



Development Priority of Tanjung Tembaga Port with AHP (Analytical Hierarchy Process) Method

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Abstract: The world of transportation's development from time to time also demands development of its facilities and infrastructure, one of them is sea transportation. The port is a supporting facility for sea transportation that continues to develop to adapt to the demands of the times. The purpose of this research is to analyze the development potential of the Tanjung Tembaga Port which is then determined by the priority ranking of the options that have been obtained. This research using the AHP (Analytical Hierarchy Process) method in the form of a questionnaire addressed to the officials of PT. Pelabuhan Indonesia III Probolinggo. The results showed that the construction of a jetty was the most important thing to be realized immediately by obtaining a value of 29%, followed by the construction of a passenger terminal with a value of 22%, the application of the Greenport or Eco-port concept with a value of 19.5%, additional warehouse units with a value of 15.1%, construction of stacking yards with a value of 8.2%, and procurement of loading and unloading equipment with a value of 6.2%.

Keywords: Port Development, Tanjung Tembaga Port, AHP

The development of transportation technology following the development of trade and economy, and vice versa, the development of trade is also has the following impact from transportation technology. Transportation makes the distribution coverage area become wider, supports the industrial inputs' distribution become more efficient, and allows for a pattern of specialization in production activities. These things can create production activities' concentration in a certain place which will create an "Economic of Scale" and

"Alglomeration Economics" (Jinca, 2011).

Apart from the demands of the transportation development, the reason of development is also based on the risk factors of accidents that often occur in the world of transportation. Various problem that occur become a challenge to increase accountability by increasing openness, responding quickly to problems in the field, handling problems effectively and efficiently (Tjendani et al., 2017). The main problem of transportation

beside congestion is the high number of accidents that cause fatalities (Hartatik et al., 2021). Other than that, there are several other reasons of why a development is needed.

This research was conducted by direct survey at the Tanjung Tembaga Port in Probolinggo, East Java. Tanjung Tembaga Port is one of many port in East Java, this port has become the heart of economical activities in Probolinggo City, especially for Mayangan District. Tanjung Tembaga Port is a multi-purpose port that serves various types of cargo. This port is currently managed by PT. Pelabuhan Indonesia III Probolinggo, which high-ranking officers will become the respondents.

Analysis of port potential development is carried out by making a questionnaire using the AHP (Analytical Hierarchy Process) method, Thomas L. Saaty is the originator of this method, precisely in the 1970s. In the process of making a decision, this method is oftenly used by the decision makers (Firdasari & Iqbal, 2019). The Analytic Hierarchy Process (AHP) is an assessment method with pairwise comparisons and requires expert opinion to determine priorities. This scale assesses things that normally have no form. Making comparisons using an absolute rating scale that represents, how much, the elements that dominate each other and are in harmony with the given attributes (Saaty, 2008).

LITERATURE REVIEW

Port

Port is an area of water that is protected from waves, equipped with facilities such as docks for ships to dock and carry out loading and unloading activities, cranes to facilitate loading and unloading

activities, warehouses and loading and unloading places for cargo ships and warehouses that can store goods for a longer period of time to wait for delivery to certain destinations . It would be better if the port is equipped with easy access, especially roads or trains and others (Triadmodjo, 2010).

The port is a gateway to enter a region or country and as a liaison infrastructure between regions, between islands or even between countries, continents and nations. With this function, port development must be accountable both socially, economically and technically.

Analitycal Hierarchy Process (AHP) Method

In a fairly complex problem, the use of this method is very important in producing an effective decision by creating a hierarchy of criteria, stakeholders, outcomes and by describing various considerations for developing priorities. This method also combines logic and the power of feelings that have been involved in various problems, then makes a synthesis of various considerations into results that are in accordance with the estimates as presented in the various options that have been made (Saaty, 1980).

The hierarchical process is a process that gives a chance for each person or groups to design ideas and explain a problem in the way they assume themselves and get the solution they want. There are two main reasons to believe that an action will be better than another action. The first is that the effects of an action are usually incomparable due to different sizes or areas and the second, states that the effects of an action are usually opposite from one another, meaning that increasing the impact of one action can be achieved, achieved by exacerbating the other. Both of these reasons will make it difficult

to strike a balance between impacts, so a flexible scale is needed which named priorities.

Principles of Analytical Hierarchy Process

The principles below are used in the Analytic Hierarchy Process method.

