Determination of freight transport terminal location by using the AHP method for sustainable urban development

T A Putri¹ and N Sari²

¹Student, Polytechnic of Indonesian Land Transport Academy, Ministry of Transportation, Bekasi 17001, Indonesia
²Lecturer, Polytechnic of Indonesian Land Transport Academy, Ministry of Transportation, Bekasi 17001, Indonesia

E-mail: tiara6917@gmail.com

Abstract. The rapid economic growth in Samarinda encourages higher demand for logistics that required vehicles and infrastructure for freight transport. The movement of goods in Samarinda is not supported yet by strategic freight transport. This cause many of freight transport parked and unload along the roadside. Writers did some research to determine the best location for freight transport terminal development using an AHP (Analytical Hierarchy Process) method. AHP (Analytical Hierarchy Process) method combines several considerations such as accessibility, traffic performance, regional pattern of transportation to reach multi criteria problem solving. The result of the analysis points out the score for Simpang Pasir Regency which is , the evaluation quality of accessibility 64%, traffic performance 23%, and regional pattern of transportation 12%. With that result Simpang Pasir Regency is chosen as the best alternative location for freight transport terminal development.

Keywords: Analytical Hierarchy Process, freight transport terminal, sustainable urban development

1. Introduction

1.1 Background

Samarinda is the capital city of East Kalimantan with increasing economic growth. The growth caused the demand for logistics also increased. The increase of logistic demand in Samarinda causes the development of tools and infrastructure of freight. The private sector and company compete to gain profit to fulfill the demand for freight transportation so that the in and outflow of logistic in Samarinda could be fill up. The high volume of goods movement with the domination of internal and external trips has not been supported by the existence of a strategic freight terminals. It caused a lot of on-street parking and unloading activity on the roadside and caused the decreasing of a road segment performance. The decreasing performance of road segment happened in Jalan Jakarta, Jalan Ir. Sutami, and many more. The problem can be solved with a few solutions; one of them is to build a freight terminal. Samarinda had already had a freight terminal that was built in 2010 and launched in 2011. Still, it didn’t work well while operated because the location is not strategic enough with the road network that passed by freight, and it becomes unfit to operate anymore.

It needs to consider the aspect of location considering the freight terminal has a more elaborate scale and there are a lot of activities inside while planning the freight terminal. Freight terminal is expected to become a place that is representative and adequate to
accommodate the land transport activity, especially goods distribution.

1.2 Research Problem
The high volume of goods movement has not been supported by the location of a strategic freight terminal. This caused many on-street parking and unloading goods on the roadside. It made the performance of the road segment decreased. The performance reduction of road segment can be found in road passed by freight such as Jl. Jakarta, Jl. IR. Sutami, and many more.

1.3 Research Focus
The determination of several locations that have the potential to become an alternative for the construction of a freight terminal in Samarinda based on the selection factor using a Likert scale and analyze the selection of the most appropriate alternative development location using the Analytic Hierarchy Process (AHP) method.

2. Literature Review

2.1. Terminal
Based on Regulation of the Minister of Transportation of the [1], terminal is base of a general motor vehicle that used to arrange the departure and arrival, load and unloading people and, or goods, and mode transfer.

2.2. Determination of Location
Based on [2] the existing literature, which describes and evaluates the aspects of quality and productivity of terminals, the necessary criteria to define how the intermodal terminal's network were selected. In selecting the criteria, several sources from actual studies and the literature are being analyzed, and a list of the criteria and their subcriteria were created. Based on the critical analysis and the method of surveying traffic experts (road, rail, water, and air traffic), the relevant criteria and subcriteria will then be selected. The recognized criteria include legislative, environmental; goods flows, spatial, technical-technological, and organizational. The legislative and environmental criteria are not evaluated in parallel with the other criteria, since they depend on individual states’ legislation. Thus, it is first necessary to check whether specific locations meet the required legislative and environmental criteria to establish intermodal terminals in these areas.

2.3. Transportation and Freight
Based on Technical Guidelines for the Implementation of Freight Transportation, Transportation is moving people and, or goods from one place to another by vehicle and Car for goods is every motor vehicle other than a motorcycle, passenger car, and bus.

2.4. Metode Analytical Hierarchy Process (AHP)
Based on [3] Analytical Hierarchy Process (AHP) method was developed by Thomas L. Saaty in 1970 in Warston School. AHP method is a method that used in decision making with several consideration such as perception factors, preference, experience, and intuition. AHP combines valuation and personal value in one logical way.

