Decision Support System for Determining Floating Dock Locations in Maluku Islands Using AHP-TOPSIS

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Abstract. The number of shipyards that can carry out maintenance and repair work in the province of Maluku is very small, causing many docking queues, causing many companies to choose to dock outside the Maluku province, even though Maluku has a large and good area to build a shipyard. To increase the number and capacity of ship docking sites, the floating docking system was chosen to be developed because it is cheaper and very flexible to be moved because Maluku has two different wind seasons that affect the ship docking process. This study aims to determine the right location for the development of floating docking development in Maluku Province. This study uses a combination of two methods namely AHP-TOPSIS. AHP is used to determine the level of importance between criteria, criteria consisting of aspects of meteorology, geography and oceanography, environmental and population aspects, and aspects of facilities and infrastructure. The results of priority analysis through the weighting of criteria from several experts with the AHP approach to the selection of the best alternative regions using the TOPSIS method. The AHP-TOPSIS calculation results give the first priority value in the Dobo region with a total of 41%, the second in the Saumlaki region with a total of 27%, the third in the Tual region with a total of 24%, and the fourth is the Tiakor region around 8%.

1. Introduction

The State of Indonesia is an archipelagic country consisting of 17,504 islands, both large and small islands, where each island or archipelago is separated by ocean. The existence of islands and islands bounded by the sea makes sea transportation a necessity for connecting scattered and remote islands in Indonesian waters [1].

The Provinces of Maluku and North Maluku are provinces that have received the attention of the central government in the sea transportation sector through the Sea Toll program with thirty-one pioneer ships because of the Provinces of Maluku and North Maluku are geographically islands [2], [3]. Therefore, Maluku province has the most pioneering sea transport vessels to revive the economy of the island community so that transportation access between islands is easier and more affordable. The above will also provide an overview of different development approaches for each island region but transportation infrastructure especially sea transportation as the main support for regional development must be developed in synergy so as to provide optimal services in supporting the Sea Toll.

Shipyard is one of the important infrastructures in Maluku Province to support business continuity from various industries, specifically those whose business processes are related to logistical activities and cross-island transportation [4]. The shipyard serves as a place to build, repair and maintain ships according to the needs of the owner and the type of ship he serves. The availability of facilities in the Maluku region varies considerably depending on the weight of the ships that can be served. There are three shipyard companies operating in Maluku, namely PT. Doc and Shipping Wayame Ambon, PT. Tawiri Doc and Shipping and PT. Maluku Nusantara Fisheries [3].

The number of ships operating in the waters of Maluku is around five hundred units with weights varying from 100 DWT, 500 DWT, 1,000 DWT, and also above 1,000 DWT. With such a large number of ships, shipyard companies in Maluku must be able to answer the repair services of these vessels. But in reality, the three shipyards have not been able to serve docking ships with capacities above 500 DWT, so ships that have weights above 500 DWT are forced to carry out maintenance and repairs outside Maluku [2].

Docking companies in Maluku want to develop floating dock technology. The reason for the development of floating dock as an alternative in ship repair services, because floating dock has the advantage of not consuming land so it does not need land rent and also making it cheaper than making graving dock [4]. Seeing these various facts, if the shipyard company in Maluku wants to continue to compete with other shipyard companies in the region and is able to accommodate more ships, it is necessary to build a new dock. The dock built must be a dock that has 500-1000 DWT capability, so that the floating dock is considered to be able to answer the problem but the next problem is how to conduct a feasibility study of floating dock as an alternative dock for the Maluku islands region in support of sea highway [5].

Figure 1. Map of Maluku Province Regency [3]

This study will analyze what aspects affect the feasibility of floating dock development, as well as choosing the right strategic area for the floating dock development. To determine the feasibility study of the doc, several aspects of consideration are needed, including aspects of infrastructure (C1), socio-cultural aspects (C2), economic aspects (C3), meteorological aspects (C4), geophysical aspects (C5), oceanographic aspects (C6), population aspects (C7) and environmental aspects (C8).