1. Decomposition

In decomposition, an attempt is made to break down the whole problem into its elements after the problem is defined. Solutions are also performed on the finite element to the point where this solution is possible, that’s the way to get an accurate result. This reason cause this process is named a hierarchy. Complete and incomplete are two types of hierarchies. When all elements at one level have all elements present in the next level, that situation is a complete hierarchy. Whereas in reverse, it is an incomplete hierarchy.

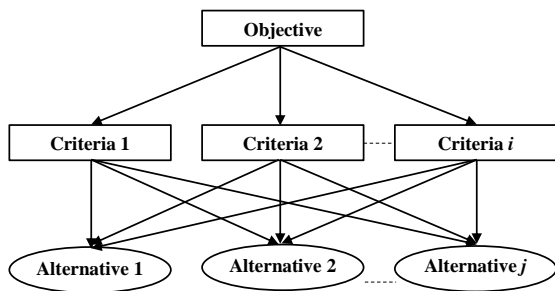


Figure 1. Example of Analytic Hierarchy Process Flowchart

2. Comparative Judgement

This stage analyzes the relativity of interest at a certain level of the two elements related to the level above it. The most important thing about AHP is this analysis, because this will have an impact on the priority of the elements. It will look better if the results of the analysis are described in the form of matrix, the matrix is called a pairwise comparison. The beginning of the AHP method is the creation of a hierarchical structure of something to be

prioritized. To build the relationship in structure, pairwise comparisons are used. In the hierarchical structure there are main objectives, criteria, sub-criteria, and alternatives that will be discussed. The pairwise comparison result will in the form of a matrix, and the scale ratio is came from the form of the main eigenvector or eigenfunction. To get a useful scale in the comparison of two elements, someone who will provide an answer requires a deep understanding of the compared elements and their relevance to the objectives or main criteria to be obtained.

In the Analytical Hierarchy Process (AHP), the importance scale’s preparation is based on the Table 1 below:

Table 1. Fundamental Scale

Level of Importance	Meaning	Description
1	Equal importance	Both elements contribute equally to the goal
3	Moderate importance	Decisions indicate a tendency towards one element over another
5	Essential/strong importance	
7	Very strong importance	
9	Extreme importance	
2, 4, 6, 8	The middle value between two adjacent decision values	
Reverse	If activity i gets 1 point when compared to activity j, then j has the opposite	

Source: Pramesti (2015)

The relative importance of each factor from each row of the matrix, can be described as the relativity of weights which has been normalized. This normalized relative weight is a weighted

relative value for each factor in each column, by comparing each scale value with the number of columns. The normalized principal vector (normalized relative weight) is identical in the pairwise matrix to normalizing its columns. The priority weight is the weight of the overall average value, which is obtained from the average normalized relative weight of each factor in each row.

3. Synthesis of priority

The eigenvector is searched to get local priority from each pairwise comparison matrix. To get global priority, local priority need to be synthesized, this is because pairwise comparison matrixes performed on every level. The procedure for synthesizing differs depend on the hierarchy form. The priority setting is the process of elements ordering depend on their importance relativity with a synthesis procedure.

4. Logical Consistency

Logical consistency states a measure of whether or not an assessment is consistent or weighted pairwise comparisons. This test is necessary, because there will be some relationships and deviations in actual conditions, this caused the inconsistency of the matrix.

Advantages and Disadvantages of Analytical Hierarchy Process

The AHP "pairwise comparison" method has the problem solving ability studied by multi-criteria and multi-object based on the preferences comparison in every element of hierarchy, so the AHP is a comprehensive model. The decision maker makes a choice over a simple pair of comparisons, establishing all the priorities for a sequence of alternatives. "Pairwise comparison"

AHP uses existing qualitative data based on perception, experience, intuition so that it is felt and observed, but does not support quantitative modeling however complete the numerical data.

The advantages of AHP (Analytical Hierarchy Process) method is its hierarchical structure because the criteria up to the selected sub-criteria are the deepest. Then calculate the validity to the tolerance limit of inconcentration of the criteria and alternatives chosen by the decision makers. Then calculate the consistency of the sensitivity analysis of decision-making.

While the disadvantages of this method is the dependence of the AHP model on the main input. The model is useless if the expert's judgment turns out to be wrong, this is because the main input is in the form of expert opinion so that in this case it concerns expert subjectivity. To make an improvement of the decision, the AHP process must be started again from the first stage.

Analytical Hierarchy Process (AHP) is realible because in this method a priority is composed of various optionns which can be in the form of criteria that have been previously decomposed (structured) first, so that priority setting is based on a structured (hierarchical) and reasonable process.

