

Analysis of the Choice of Transportation Modes from Lhokseumawe City to Medan City Using the Analytical Hierarchy Process Method

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Abstract

Inter-provincial movement activities from Lhokseumawe to Medan are busy travel routes because land routes connect many cities. Minibusses and buses serve transportation needs across these cities. Travelers choose minibusses because of their convenience, fast travel time, and comfort. The bus mode also offers smooth and comfortable travel, making it a popular choice among travelers on the Lhokseumawe to Medan route. This research aims to determine the characteristics and percentage of transportation mode choices by travelers. The approach used is the analytical hierarchy process method. The results of the analysis showed that the percentage of travelers interested in choosing a particular mode resulted in 42% of passengers choosing the Hiace Minibus, 24% selecting the Sempati Star Bus, 20% choosing the Putra Pelangi Bus, and 14% selecting the Kurnia Bus. The criteria that influence the choice of transportation mode are convenience with a percentage of 22%, time with a percentage of 19%, comfort with a percentage of 16%, cost with a percentage of 15%, headway and safety with a percentage of 14%.

Keywords: Activity, City, Transportation, Analytical Hierarchy Process.

1. Introduction

Transportation is the movement of goods and people from the point of origin to the destination. This activity includes three main elements: the cargo being transported, the availability of vehicles as means of transportation, and accessible routes. The process starts from the origin movement, where the transportation activity begins, and ends at the destination, where the activity ends. Therefore, the transportation sector is vital in supporting economic activities and providing services that contribute to economic development.

The city of Lhokseumawe has an area of 181.06 km². When traveling from Lhokseumawe to Medan and vice versa, travelers must choose various types of land transportation, especially buses or minibusses. To determine the mode of transportation, travelers consider multiple factors such as the purpose of the trip, distance traveled, cost, and other related factors.

Choosing a mode of transportation involves various aspects and criteria for smooth travel using transportation from the place of origin to the destination. These aspects and criteria include travel time, cost, headway, convenience, comfort, and safety. To determine which criteria are most important in choosing a mode of transportation, it is necessary to prioritize these criteria [3]. This research aims to assess the weight of these different criteria, identifying priority criteria that should be emphasized in the management and improvement of public transportation.

2. Literature Review

2.1. Transportation

The term transportation comes from the Latin word *transportare*, where *trans* means to cross and *portare* means to carry or transport (something) from one place to another. This means that transportation is a service that can move people and goods from one place to another. Thus, transportation can be defined as the business and activity of transporting or carrying goods and passengers from one place to another.



2.2. Analytical Hierarchy Process (AHP)

Analytical Hierarchy Process (AHP) is a method known as multi-criteria decision-making, which is used to solve problems with many criteria. AHP works by prioritizing important alternatives following predetermined criteria. More specifically, the AHP Method outlines the objectives, criteria, and options for completing the ranking of various hierarchical structures.

1. Priority Setting

Determining the element priority plan is done by compiling pairwise comparisons, namely comparing all the elements for each sub-hierarchy in pairwise form. The comparison is transformed in matrix form. For example, are n objects denoted by (A1, A2, ..., An), which will be assessed based on their importance levels, including Ai and Aj, presented in a pairwise comparison matrix.

Table 1. Pairwise Comparison Matrix

	A1	A2	...	An
A1	a11	a12	...	a21
A2	a21	a22	...	a2n
:	:	:	:	:
An	am1	am2	:	Amn

The value a11 is the comparison value of element A1 (row) to A1 (column), which states the relationship:

1. How important is A1 (row) to criterion C compared to A1 (column) or
2. How much does Ai (row) dominate over Ai (column)
3. How many characteristics of criterion C are found in A1 (row) compared to A1 (column)

Table 2. Hierarchy Element Rating Scale

Intensity of Interest	Verbal Definition	Explanation
1	Equally important	Both elements have the same influence
3	A little more important	The assessment slightly favors one element compared to its partner.
5	More important	The assessment strongly favors one element compared to its partner
7	Very important	One element is very influential, and its dominance is visible
9	More important	The evidence that one element is more important than its counterpart is clear.
2,4,6,8	The middle value of the assessment above	A grade is given if there is doubt between two assessments
	Reciprocal	If the comparison between elements i and j produces one of the values above, then the comparison between elements j and i will produce the opposite value

The numerical values used in calculating all comparisons are obtained from the comparison scale determined by Saaty, which has a value range between 1 and 9. The AHP model is based on a pair comparison matrix, where the matrix's elements are the decision maker's judgments. A decision maker will evaluate, understand, or estimate the possibility of a thing or event faced. These matrices are found at each hierarchical level of the AHP model structure, which systematically breaks down a problem.