Determining the location or region of floating dock is a complex problem because it is influenced by many criteria and each criterion has a strong relationship, as well as different levels of importance so that the problem is very suitable if resolved by Multi Criteria Decision Making [6], [7]. Several previous studies have suggested that when completing group decision making the most suitable method is Analytic Hierarchy Process (AHP), but the AHP method has limitations if the number of criteria and alternatives is large. To cover the weaknesses, the researchers made a combination of AHP method with TOPSIS, TOPSIS method was used to rank alternative decisions with the closest distance solution approach with positive ideal values using Euclidean distance in each alternative to get the optimal solution[8], [9], [10], [11].

2. Material and Methods

2.1. Research stages

Based on Figure 2, in order to achieve the research objective of determining the strategic area for floating dock development, several research stages are arranged, namely: First is identifying problems, conducting a literature review, data collection process and conducting a strategic area study in Maluku province as a research base. The second is to determine the eligibility criteria for floating dock development and determine several alternative regions that have the potential for floating dock development. Third is calculating the criteria weights using the AHP method. The fourth is to calculate using the TOPSIS method by making the AHP weighting results a weighting consideration of the experts.

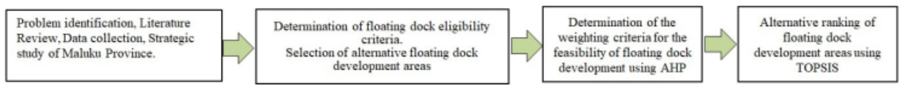

Figure 2. Research stages

2.2. Floating Dock
Floating dock is a building construction at sea that is used to dredge ships by sinking and floating in a vertical direction as shown in Figure 3.

Figure 3. Floating dock

Floating dock construction is generally made of steel and plates, where the supply of electricity can be classified into two, namely electricity supply from the ground or from the floating itself. One of the most visible things of this floating dock is its ability to repair self-docking [5], [4]. The main parts of the floating dock.

- Pump dispensing
- Entry valves
- Anchors and anchor chains
- Lifting cranes

Pumps and valves and main pipes, for which this pumping can be controlled from a place called a control house. Besides that, because floating dock is a floating building, it is necessary to have equipment to be tethered so as not to shift its position caused by currents, waves, or wind. This tethering equipment is evident by the anchors and chains, which are sometimes also used concrete buildings or pipe stakes-placed at the bottom of the water as an aid. Besides the floating dock is also equipped with equipment to pull or shift the ship to be upgraded and the taps needed for transportation at the time of repair.

Benefits of floating dock:

- Floating dock where it can be moved.
- The cost of making a floating dock is cheaper than a graving dock.
- Floating docks can float a ship with a longitudinal and transverse slope that is large enough.
- Floating docks can raise ships with a length of more than 15-20% of the length of the floating docks themselves, while a floating dock cannot.

Floating dock disadvantages:

- The age of using a floating dock is lower than graving dock.
- The floating dock requires a fairly deep water area so that the floating dock does not sit in the mud (bottom of the water) when boarding the ship.
- Floating dock uses more power than a graving dock.

2.3. Analytic Hierarchy Process (AHP)

Analytical Hierarchy Process (AHP) is one of the decision support system methods that is unique compared to other methods, because the weighting of criteria is not determined from the start but is determined using a formula based on the priority scale Saaty [12].

Decision making is a process of selecting the best alternatives from a number of alternatives systematically to be used as a way of solving problems. AHP, developed by Thomas L. Saaty, can solve a fairly complex problem in which there are quite a number of aspects or criteria. In essence, AHP is a comprehensive model of decision making by taking into account qualitative and quantitative matters [13], [14]. In the decision-making model with AHP basically trying to cover all the shortcomings of the previous models. With AHP it is also possible to measure and manage the impact of an interacting component in a system on system errors.