Analytic Hierarchy Process (AHP) can solve complex multi-criteria problems into a hierarchy. A complex problem is that it consists of many criteria (multi-criteria), unclear problem structure, indefiniteness opinion from a decision maker. According to Saaty, hierarchy is a representative from a complex problem in a multilevel structure in which the first level in purpose, followed by factor level, criteria, sub criteria, and until last level of the alternative. With hierarchy, a complex problem could be divided into a group that later will create a hierarchy so the problem will be more structured and systematic.
This method is a frame to make an effective decision to simplify decision making and quicken the decision making by solving problems into parts, arrange the part or variable into a hierarchy structure.

3. Research Methodology

3.1. Collecting data
Data collected in this research consists of two kinds of data, which are primary and secondary data. The collecting of primary data done with observation and interview. The collecting of secondary data aims to collect the data needed to support research. Data such as RTRW of Samarinda City, RDTR Samarinda City, Road Network Map, Freight Network Map, Landscape Map, Administrative Map of Samarinda City, and Topography Map.

3.2. Method of Analysis
According to one of the research purposes that has been appointed is to analyze the determination of freight terminal construction location that suitable with criteria of freight terminal construction. The determination of factor that used to analyze the potential location of freight terminal is Likert scale consists of The availability of Spatial Land, Condition of Land Use, Topography Condition, Population and Road Network.

The location determination of freight terminal used the AHP method that combined various considerations to solve multi-criteria problems. The main purpose of the AHP method is to determine priority and judgment score to find out how important a location factor compared to other location.

The determination criteria are used to choose the construction location of the freight terminal with AHP method consists of Accessibility Criteria, Road Performance Criteria, and Transport Regional Pattern Criteria.

4. Research Analysis

4.1. Collecting Data
Selection of Potential Alternative Location for Freight Terminal. The result of selection was made to obtain five potential locations. Then the selection will used Likert scale to get the score result from each criteria and statement indicators to get the alternative location of the freight terminal.

Determination factors that are used in analyze the potential alternative location of freight are using Likert scale involve of The availability of Spatial Land, Condition of Land Use, Topography Condition, Population and Road Network.

After analysis of each selection factor determining locations of freight terminal construction, the result of assessment shows the top three alternative locations of freight terminal with the biggest score based on the total score of each selection factor of freight terminal construction in Samarinda which zona 10 (Kelurahan loa bahu), zona 20 (Kelurahan Bukuan), dan zona 22 (Kelurahan Simpang Pasir).

4.2. Location Determination of Freight Terminal Construction with Analytical Hierarchy Process Method
There is a lot of decision-making method in the location determination of freight terminal. Therefore to get the most suitable location, each location should have all the expected criteria. The difference of importance level of each location factor become a problem, because not all specified criteria has the same fulfillment with the sum number of fulfilled criteria.

The method that can be used to measure the priority or the quality of importance level of location factor against location determination is Analytical Hierarchy Process (AHP)
5. Result and Discussion

5.1. Determination of Criteria Priority

The analysis steps were made to determine the priority of criteria with the Analytical Hierarchy Process (AHP) method [10][11][12]. Based on the results of the questionnaire survey done in 10 respondents, a comparative value obtained then shows in Table 1 below:

Table 1 Pairwise Comparison Matrix Criteria for Determining the Location of Freight Transport Terminals in the Samarinda

| CRITERIA                        | Accessibility | Traffic Performance | Transport Regional Pattern |
|---------------------------------|---------------|--------------------|---------------------------|
| Accessibility                   | 1             | 3                  | 5                         |
| Traffic Performance             | 1/3           | 1                  | 2                         |
| Transport Regional Pattern      | 1/5           | 1/2                | 1                         |

The table above shows that the highest scale score of comparison of each criterion is criteria 1 (Accessibility) and criteria 3 (Transport Regional Pattern), which is equal to 3. Generally, the comparison scale score of criteria 1 (Accessibility) and other criteria show the dominant number. The result shows that most of the respondents assumed that the freight terminal should be located near the location of distribution goods such as the market, warehouse, and port of goods.

Table 2 is the beginning matrix, the initial matrix form of comparison between criteria, then the priority vector value is calculated by normalizing the initial matrix. So that the results of the priority vector calculation are as follows:

Table 2 Normalization Matrix and Priority Vector Criteria

| CRITERIA                        | Accessibility | Traffic Performance | Transport Regional Pattern | Priority Vector |
|---------------------------------|---------------|--------------------|---------------------------|-----------------|
| Accessibility                   | 0.652         | 0.667              | 0.625                     | 0.648           |
| Traffic Performance             | 0.217         | 0.222              | 0.250                     | 0.230           |
| Transport Regional Pattern      | 0.130         | 0.111              | 0.125                     | 0.122           |

Based on the calculation in the table above, the results show that the priority vector column shows that criteria 1 (Accessibility) is the most important criteria among others because it has the most significant grade, which is 0.648 (64.8%), followed by criteria 2 (Traffic Performance) which is 0.230 (23%) and criteria 3 (Transport Regional Pattern) which is 0.122 (12.2%). The result shows the respondents’ perception stated that to determine the location of freight terminal, the most important criteria is accessibility from and to the industry location and distribution such as market, warehouse, the port of good.