2. Eigen Value and Eigen Vector

A comparison matrix is arranged at each level (level) to determine which criteria are most preferred or essential if the decision maker has included his perception or assessment for each comparison between criteria at one level (level) or which can be compared.

3. Weighting for Each Criterion and Alternative

In the AHP method, the weighted average calculation uses the geometric average. The geometric mean value results from a group assessment of the values given by respondents. The following is an example of calculating the geometric mean:

Then, the geometric mean:

$$XG = \sqrt[63]{(1/9) \times (1/9) \times \dots \times (9)} \dots \dots \dots (1)$$

4. Calculation of Partial Weights and Matrix Consistency

Calculation of the consistency ratio and consistency matrix uses the following formulas.

- Consistency Ratio Calculation
= (Weighted Average Calculation Matrix) x (Weight Vector for each row)(2)
- Vector Consistency Calculation
= (Consistency Ratio / Partial Weight of each row)

- Average Entry (Z_{max})
 $Z_{max} = (\text{Vector Consistency}) / n$ (3)

- Consistency Index (CI)
 $CI = (Z_{max} - n) / (n - 1)$ (4)

- Consistency Ratio (CR)
 $CR = CI / (\text{Random Consistency Index})$ (5)

The respondent's response is said to be consistent if the CR value is < 0.1 . The random index value for $n = 6$ is 1.24, and for $n = 4$ is 0.90 (obtained from the random index value table).

5. Consistency and Ratio Test

One of the AHP methods that differentiates it from other decision-making models is that there is no absolute consistency requirement. Collecting opinions between one factor and another is independent of each other, which can lead to inconsistencies in the answers given by respondents. However, too much inconsistency is also undesirable. If there are significant inconsistencies, it may be necessary to re-interview with the same number of people.

The following formula can be used to determine the Consistency Index of a matrix of order n :

$CI = (\lambda_{max} - n) / (n - 1)$ (6)

3. Research Method

The research method that will be carried out is to conduct field research to identify the choice of transportation modes. The technique used to identify the preferred mode of transportation is the Analytic Hierarchy Process (AHP) method. Using this method, a priority scale will be found for several alternative transportation routes from Lhokseumawe to Medan. The complete research steps of the AHP method are shown in Figure 1 below:

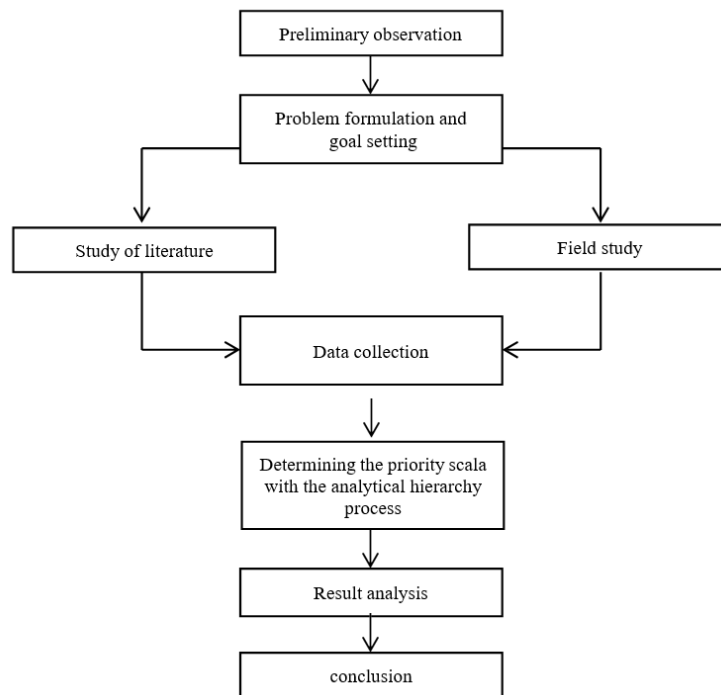


Fig 1. Research Methodology

4. Result and Discussion

The hierarchical structure in the problem of determining the choice of transportation mode can be seen in the picture below.