The steps and process of AHP are as follows [15]:

1. Define the problem and set goals. If AHP is used to choose alternatives or develop alternative priorities, at this stage an alternative development is carried out.
2. Arranging problems into a hierarchy so that complex problems can be viewed in terms of detail and measurable.
3. Arranging priorities for each problem element in the hierarchy. This process results in weighting or contributing elements to the achievement of objectives so that the element with the highest weight has priority handling. Priority results from a pairwise comparison matrix between all elements at the same hierarchical level.
4. Conducting consistency testing of comparisons between elements found at each level of the hierarchy

2.4. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is a decision support system method with a simple concept but complexity in problem solving is very good, because the process of selecting the best alternative not only has the shortest distance from the positive ideal solution but also has the longest distance from the negative ideal solution [16],[17],[18].

The use of the TOPSIS method is used because it has several considerations, namely: (a) the concept is simple and easy to understand, this simplicity is seen from the flow process of the TOPSIS method which is not so complicated, (b) using indicator indicators and alternative variables as helpers to make decisions, (c) the computational system is efficient, the computation calculation is more efficient and fast, (d) able to be used as a measure of alternative performance and alternative decisions in a simple form of computational output, and (e) can be used because the decision-making method is faster and efficient.

To solve multi-criteria problems using the TOPSIS method, there are several stages that must be completed, namely [19], [20]:

1. First, first define an alternative solution.
2. Second, normalizing each alternative and weighted normalized matrix.
3. Third, calculate the value of positive and negative ideal solutions.
4. Fourth, calculate the weighted distance of each alternative to the positive and negative ideal solutions.
5. Fifth, calculate the preference value of each alternative
6. Sixth, ranking process

2.5. Research methods

AHP method is one of the Multi-Criteria Decision Making (MCDM) methods that are very good at modeling the opinions of experts in decision support systems. The AHP method itself is inseparable, the AHP method is not effective if it is used in cases with a large number of criteria and alternatives, therefore another method is needed to be combined with the AHP method to obtain more effective results [21].

Many methods in decision support systems have been combined with AHP methods, one of them is the PROMETHEE method combined with AHP methods. The combination of AHP and PROMETHEE methods has been used to evaluate a major Indonesian marine security unit, the AHP method itself is used for weighting criteria while the PROMETHEE method is used to evaluate each alternative, from previous studies it was concluded that a combination of AHP and PROMETHEE methods can be used in the analysis of qualitative criteria [16].

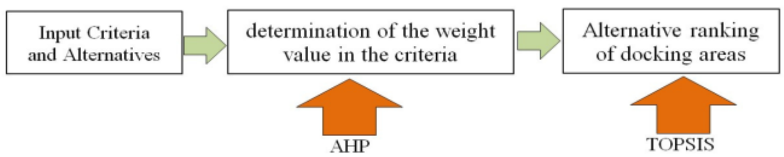

Figure 4. Block diagram of the AHP-TOPSIS Method

The combination of AHP and TOPSIS methods was chosen because it was to produce the best decision solutions and cover each other's deficiencies in the decision support system methods. Based on Figure 4, the AHP method works to analyze the importance of the criteria and consistency analysis, the results of the AHP weighting will be used as a multiplier in the ranking process with the TOPSIS method to obtain an alternative ranking [18], [22], [23].

3. Results and Discussion

This study begins by determining the criteria to consider in the selection of suitable areas for floating dock development such as Table 1. After the criteria are agreed upon, then determine the alternatives (floating dock development area) to be assessed as Table 2.

Table 1. Floating dock development criteria and alternatives

Code	Criteria
C1	Facilities and infrastructure
C2	Socio-cultural
C3	The economy
C4	Meteorologist
C5	Geophysics
C6	Oceanographic
C7	Population
C8	Environment

Code	Alternative
A1	Tual
A2	Saumlaki
A3	Dobo
A4	Tiakor

This study begins with the distribution of questionnaires to several respondents (experts) who understand and understand the conditions of the shipping world, sea transportation and social culture of the Maluku people:

- 5 = Very Good, 4 = Good, 3 = Good Enough, 2 = Not Good, 1 = Bad

The results of the questionnaire assessment are based on a predetermined rating value. The number of respondents who filled out the data was ± 100 respondents.