RESEARCH METHODOLOGY

The development solutions that have been collected will become options and the priority ranking is determined by making a questionnaire wiith the method of AHP (Analytical Hierarchy Process). In the AHP method's implementation, the data quality from the respondents is a priority and the quantity is not too influential (Saaty, 1980). That's why the respondents for AHP method need

experts. The experts here are competent people who really understand and influence decision making.

This questionnaire is addressed to company officials and employees at PT. Pelindo III Probolinggo as operator of Tanjung Tembaga Port. The AHP Method does not have a certain number of respondents, but is only limited to a minimum of two respondents (Saaty, 1980).

Questionnaire of Tanjung Tembaga Port Potential Development

At this stage, the data obtained is processed to be used as input in carrying out further calculations. Data processing is carried out to find out several things, namely:

1. Knowing the aspects for port development.
2. Create a hierarchical structure, which describes the objectives, criteria, aspects and options.
3. Making AHP questionnaires, making questions to be asked according to the hierarchical structure.
4. The AHP method, what is meant here is how to fill out the questionnaire, in the form of multiple choice or essays.

Stages of Analytical Hierarchy Process Method

The stages below is the preparation and execution of an analytical hierarchy process.

1. The problem identification and define specifically the expected goal.
2. The preparation of the hierarchy begins with objectives, criteria, then followed by alternative solutions at the lowest level.
3. Compile a pairwise comparison matrix that has a contribution relationship to each goal to be developed at a higher level.

4. Comparing pairs so that a total of $(n(n-1)/2)$ judgments are obtained, where the number of compared components symbolized by n .
5. After the pair comparison data is obtained, the eigenvector values are calculated and the consistency index is checked. The data collection must be repeated if it is not consistent.
6. Repeat 3-5 steps on every levels and hierarchical groups.
7. Calculate the eigenvector of each pair comparison matrix above, where the value of the eigenvector is the weight of each component.
8. Examine the consistency index of the hierarchy CR (Consistency Ratio), if the CR value is greater than 10% (0.1), it is necessary to correct the assesment data.

RESULT AND DISCUSSION

Structure of Analytical Hierarchy Process

In the structure of the AHP, each structure is divided into several stages. These stages are objectives, criteria and choices. The objectives indicate the results to be achieved in the Tanjung Tembaga Port development plan. The criteria indicate things that need to be considered related to the Tanjung Tembaga Port development plan, the criteria that are considered are economic, environmental, social and transportation aspects. Options is a collection of several development options that will be ranked in priority, The Table 2 below describes the development options and the references.

Table 2. Tanjung Tembaga Port Development Options

No.	Development Options	References
1	Jetty Construction	(Putra & Djalante, 2016)
2	Stacking Field Construction	(Putra & Djalante, 2016)
3	Passenger Terminal Construction	(George et al., 2013)
4	Addition of Warehouse Unit	(George et al., 2013)
5	Procurement of Loading and Unloading Equipment	(George et al., 2013)
6	Implementation of the Greenport or Eco-port Concept	(Malisan et al., 2020)

Source: Result of Collected Data (2022)

The objectives, criteria and options are then compiled into the Analytical Hierarchy Process' structure. The Analytical Hierarchy Process' structure to determine the development priorities of Tanjung Tembaga Port can be seen on Figure 2 below.

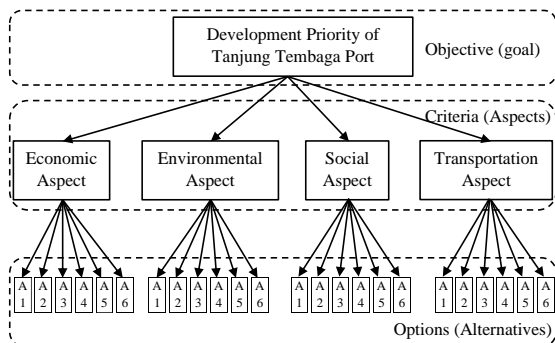


Figure 2. Structure of Analytical Hierarchy Process

Description:

A1 = Pier Construction (Jetty)

A2 = Stacking Field Construction

A3 = Passenger Terminal Construction

A4 = Addition of Warehouse Units

A5 = Procurement of Loading and Unloading Equipment

A6 = Application of the Greenport or Eco-port Concept

Determination of the Port Development Plan Priority

Derived from the Structure of Analytical Hierarchy Process which has been compiled, the determination of port development priorities will be analyzed using Expert Choice software. The stages of analysis are as follows:

1. Determine the pairwise comparison of development aspects

At this stage, each development aspect will be compared to find out which aspects are prioritized in determining port development. The aspects that will be compared are economic aspects, environmental aspects, social aspects and transportation aspects. Table 3 below is the result of the comparison of these aspects.