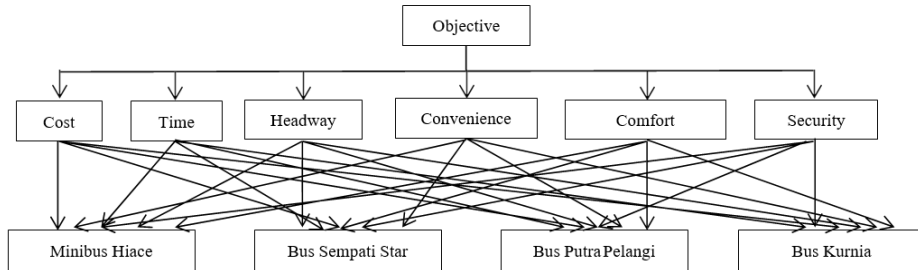


Fig 2. Hierarchical structure of alternative mode selection

Based on Figure 1, the criteria include time, cost, headway, convenience, comfort, and safety. Alternatives are Hiace minibusses, Sempati Star buses, Putra Pelangi buses, and Kurnia buses. The selection of these criteria is based on the perceived impact on the choice of transportation mode. At the same time, the alternative was chosen because the alternative is an option that serves trips from the city of Lhokseumawe to the city of Medan.

The output criteria analysis aims to determine which criteria influence travelers when traveling from the city of Lhokseumawe to the city of Medan. The results in the image below are the combined results of all respondents.

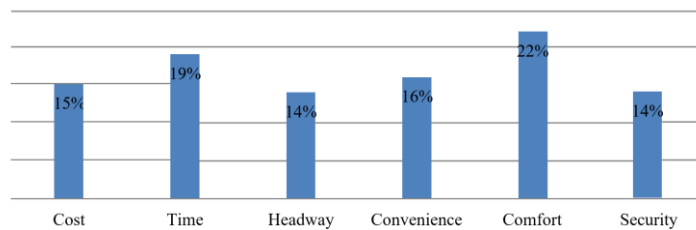


Fig 3. Percentage graph in choosing mode

Based on the graph above, it is found that the weight of the percentage value of travelers on the factors that influence the choice of mode is the convenience criterion with a weight of 22%. Furthermore, the time factor weighs 19%, the comfort factor is 19%, the cost factor is 15%, and the headway and safety factor is 14%. The convenience factor is the central aspect, according to respondents.

Analysis of the output of alternative modes is to obtain priority weight values in choosing the mode of transportation that travelers prioritize when traveling from the city of Lhokseumawe to the city of Medan in terms of each predetermined criterion. The results in the graph below are the combined results of all respondents.

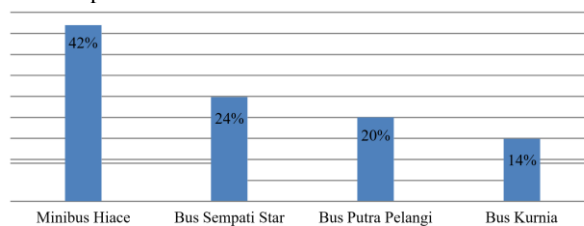


Fig 4. Graph of percentage of alternative mode choices

Based on the graph above, it is found that the priority mode of transportation when traveling from Lhokseumawe City to Medan City based on the traveler's weight value is the Hiace minibus, with a weight of 42%. Furthermore, the Sempati Star bus weighs 24%, the Putra Pelangi bus weighs 20%, and the Kurnia bus weighs 14%. This proves that Hiace minibusses are the alternative mode of choice for respondents.

The following steps were carried out based on the research results and data processing obtained using the Analytical Hierarchy Process (AHP) method.