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Table 2. Recapitulation of the average value of questionnaire entries

	x_{ij}	Criteria (j)							
		C1	C2	C3	C4	C5	C6	C7	C8
Alternative (i)	A1	5,8	5,4	4,1	5,3	5,0	6,2	5,3	6,1
	A2	6,8	4,9	5,1	4,0	4,2	5,3	6,9	7,0
	A3	6,1	6,8	5,9	5,2	5,0	4,9	5,1	6,2
	A4	5,2	7,8	5,4	4,1	4,2	4,0	3,8	8,7

After the questionnaire results are obtained, then the AHP decision matrix model is made. The value of the AHP model obtained from the questionnaire was used to compare each criterion. The results of the questionnaire were compared based on the assessment of the intensity of the Saaty interests, which was obtained by the interest model as shown in Table 3.

Table 3. The results of a comparison matrix between the criteria

Criteria	C1	C2	C3	C4	C5	C6	C7	C8
C1	1,000	5,000	3,000	3,000	3,000	3,000	3,000	7,000
C2	0,200	1,000	0,333	0,333	0,333	0,333	0,333	3,000
C3	0,333	3,000	1,000	3,000	5,000	5,000	3,000	5,000
C4	0,333	3,000	0,333	1,000	1,000	1,000	1,000	5,000
C5	0,333	3,000	0,200	1,000	1,000	1,000	1,000	5,000
C6	0,333	3,000	3,000	0,333	1,000	1,000	1,000	5,000
C7	0,333	0,200	0,333	0,200	1,000	1,000	1,000	5,000
C8	0,143	0,333	0,200	0,200	0,200	0,200	0,200	1,000
Total	**3,010**	**18,533**	**8,400**	**9,067**	**12,533**	**12,533**	**10,533**	**36,000**

Then the comparison matrix elements in Table 4, divided by the values in the number row. After that, look for eigenvectors or weights of each criterion by adding up the values in each row, then divided by the number of criteria.

Table 4. Results of respondents with AHP analysis for weight ranking

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	Number of Rows	Normalized Eigen Vector
C1	0,332	0,270	0,357	0,331	0,239	0,239	0,285	0,194	2,248	0,281
C2	0,066	0,054	0,040	0,037	0,027	0,027	0,032	0,083	0,365	0,046
C3	0,111	0,162	0,119	0,331	0,399	0,399	0,285	0,139	1,944	0,243
C4	0,111	0,162	0,040	0,110	0,080	0,080	0,095	0,139	0,816	0,102
C5	0,111	0,162	0,024	0,110	0,080	0,080	0,095	0,139	0,800	0,100
C6	0,111	0,162	0,357	0,037	0,080	0,080	0,095	0,139	1,060	0,132
C7	0,111	0,011	0,040	0,022	0,080	0,080	0,095	0,139	0,577	0,072
C8	0,047	0,018	0,024	0,022	0,016	0,016	0,019	0,028	0,190	0,024
Cek	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**8,000**	**1,000**

Furthermore, to ensure the consistency of the assessment, it is necessary to find the eigenvalue (λmax) by adding up the multiplication results between the weight of the criteria with the values from the sum of the comparison matrix Table 5.

λmax = 8.962

After obtaining the eigenvalue (λmax), then the CI (consistency index) and CR (consistency ratio) values are sought.

CI = 0.137 CR = 0.097

So, in the process of evaluating the criteria as in Table 4, it can be said to be consistent, because the CR value <0.1 and can be continued in the next stage, so that the weighting results obtained by ranking the criteria weights as shown in Figure 5.