Table 3. Pairwise Matrix of Development Aspects

Aspect	Eco- nomic	Envi- ronment	Social	Trans- portation	Relative Priority
Econo- Mic	1	4.2	5.667	5.62	0.607
Envi- Rontment	0.25	1	2.444	4.43	0.22
Social	0.167	0.4	1	2.67	0.115
Trans- Portation	0.167	0.222	0.375	1	0.063
Consistency Ratio					0.069

Source: Result of Data Analysis (2022)

Based on Table 3 above, with a relative priority value of 0.6026, it can be concluded that the economic aspect is the priority aspect in port development.

2. Determine pairwise comparison of development options from each development aspect

At this stage, development options will be compared. This comparison consists of four stages according to the number of aspects of port

development. This is done to find out which options are prioritized for each aspect of port development.

a. Pairwise comparison of development options (economic aspect)

Table 4. Pairwise Matrix of Development Options (Economic Aspect)

Options	A1	A2	A3	A4	A5	A6	Relative Priority
A1	1	6	2.8	0.83	2.6	1.67	0.274
A2	0.17	1	1.2	0.17	1.63	1.2	0.088
A3	0.33	0.83	1	0.2	2.14	1.29	0.099
A4	1.2	6	5.17	1	5	2.11	0.362
A5	0.4	0.62	0.5	0.2	1	1	0.071
A6	0.6	0.83	0.78	0.5	1	1	0.105
Consistency Ratio							0.055

Source: Result of Data Analysis (2022)

Based on Table 4 above, with a relative priority value of 0.3624, it can be concluded that the addition of a warehouse unit is a priority development option when viewed from the economic aspect.

b. Pairwise comparison of development options (environment aspect)

Table 5. Pairwise Matrix of Development Options (Environment Aspect)

Options	A1	A2	A3	A4	A5	A6	Relative Priority
A1	1	3.11	1	1.33	2.22	0.33	0.151
A2	0.33	1	0.67	1	2	0.17	0.082
A3	1	1.44	1	0.71	1.6	0.17	0.101
A4	0.75	1	1.37	1	4.25	0.2	0.125
A5	0.44	0.5	0.62	0.25	1	0.17	0.054
A6	3.17	6.5	5.86	5.17	5.78	1	0.486
Consistency Ratio							0.042

Source: Result of Data Analysis (2022)

Based on Table 5 above, with a relative priority

value of 0.4864, it can be concluded that the application of the Greenport or Eco-port concept is a priority development option when viewed from an environmental aspect.

c. Pairwise comparison of development options (social aspect)

Table 6. Pairwise Matrix of Development Options (Social Aspect)

Options	A1	A2	A3	A4	A5	A6	Relative Priority
A1	1	4	0.6	4	4.25	2.67	0.263
A2	0.25	1	0.2	2.5	3.11	1.67	0.12
A3	1.67	5.17	1	5.62	5.4	3.75	0.395
A4	0.33	0.4	0.17	1	3.43	0.5	0.076
A5	0.25	0.33	0.2	0.29	1	0.37	0.044
A6	0.37	0.6	0.25	2	2.67	1	0.103
Consistency Ratio							0.055

Source: Result of Data Analysis (2022)

Based on Table 6 above, with a relative priority value of 0.3947, it can be concluded that the Passenger Terminal Development is a development option that becomes a priority when viewed from the social aspect.

d. Pairwise comparison of development options (transportation aspect)

Table 7. Pairwise Matrix of Development Options (Transportation Aspect)

Options	A1	A2	A3	A4	A5	A6	Relative Priority
A1	1	7.22	3.5	7.5	5.8	5.5	0.471
A2	0.14	1	0.17	0.75	0.37	0.33	0.037
A3	0.29	6.12	1	6.5	5.44	5	0.283
A4	0.14	1.33	0.17	1	0.33	0.37	0.041
A5	0.17	2.75	0.2	2.8	1	0.88	0.081
A6	0.2	3.2	0.2	2.62	1.12	1	0.087
Consistency Ratio							0.05

Source: Result of Data Analysis (2022)

Based on Table 7 above, with a relative priority value of 0.4710, it can be concluded that Jetty Development is a priority development option when viewed from the transportation aspect.

3. Determine the weight of local priority for each development aspect

This stage is to give weight to each port development option in each port development aspect. Table 8 below describes the weight of each port development option in each port development aspect.

