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The Use of Analytical Hierarchy Process (AHP) Method in Analysis of Factors Affecting the Demand for Trans Malang Bus Passengers in Malang City

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Abstract *— Analysis of factors that influence the demand for public transport passengers is very useful for planning public transport lines in an area. One method that can be used to determine the factors that affect passenger demand is the Analytical Hierarchy Process (AHP) method. AHP method is one of methods that can be used in determining the priority of a number of available criteria. This system draws criteria with a hierarchy and each hierarchy will be pairwise comparison, i.e. pairwise comparisons between criteria, so that a comparison of relative importance between one criterion and another criterion is obtained. The results of this comparison were then analyzed to get the priority of each criterion. After completion, it is assessed on the alternative choices to be compared and calculated to get the best alternative according to established criteria. The parameters that affect passenger demand involve several sectors so this is the reason for using the AHP method. The research begun with a literature study from related sources, field observations, parameter identification, parameter hierarchy preparation, discussion, confirmation to the experts and an assessment of the interests of the experts. The results of the analysis of the AHP method were weight values given to each parameter. The results of the analysis showed that the main factors affecting the demand for public transport passengers were the density of public facilities that was equal to 39.15%, other transportation networks by 33.69%, land use factors by 11.73%, road class factors by 9.77%, and population density factors by 5.67 % These results can be used to plan Trans Malang Bus lanes and determine the best location of bus stops for decision making in the development of sustainable transportation.*

Keywords*— Analytical Hierarchy Process (AHP), passenger demand, public transportation line planning.*

I. INTRODUCTION

Traffic jam or traffic congestion in big cities is a phenomenon that often occurs. Malang is the second largest city in East Java after Surabaya. One of the causes of traffic congestion in Malang is the growth the number of private vehicles that is not proportional to the growth of infrastructure. People prefer private vehicles to public transportation. It is because public transportation in Malang is considered not good. Public transportation is often identified with low quality, lack of comfort, safety, affordability, and gives impression of high social and economic costs (Huda, 2012).

Various ways have been done by the government to reduce congestion, namely increasing road capacity, traffic engineering or traffic management. But up to now traffic congestion in Malang has not been resolved. To overcome the traffic congestion, it is needed a new breakthrough in the field of transportation. One way is to accustom the changes of modes from private transportation to public transportation. The transformation from private transportation to public transportation makes the capacity of the highway function more effectively and efficiently. Traffic congestion can slowly be overcome. A new breakthrough to overcome the traffic congestion faced by Malang is by planning a mass transit highway Trans Malang Bus (using the BRT / Bus Rapid Transit system).

In order to Trans Malang Bus plan can be utilized as well as possible and can bring benefits to the government and the people of Malang City, then the route and location of the Trans Malang Bus stop must pass through areas that really need that mode of transportation. To determine the Trans Malang Bus lane that is by analyzing the factors that influence the Trans Malang Bus passenger demand, so that the top priority is obtained in determining the Trans Malang Bus lane. Weighting is done by using the Analytical Hierarchy Process (AHP) Method to rank the needs / priorities for the use of influential parameters. The factors are arranged in a hierarchical structure in the comparison of alternative pairs with a qualitative scale. Experts or decision makers can assess the comparison i.e. the similarity, a little strong, strong, and very strong by giving different weighting to each parameter (Bhushan and Rai, 2004). This weighting is what determines the results of passenger demand analysis. Therefore, this weighting need to be arranged based on the needs of the community then it is confirmed and given a ranking of interests from experts in the field of transportation.

II. RESEARCH LOCATION

The location of the study was conducted in the city of Malang. This city has an area of 145.28 km2. Malang, which is located at an altitude of 440 - 667 meters above sea level, is one of the tourist destinations in East Java because of its natural and climatic potential. It is located in the middle of the Malang Regency area astronomically located 112.06 ° - 112.07 ° East Longitude and 7.06 ° - 8.02 ° South Latitude, with the following borderline:

- North: Singosari and Karangploso Distric, Malang Regency
- East: Pakis District and Tumpang District, Malang Regency
- South: Tajinan District and Pakisaji District, Malang regency
- West: Wagir District and Dau District Malang Regency

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III. RESEARCH METHODOLOGY

A. Research Material

The material used in this study was Primary Data, namely data from interviewees in the field and from filling out questionnaires by experts.