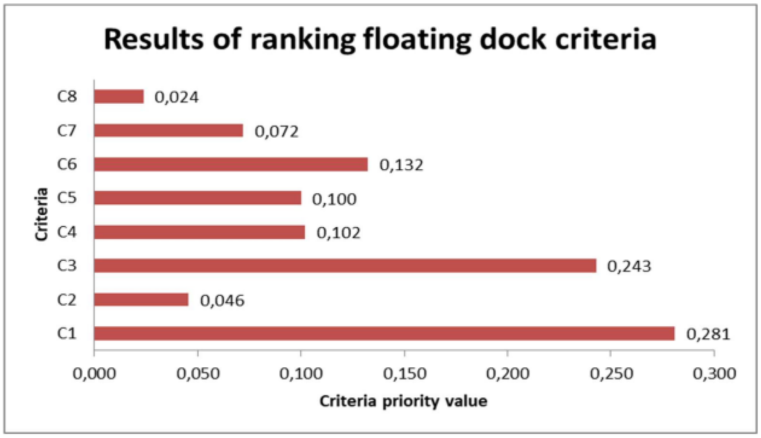

Figure 5. Graph of criteria weights

Based on Figure 5, is the result of the assessment of criteria weights that have been generated from the calculation of the AHP method, the graph explains that the first priority criteria are facilities and infrastructure criteria with a weight value (C1 = 0.281), second is an economic criterion with a weight value (C3 = 0.243), third is oceanographic criteria with weight values (C6 = 0.132), fourth is meteorological criteria with weight values (C4 = 0.102), fifth is geophysical criteria with weight values (C5 = 0.100), sixth is population criteria with weight values (C6 = 0.072), the seventh is a socio-cultural criterion with a weight value (C6 = 0.046), and the eighth is an environmental criterion with a weight value (C8 = 0.0.24). The criteria with the three largest values are the main factors that become the main considerations for the construction of a floating dock in the region.

Table 5. Square value and root of the questionnaire results TOPSIS value

		Criteria (j)							
		C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
Alternative (i)	**A1**	33,64	29,16	16,81	28,09	25,00	38,44	28,09	37,21
	A2	46,24	24,01	26,01	16,00	17,64	28,09	47,61	49,00
	A3	37,21	46,24	34,81	27,04	25,00	24,01	26,01	38,44
	A4	27,04	60,84	29,16	16,81	17,64	16,00	14,44	75,69
Square		**144,13**	**160,25**	**106,79**	**87,94**	**85,28**	**106,54**	**116,15**	**200,34**
Root		**12,01**	**12,66**	**10,33**	**9,38**	**9,23**	**10,32**	**10,78**	**14,15**

The criteria for determining the feasibility of developing a floating dock in each region are the condition of facilities and infrastructure/infrastructure and the economic condition of the community because if the condition of infrastructure in a region is weak, it means that the economy of the region runs in a very inefficient manner. Logistical costs are very high, resulting in companies and businesses that lack competitiveness (due to high business costs). Infrastructure development and macroeconomic development should have a reciprocal relationship because infrastructure development gives rise to economic expansion through a multiplier effect. While economic expansion raises the need to expand existing infrastructure, to absorb the greater flow of goods and people circulating or circulating throughout the economy. Furthermore, after obtaining the criteria weights, the next step is to continue

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the calculation of the TOPSIS method by finding the square and root values according to the results of the assessment with the questionnaire in Table 1.

After obtaining the root value in the TOPSIS decision matrix in Table 5, the next step is to look for a normalization matrix by multiplying each matrix value by the criteria root value, so that the normalized matrix values such as Table 6 are obtained.

Table 6. Normalized matrix value TOPSIS

		Criteria (j)							
		C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
Alternative (i)	**A1**	0,48	0,43	0,40	0,57	0,54	0,60	0,49	0,43
	A2	0,57	0,39	0,49	0,43	0,45	0,51	0,64	0,49
	A3	0,51	0,54	0,57	0,55	0,54	0,47	0,47	0,44
	A4	0,43	0,62	0,52	0,44	0,45	0,39	0,35	0,61

The next step is to find the weighted normalization matrix by multiplying the TOPSIS normalization matrix by the AHP weighted matrix value. For detailed results of the multiplication between AHP weighted matrices and TOPSIS normalization matrices can be seen in Table 7.