The next step is to do a consistency test with firstly calculate the maximum eigenvalues ($\lambda$ maximum) with formula IV.1 and index consistency (CI) using formula IV.2 then...
calculate consistency ratio (CR) using formula. The calculation result of CI and RI which tabulated in table 3 below.

| CRITERIA       | Accessibility | Traffic Performance | Transport Regional Pattern | Eigen Vector | E vector/Priority Vector |
|----------------|---------------|---------------------|----------------------------|--------------|--------------------------|
| Accessibility  | 0.652         | 0.667               | 0.625                      | 1.948        | 3.007                    |
| Traffic        | 0.217         | 0.222               | 0.250                      | 0.690        | 3.003                    |
| Performance    | 0.130         | 0.111               | 0.125                      | 0.366        | 3.001                    |
| Regional Pattern | 0.130    | 0.111               | 0.125                      | 0.366        | 3.001                    |

\[ \lambda \text{ maks} = \text{rata-rata(e-vector/priority vector)} = 3,003 \]

\[ CI = \frac{\lambda \text{ maks} - n}{n - 1}; n = 3 \rightarrow CI = 0.0018 \]

\[ CR = \frac{CI}{RI}; RI = 0.98 \text{ (Tabel IV.3)} \rightarrow CR = 0.001 \]

Based on the calculation in the table above, the result of consistency ratio is 0.0018 which already fulfilled the requirements of consistency test which is smaller than 0.1. Consistency is needed for the results of weighting to be accepted. After determining the weight in each stage starting from performance weight, sub-criteria weight until each weight of alternative toward sub-criteria, then recapitulation of weighting result or priority vector was done which is the result of priority weight of each step.

The result contains two kinds of weight assessment which is criteria and sub-criteria weight assessment. The calculation was done to get the real weight of each sub-criteria. Accessibility criteria have 0.64 weight while sub-criteria with distance from the market has 0.17 weight. Furthermore, multiplication is carried out to determine the results in the table below, which is the final weight from each sub-criteria where for distance to market sub-criteria has a final weight of 0.11. Likewise, for the sub-criteria, then the same calculation method is carried out so that the final results of the weight assessment of each alternative location against the sub-criteria are as shown in the the table 4.

| Criteria      | Accessibility | Traffic Performance | Regional Transport Patterns |
|---------------|---------------|---------------------|-----------------------------|
| Criteria weights | 0.64         | 0.23                | 0.12                        |
| Sub-criteria  | Distance to market | Distance to port   | Distance to warehouse V/C Ratio | Speed | Density | Volume HV | Volume LV | Volume UM |
| Weight of Sub-criteria | 0.17 | 0.35 | 0.48 | 0.35 | 0.15 | 0.50 | 0.63 | 0.26 | 0.11 |
| Alternative 1 | 0.64 | 0.23 | 0.52 | 0.16 | 0.37 | 0.30 | 0.16 | 0.28 | 0.58 |
| Alternative 2 | 0.23 | 0.65 | 0.30 | 0.30 | 0.45 | 0.16 | 0.30 | 0.22 | 0.11 |
| Alternative 3 | 0.12 | 0.12 | 0.17 | 0.54 | 0.20 | 0.54 | 0.54 | 0.50 | 0.30 |
After each alternative location weight against sub-criteria were obtained, then an assessment is carried out for each of the alternative locations to obtain priority ranking to become the chosen alternative location for the construction of a freight terminal. The calculation from each alternative location is obtained from the multiplication results between each sub-criteria weight with the results of the assessment of alternative locations for each sub-criteria. The following is a table of the results of calculating the total score of each alternative location.

Based on table 5 above, the first rank of the alternative location for the construction of a freight terminal is alternative one, which is located in Zone 22, Simpang Pasir Village in JL. Trikora section with total score of 0.372. The second rank is alternative two, which is located in Zone 20, Bukuan Village in JL. Ampera section with total score of 0.353. At the same time the third rank is alternative three, located in Zone 10, Loa Bahu Village in JL. Ring Road section. So, in the analysis of determining the freight terminal location using the Analytical Hierarchy Process method, the results of the selected location are obtained, namely Alternative 1.

