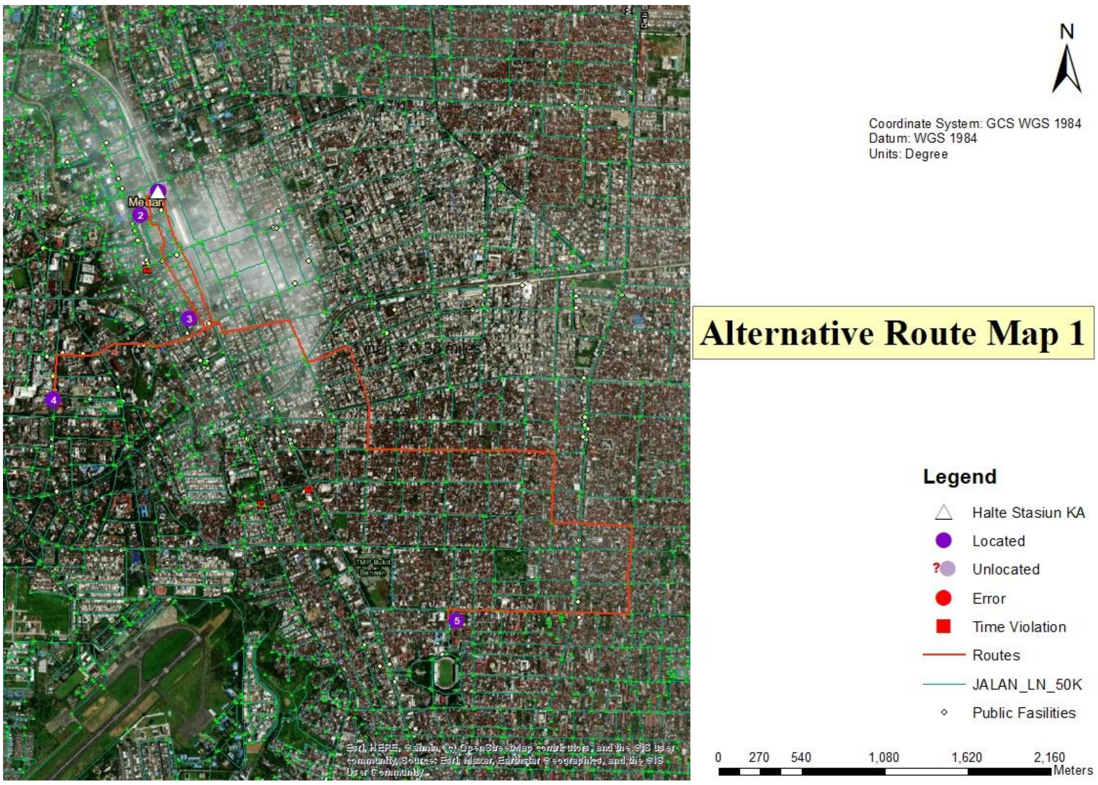

Figure 9. Alternative Route Map 1 Medan Historical Tourism Transport

Fig. 9 illustrates the first alternative transportation route where there are four historical tourist destinations in Medan City:

- Kantor Pos Pusat
- Tjong A Fie Mansion
- GPIB Immanuel
- Museum Negeri Provinsi Sumatera Utara