B. Equipment

The equipment used in this study were:

1) Hardware: a set of laptops, a set of stationery, and a form
2) Software: Ms. Office 2010

C. Method of Data Acquisition

Interviews were conducted by asking a number of questions to respondents regarding research activities and their objectives so that they were expected to get feedback from respondents. The results of this interview were in the form of arguments from respondents on the research problem. The questionnaire was set based on variable criteria obtained from the results of the literature study. Discussions on the criterion variables were also conducted by researchers against respondents to get the selection of the criterion variables together. The questionnaire was accomplished by giving a number of questions which were arranged in writing in a tabular form to obtain information. The results of processing this questionnaire were in the form of an assessment of aspects / criteria used to determine the weight / level of importance using the AHP method.

D. Implementation

1) Identification of parameters: The parameters used in this study were obtained from literature studies and arranged into a parameter hierarchy. In identifying these parameters, in addition to adopting regulations, they were also adopted from similar studies that had been conducted previously at different research sites (Magnanti and Wong, 1984; Hermawan, Riyanto ang Basuki, 2008; Zhu, 2012; Cooper, 2017). The hierarchy was arranged based on the concept of setting the parameter hierarchy in the AHP process, so that the AHP results were more easily understood and be able to be evaluated subjectively by experts in their fields.
2) Selection of experts: this study has determined respondents by *purposive sampling* of experts or related policy makers. Based on the concept of the AHP method, giving value to the parameters of pairs must be done by experts in their field (Bhushan and Rai, 2004). Researchers have gone through the stages of obtaining information from selected respondents. Respondents who fill in the questionnaire were competent and selected to represent in providing information needed by researchers. The following is the list of respondents in filling out the questionnaire shown in Table 1 below.
3) *Analytical Hierarchy Process* (AHP): The parameters that had been identified consisted of several sectors that need to be arranged hierarchically. Each parameter used had different characteristics, so it needed different weighting. AHP provides a means to divide problems into a hierarchy of problem chapters that can be more easily understood and evaluated subjectively. Subjective evaluations are converted into numerical values and processed to rank alternatives on a numerical scale (Bhushan and Rai, 2004). Therefore, the weighting process in this study used the *Analytical Hierarchy Process* (AHP) method. AHP is a pairwise comparison procedure designed to capture relative assessment by ensuring consistency (Saaty, 1980). Expert assessment was made in a specially designed format like the picture shown in Figure 1. Comparisons were made for each criterion and converted to quantitative figures such as Table 2.

TABLE 1. Expert Identity Respondent Table

No	Name	Institute	Position
1	O'ong Ngoedijono	Transportation Department of Malang	Head of Road Transportation
2	Agoes Moeliadi	Transportation Department of Malang	Head of Traffic
3	Dwi Ratnaningsih	State Polytechnic of Malang	Lecturer of Transportation

Criteria	Assessment										Criteria
A	9	8	7	6	5	4	3	2	1	2 3 4 5 6 7 8 9	B

Fig. 1. Comparison of pairwise assessment formats

TABLE 2. Grading Gradation for Quantitative Comparisons of Alternatives

Importance Integrity	Definition
1	Both elements are important
3	One element is slightly more important than the other element
5	One element is very important than the other elements
7	One element is clearly more important than another
9	One element is absolutely more important than the other elements
2, 4, 6, 8	Values between two adjoining considerations

The results of the assessment of paired variables produced data on the opinions of each respondent to the pairwise comparison of the criteria variables that had been arranged. The results of the assessment were then calculated on average to determine the single value of all respondents (Susanta and Trias, 2018).

The data processing for parameter weighting using the AHP method was carried out with the steps in Figure 2 as follows.

Explanation of flow diagram as follows:

a) Enter the importance ratio of the results of the questionnaire.
b) Pairwise Comparison Matrix, by adding up the value of elements per column.
c) Matrix Normalization, done by dividing each element by the appropriate amount per column.
d) Add up each row and calculate the priority (dividing the number of each row by the number of elements)
e) Multiply the elements in the initial matrix with the corresponding priority values and add up each row

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f) Divide the sum of each row with the corresponding priority
g) Add up results to process (f).