Table 8. Weight of Local Priority for Option Based on Port Development Aspect

Development Options	Aspect			
	Economic	Environment	Social	Transportation
Jetty Construction	0.274	0.151	0.263	0.471
Stacking Field Construction	0.088	0.082	0.12	0.037
Passenger Terminal Construction	0.099	0.101	0.395	0.283
Addition of Warehouse Unit	0.362	0.125	0.076	0.041
Procurement of Loading and Unloading Equipment	0.071	0.054	0.044	0.081
Implementation of the Greenport or Eco-port Concept	0.105	0.486	0.103	0.087

Source: Result of Data Analysis (2022)

4. Determine the priority level of port development based on relative priority

This is the last stage, where the priority order of port development will be obtained. The results of the analysis above will be processed and will produce a priority order of port development. The port development priorities as in Figure 3 and 4

below.

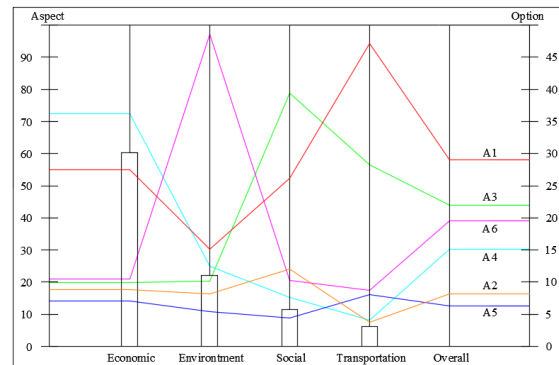


Figure 3. Performance Sensitivity Analysis

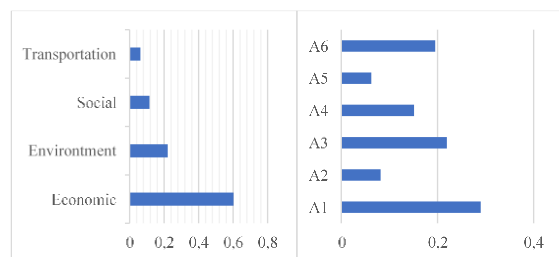


Figure 4. Dynamic Analysis

The results of the sensitivity analysis show the priority ranking of port development based on the criteria for port development aspects. It can be concluded that the most priority is the construction of the jetty. The following is the relative priority value of port development in terms of the criteria for port development aspects, which can be seen in Table 9 below.

Table 9. Relative Priority Value

Port Development Options	Relative Priority
Jetty Construction	0.29
Stacking Field Construction	0.082
Passenger Terminal Construction	0.22
Addition of Warehouse Unit	0.151
Procurement of Loading and Unloading Equipment	0.062
Implementation of the Greenport or Eco-port Concept	0.195
Overall Consistency Index	0.05

Source: Result of Data Analysis (2022)

Based on Table 9, the priority ranking of Tanjung Tembaga Port development is obtained as follows:

1. Jetty Construction
2. Passenger Terminal Construction
3. Implementation of the Greenport or Eco-port Concept
4. Addition of Warehouse Unit
5. Stacking Field Construction
6. Procurement of Loading and Unloading Equipment

Based on the AHP (Analytical Hierarchy Process) results, the construction of the dock was founded as the most important thing to be realized. The most suitable type of dock is a jetty that can be built on the north side of Tanjung Tembaga Port.

CONCLUSION AND RECOMMENDATION

Conclusion

The result of the AHP (Analytical Hierarchy Process) questionnaire for determining the priority of Tanjung Tembaga Port development is as follows:

- a. Based on the results, it was found that the construction of the dock is the most important thing to be realized. The most suitable type is a jetty that can be built on the north side of Tanjung Tembaga Port.
- b. The order of priority for the development of Tanjung Tembaga Port is as follows:
 1. Jetty Construction
 2. Passenger Terminal Construction
 3. Implementation of the Greenport or Eco-port Concept
 4. Addition of Warehouse Unit
 5. Stacking Field Construction

6. Procurement of Loading and Unloading Equipment

Recommendation

The recommendations that the author can give as an efforts to improve the performance of port services and for the development of writing this final project in the future are as follows:

1. Need research that has a wider scope, not only limited to PT. Pelindo, but can also reach out to other agencies such as Organda, ALFI, INSA, KSOP, government and also the costumer of the port.
2. Based on the results of the research that has been carried out, it is hoped that there will be research that discusses more deeply about the development of the Tanjung Tembaga Port, especially for the construction of jetty which is a top priority.

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