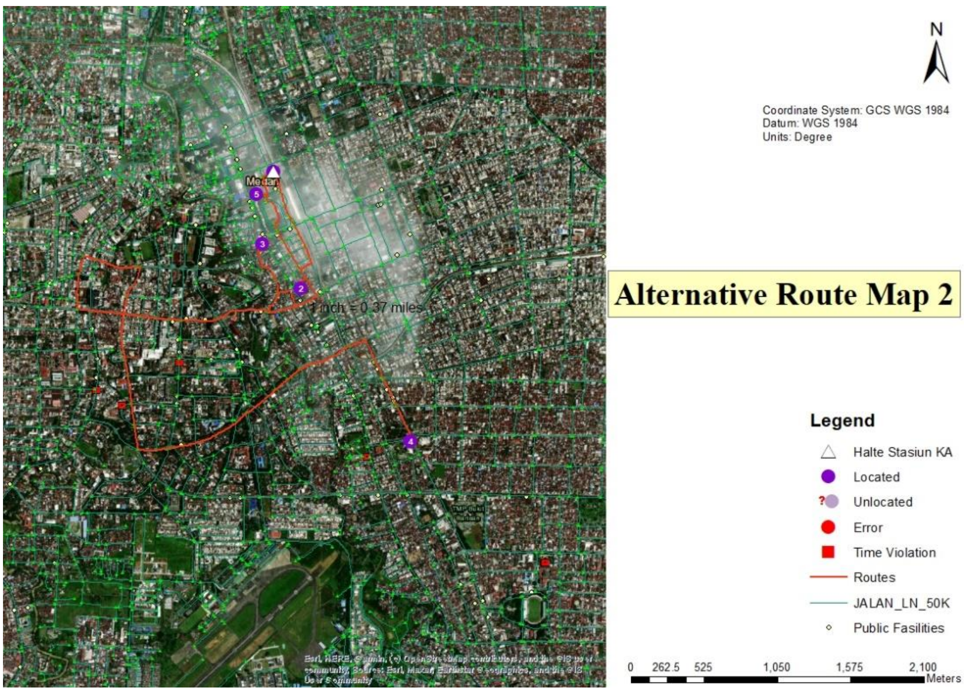

Figure 10. Alternative Route Map 2 Medan Historical Tourism Transport

Fig. 10 illustrates the second alternative transportation route where there are four historical tourist destinations in Medan City:

- Gedung London Sumatera
- Tjong A Fie Mansion
- Masjid Raya Al Mashun
- Kantor Pos Pusat

Fig. 11 illustrates the third alternative transportation route where there are four historical tourist destinations in Medan City:

- Rahmat International Wildlife Museum & Gallery
- Vihara Gunung Timur
- Istana Maimun
- Gedung London Sumatera