Table 7. The matrix multiplication value is AHP and TOPSIS

		Criteria (j)							
		C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
Alternative (i)	**A1**	0,136	0,02	0,1	0,06	0,05	0,08	0,04	0,01
	A2	0,159	0,02	0,12	0,04	0,05	0,07	0,05	0,01
	A3	0,143	0,02	0,14	0,06	0,05	0,06	0,03	0,01
	A4	0,122	0,03	0,13	0,04	0,05	0,05	0,03	0,01

After obtaining the normalized value of the weighted matrix TOPSIS and AHP, then look for the value of positive solutions (benefits) and negative solutions (cost), by finding the maximum and minimum values.

Table 8. Alternative distance values for positive and negative ideal solutions

A	Criteria (j)							
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
y_i^+	0,162	0,028	0,127	0,059	0,059	0,073	0,044	0,016
y_i^-	0,120	0,018	0,114	0,041	0,041	0,047	0,024	0,009

The next stage is determining the distance between the values of each alternative and the positive ideal solution matrix & the negative ideal solution matrix. To find the distance between alternatives with a positive ideal solution matrix can use equation 1.

$$D_i^+ = \sqrt{\sum_{j=1}^{n}(y_i^+ - y_{ij})^2} \quad i=1,2,..,m \tag{1}$$

The distance between alternative A and the negative ideal solution is formulated as equation 2.

$$D_i^- = \sqrt{\sum_{j=1}^{n}(y_{ij} - y_i^-)^2} \quad i=1,2,..,m \tag{2}$$

The results of the range of positive and negative ideal solutions can be seen in Table 8. Next, determine the square and root values of the positive ideal value and the negative ideal value. The results of the quadratic values can be seen in Table 9.

Table 9. Ideal solution distance

	D	D_i^+	D_i^-
Alternative (I)	**A1**	0,031	0,036
	A2	0,030	0,040
	A3	0,008	0,058
	A4	0,060	0,012

The results of the ranking of preference values can be seen in Table 10. Based on the ranking of preference values in each alternative region that has adequate facilities and infrastructure and a good economy is prioritized, so the recommended areas are regions that have adequate facilities and infrastructure, the regional economy with advanced oceanographic conditions. These three criteria are alternative values for determining the most ideal area to be built floating dock.

Table 10. Preference value

No	**Alternative**	**Code**	**Value**	**Normalization**	**Percent**
1	Dobo	A3	0,872	0,41	41%
2	Saumlaki	A2	0,574	0,27	27%
3	Tual	A1	0,536	0,25	25%
4	Tiakor	A4	0,167	0,08	8%
			2,149	**1**	**100%**

4. Conclusion

Aspects that support the construction of floating dock include aspects of facilities and infrastructure, social and cultural aspects, economic aspects, meteorological aspects, geophysical aspects, oceanographic aspects, population aspects and environmental aspects. The results of the analysis of the level of importance with the AHP approach revealed that the most influential aspects to the development of the floating dock area, the first was the aspect of facilities and infrastructure (0.281), the second was the economic aspect (0.243), the third was the aspect of oceanographic criteria (0.132), the fourth was the aspect of meteorology (0.102), the fifth is the geophysical aspect (0.100), the sixth is the population aspect (0.072), the seventh is the socio-cultural aspect (0.046), and the eighth is the environmental aspect (0.024).

One of the findings in this study shows that the region that has the highest priority for floating dock development in Maluku province, the first is the Dobo region with a priority value of 41%, the second is the saumlaki region with a priority of 27%, the third is the tual region with a priority of 25% and fourth is tiakor area with a priority value of 8%. This research can be used as a supporter of the Maluku Provincial Government's decision to develop floating dock development in Maluku province which has economic potential in the maritime and shipping sectors.

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