1. Pairwise comparison matrix

The pairwise comparison matrix at level 2 (reasons) was obtained from distributing questionnaires to travelers. This matrix is designed to compare each criterion and assess the importance of one criterion compared to others.

Information:

(X): Average weight value of the questionnaire matrix

(Y): Weight vector for each row

(Z): Consistency ratio value

5. Vector Consistency

= Vector consistency = (Consistency Ratio / partial weight of each row)

$$\begin{aligned}
 1.181 & / 0.192 & = & 6.147 \\
 1.054 & / 0.174 & = & 6.060 \\
 1.093 & / 0.180 & = & 6.060 \\
 1.005 & / 0.166 & = & 6.059 \\
 0.908 & / 0.150 & = & 6.060 \\
 0.835 & / 0.138 & = & 6.059
 \end{aligned}$$

The consistency vector value is determined by dividing each consistency ratio value by the weight of the partial values for each row.

6. Average entry (Zmax)

$$\begin{aligned}
 Z_{maks} &= \frac{\text{Konsistensi Vektor}}{n} \\
 Z_{maks} &= \frac{6.147 + 6.060 + 6.060 + 6.059 + 6.060 + 6.059}{6} \\
 Z_{maks} &= 6.074
 \end{aligned}$$

7. Consistency Index (CI)

$$\begin{aligned}
 CI &= \frac{Z_{maks} - n}{n - 1} \\
 CI &= \frac{6.074 - 6}{6 - 1} \\
 CI &= 0.015
 \end{aligned}$$

8. Consistency Ratio (CR)

Calculation of ratio consistency using the formula CR=CI/(Random Index).

Table 6. Random index values

Matrix	1.2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mark RI	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

$$\begin{aligned}
 CR &= \frac{CI}{\text{Random Index}} \\
 CR &= \frac{0.015}{1.24} \\
 CR &= 0.012
 \end{aligned}$$

9. Recapitulation of Partial Weights for each Level

Table 7. Recap of priority weight values for criteria and alternatives

Value of each level		Priority weight		
Level 2	Level 2	Level 2	Level 2	
Time	0.192	Minibus Hiace	0.517	0.099
		Bus Sempati Star	0.241	0.046
		Bus Putra Pelangi	0.161	0.030
		Bus Kurnia	0.080	0.015
		Minibus Hiace	0.171	0.029

Cost	0.174	Bus Sempati Star	0.248	0.043	0.174
		Bus Putra Pelangi	0.270	0.046	
		Bus Kurnia	0.311	0.054	
Headway	0.180	Minibus Hiace	0.456	0.082	0.180
		Bus Sempati Star	0.259	0.046	
		Bus Putra Pelangi	0.187	0.033	
Comfort	0.166	Bus Kurnia	0.099	0.017	0.166
		Minibus Hiace	0.327	0.054	
		Bus Sempati Star	0.274	0.045	
Convenience	0.150	Bus Putra Pelangi	0.220	0.036	0.150
		Bus Kurnia	0.179	0.029	
		Minibus Hiace	0.515	0.077	
Security	0.138	Bus Sempati Star	0.238	0.035	0.138
		Bus Putra Pelangi	0.161	0.024	
		Bus Kurnia	0.085	0.012	
		Minibus Hiace	0.225	0.031	
		Bus Sempati Star	0.293	0.040	
		Bus Putra Pelangi	0.265	0.036	
		Bus Kurnia	0.217	0.029	

The partial weight values for each level are obtained from the results of pairwise matrix normalization for each criterion and alternative. This can be seen in calculating the requirements and options for each factor.

5. Conclusion

Based on the analysis that has been carried out, it can be concluded that the characteristic factors of travelers from Lhokseumawe City to Medan City in choosing transportation modes are as follows:

1. The most influential level of criteria in selecting the Lhokseumawe-Medan route is the first level of convenience criteria with a percentage of 22%, time with a rate of 19%, comfort with a percentage of 16%, cost with a percentage of 15%, headway and safety with a percentage 14 %.
2. The best alternative modes of transportation based on consideration of the selected criteria are the first level Hiace Minibus with a percentage of 42%, Sempati Star Bus with a rate of 24%, Putra Pelangi Bus with a percentage of 20%, and Kurnia Bus with a percentage of 14%.

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