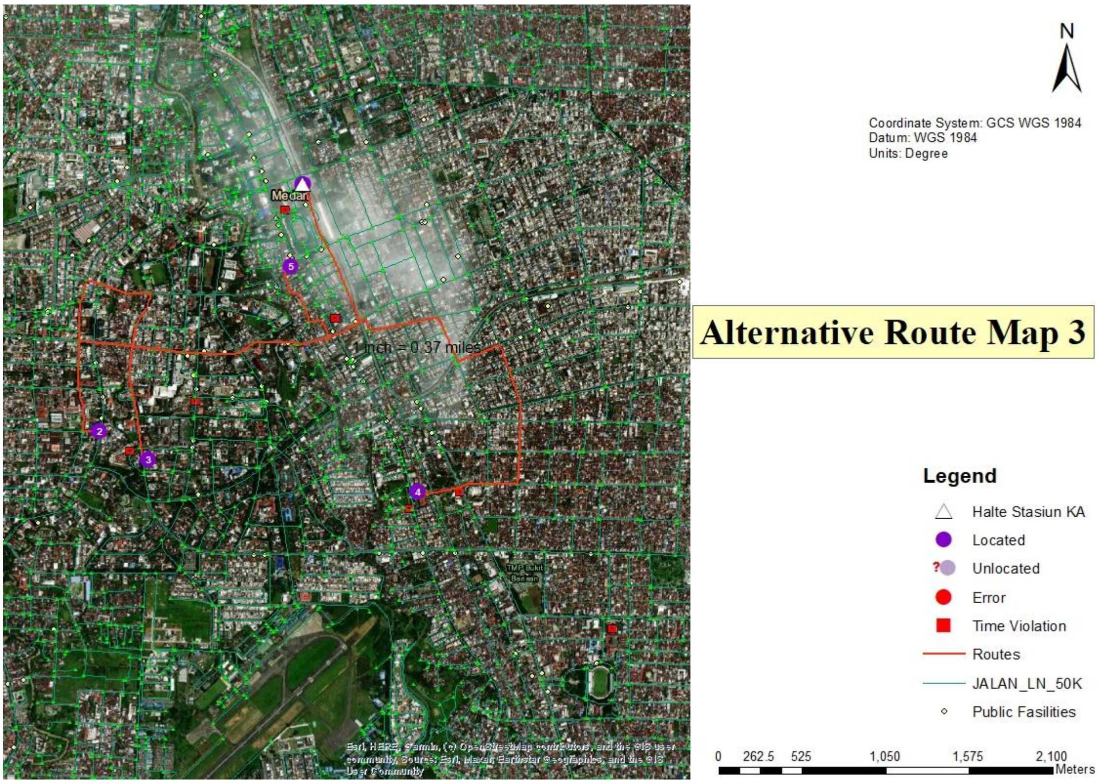

Figure 11. Alternative Route Map 3 Medan Historical Tourism Transport

Determination of Alternative Tourist Transportation Routes by Using VIKOR Method

In this study there are three alternative routes (route 1, route 2, route 3) and two criteria to be analyzed (distance and travel time). Table 5 will present the criteria value of each route alternative:

Table 5. Criteria Values for Each Route

Route	Distance (km)	Travel Time (minute)
1	15,8	55
2	7,6	35
3	10,2	34

Based on Table 5, normalization of alternative values is carried out on each cost criterion (lower is better). The normalization results are shown in Table 6 below:

Table 6. Normalized Decision Matrix

Route	Distance	Travel Time
1	0	0
2	1	0,9
3	0,7	1

Next, calculate the S and R values of each route alternative. Thus, the calculation for each alternative route is obtained as follows:

- Route 1
  $S_1 = 0{,}6(0) + 0{,}4(0) = 0$
  $R_1 = \max[0{,}6(0); 0{,}4(0)] = 0$

- Route 2
  $S_2 = 0{,}6(1) + 0{,}4(0{,}9) = 0{,}96$
  $R_2 = \max[0{,}6(1); 0{,}4(0{,}9)] = 0{,}6$
- Route 3
  $S_3 = 0{,}6(0{,}7) + 0{,}4(1) = 0{,}82$
  $R_3 = \max[0{,}6(0{,}7); 0{,}4(1)] = 0{,}42$

Based on the calculation results above, the largest value for $S = 0{,}96$ and the smallest value for $S = 0$. While the largest value for $R = 0{,}6$ and the smallest value for $R = 0$. Next, the VIKOR index value is calculated, the smallest Q value is the best alternative. The value of $v = 0{,}5$ is assumed. Here are the calculations:

- Route 1
  $$Q_1 = 0{,}5\frac{(0-0)}{(0{,}96-0)} + 0{,}5\frac{(0-0)}{(0{,}6-0)} = 0$$
- Route 2
  $$Q_2 = 0{,}5\frac{(0{,}96-0)}{(0{,}96-0)} + 0{,}5\frac{(0{,}6-0)}{(0{,}6-0)} = 0{,}5 + 0{,}5 = 1$$
- Route 3
  $$Q_3 = 0{,}5\frac{(0{,}82-0)}{(0{,}96-0)} + 0{,}5\frac{(0{,}42-0)}{(0{,}6-0)} = 0{,}43 + 0{,}35 = 0{,}78$$

Based on the results of the VIKOR method calculation, the best alternative route is route 1.

Route 1 which was selected as the optimum route is presented in Table 7 below.

Table 7. Optimum Route for Historical Tourism Destination in Medan City

Route	Destinations	Distance	Travel Time
1	Stasiun Kereta Api	0	0
	Kantor Pos Pusat	0,9 km	3 min
	Tjong A Fie Mansion	2,4 km	10 min
	GPIB Immanuel	2,6 km	8 min
	Museum Provinsi Sumut	4,4 km	14 min
	Stasiun Kereta Api	5,5 km	20 min
	Total	15,8 km	55 min

4. Conclusion

This study focuses on the effectiveness of the AHP-VIKOR method and the VIKOR method modified with AHP, which incorporates network analysis, to determine optimal route selection. The conclusions that can be drawn are as follows:

1. AHP-VIKOR Analysis:

- The weight for each criterion is calculated using AHP, to ensure a structured and objective weighting process.
- Traditional VIKOR is applied to evaluate and rank routes based on overall performance by considering all criteria uniformly across all routes.

2. Network Analysis:
   - Network Analysis is used to understand the interrelationships and influences among various criteria and routes.
   - This view helps in identifying important factors and their impact on the overall decision-making process.

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