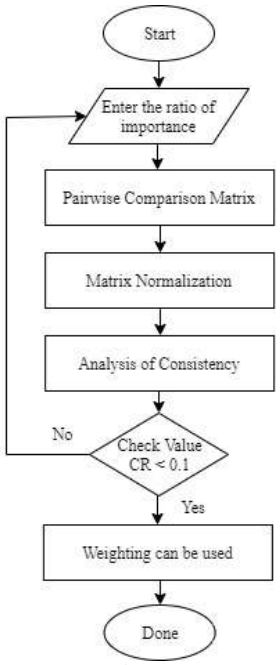

Fig. 2. Weighting of Parameters with AHP

h) Calculate λ max = result of process (g) / number of elements.
i) Calculate CI = (λ max - number of elements) / (number of elements - 1).
j) Calculate Test Ratio, CR = CI / RC
k) Check the CR value, if the CR value < 0.10 then the weighting has been considered consistent and if CR ≥ 0.10, then the weighting process is considered inconsistent so the weighting process must start from the beginning again.

IV. Results And Discussion

1) *Calculation of Criteria*

Calculation of criteria weights was done by finding the eigenvector value of the criteria matrix. Eigenvector is the percentage of interest between one criterion and another. The weight calculation procedure was accomplished to get the percentage of criteria obtained from the questionnaire results from the experts. It can be seen in the following Table 3:

TABLE 3. Pairwise Comparison Matrix for Criteria

Criteria	Population Density	Public Facilities Density	Road Class	Other Transportation System	Land Use
Population Density	1	0.20	0.33	0.20	0.20
Public Facilities Density	1/0.2	1	4	0.17	5
Road Class	1/0.33	1/4	1	0.17	0.17
Other Transportation System	1/0.20	1/0.17	1/0.17	1	0.20
Land Use	1/0.20	1/5	1/0.17	1/0.20	1
Jumlah	19.00	7.65	5.67	1.73	6.57

2) *Matrix Normalization*

Normalization of the matrix was accomplished by adding up the value of elements per column and then the results of the sum of each column divide each element accordingly. Matrix normalization can be seen in the following Table 4:

TABLE 4. Matrix Normalization Table

Criteria	Population Density	Public Facilities Density	Road Class	Other Transportation System	Land Use
Population Density	0.0526	0.0261	0.0588	0.1154	0.0305
Public Facilities Density	0.2632	0.1307	0.7059	0.0962	0.7614
Road Class	0.1579	0.0327	0.1765	0.0962	0.0254
Other Transportation System	0.2632	0.7843	0.0294	0.5769	0.0305
Land Use	0.2632	0.0261	0.0294	0.1154	0.1523

TABLE 5. Consistency Analysis Table

Criteria	Population Density	Public Facilities Density	Road Class	Other Transportation System	Land Use	Total	Average	Consistancy Measure
Population Density	0.053	0.026	0.059	0.115	0.030	0.283	0.057	4.558
Public Facilities Density	0.263	0.131	0.706	0.096	0.761	1.957	0.391	4.364
Road Class	0.158	0.033	0.176	0.096	0.025	0.489	0.098	4.517
Other Transportation System	0.263	0.784	0.029	0.577	0.030	1.684	0.337	8.932
Land Use	0.263	0.026	0.029	0.115	0.152	0.586	0.117	4.798
							TOTAL	27.168
							Elements	5
							CI	0.108
							RI	1.120
							CR	0.097

3) *Analysis of Consistency*

The next step to analyze the consistency of the weighting is:

a) Add up each row of elements
b) Calculate priorities by dividing the number of each row by the number of elements
c) Calculate the size of consistency. It can be done by using the matrix multiplication function in Excel = MMULT ()
d) Calculate Consistency Index (CI)
e) Enter the Ratio Index (RI) value obtained from the Random Consistency Index Table
f) Check the CR value, if the CR value < 0.10 then the weighting has been considered consistent and if CR ≥ 0.10, then the weighting process is considered inconsistent so the weighting process must start from the beginning again. The results of the consistency analysis can be seen in Table 5.

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V. CONCLUSIONS

From the results of research on the analysis of factors that affect the demand for Trans Malang Bus passengers using the Analytical Hierarchy Process (AHP), it is concluded that the factors that affect the demand for Trans Malang Bus passengers the most priority / dominant factor is the density of public facilities that is equal to 39.15 %, other public transportation system factors are 33.69%, land use factor is 11.73%, road class factor is 9.77%, and the smallest one is population density factor of 5.67%.

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