### 6. Conclusion

Freight transport route planning affects the economic development of a region [13,14,15]. Based on the analysis and recommended recommendations described in the previous chapter, the following are the conclusions:

1) The weighting of the criteria for the construction of a freight terminal using the Analytical Hierarchy Process (AHP) method obtained the highest weight on the accessibility criteria of 64.8%, the traffic performance criteria were 23%, and the criteria for regional transport patterns were 12.2%. The results of the weighting of the sub-criteria for the construction of a freight transportation terminal using the Analytical Hierarchy Process (AHP) method obtained the highest weight on the distance to warehousing sub-criteria by 31%, while the lowest criteria for the sub-criteria for non-motorized vehicles (UM) was 1%;

2) There are three alternative locations selected for the construction of freight transport terminals, namely in zone 10 (Loa Bahu Village), zone 20 (Bukuan Village), and zone 22 (Simpang Pasir Village). The results of the priority ranking assessment obtained that the location in the first rank is alternative one, which is located in Zone 22 of Simpang Pasir Village on the JL. Trikora section with a total score of 0.372. The second rank is alternative two, which is located in Zone 20, Bukuan Village on the JL. Ampera with a total score of 0.353. At the same time the third rank is alternative three, which is located in Zone 10, Loa Bahu Village on JL. Ring Road with a total score of 0.273. Alternative one comes out as the best alternative for freight terminal location.

3) Analysis of the determination of the main facilities and supporting facilities at the freight terminal to be built related to serving the loading and unloading activities of goods and
intermodal transportation. Based on the results of the analysis, it is found that the primary and supporting facilities for freight transportation terminals refer to the Government Regulation of the Republic of Indonesia Number 79 of 2013 on Road Traffic and Transportation Network, concerning the need for goods transportation terminal facilities.

4) To improve safety, [16] roads that are used as routes for freight transport need to be equipped with signing and marking.

References
[1] Kementrian Perhubungan, 2018. *PM 102 of 2018*
[2] Brnjac Nikolina 2015 Inland Intermodal Terminals Location Criteria Evaluation: The Case of Croatia Transportation Journal Vol. 54 p 4
[3] Kementrian Perhubungan, 2004. *Surat Keputusan SK.727/AJ.307/DRJD/2004*
[4] Saaty, Thomas L, 1990. *The Analytic Hierarchy Process: Planning, Priority, Setting, Resource Allocation.* University of Pittsburgh
[5] Adisasmita, Rahardjo. 2011. *Transportasi dan Pengembangan Wilayah.* Penerbit Graha Ilmu: Yogyakarta
[6] Aditya, Faris Prima. 2012. *Analisis Penentuan Lokasi Pembangunan Terminal Angkutan Barang di Kota Pekanbaru.* STTD Bekasi
[7] Kurniawan, Fahri. 2012. *Analisa Penentuan Letak dan Fungsi Terminal Angkutan Barang Kota Cirebon.* STTD Bekasi
[8] Morlok, Edward K. 2005. *Pengantar Teknik dan Perencanaan Transportasi.* Erlangga: Jakarta
[9] Ortuzar, J and Willumsen LG. 1990. *Modelling Transport.* John Wiley & Sons: Toronto
[10] Richard. 2018. *Analisis Penentuan Lokasi Terminal Angkutan Barang Di Kabupaten Lombok Tengah,* STTD Bekasi
[11] Putri, Sherly Nandya. 2018. *Penentuan Lokasi Pembangunan Terminal Angkutan Barang di Kawasan Perkotaan Sampit,* STTD Bekasi
[12] Tamin, Ofyar Z. 2000. *Perencanaan dan pemodelan Transportasi.* Penerbit ITB : Bandung
[13] Behrends , S. 2011. *Urban Freight Transport Sustainability The Interaction of Urban Freight and Intermodal Transport Thesis Department Of technology Management and Economics Chalmers University of technology.* Sweden
[14] Doblanc, L. 2011. *City Distribution, a key Problem for the urban economy: guidelines for practitioners*, C. Macharis and S. Melo (ed.), *City Distribution and Urban Freight Transport*, Edward Elgar, Cheltenham, UK, pp.
[15] Engstrom R 2016 *The Roads' role in the Freight system Transportation Reaserch Procedia* 14 (2016) 1443-1452 doi: 10.1016/j, trpro.2016.05.217 published by Elsevier B.V Sweden
[16] Sari, N. 2020. Transport Management of Sustainable Urban Development at Tambun Market Area IOP Publishing doi: 10.1088/1755-1315/501/1/012034