

# ANALYSIS OF THE SELECTION OF NAVAL BASES IN THE HANDLING OF PIRACY AND PIRACY CRIMES BY MEANS OF FUZZY AHP, TOPSIS AND GIS

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## ABSTRACT

*Piracy and piracy incidents that often occur in Indonesian waters greatly affect the credibility and dignity of the Indonesian nation in the eyes of the international world. Based on existing data, piracy and piracy in Indonesian waters became the most in the world, especially in the waters of the Strait of Malacca. This condition certainly has a negative impact on the Indonesian government. Even the International Maritime Bureau (IMB) gave the title 'Black Area' in the waters of the Strait of Malacca. This statement is based on the number of reports of piracy and piracy incidents in Indonesian waters. There are several studies that take the theme of location selection by Analytic Hierarchy Process (AHP) and Geographic Information System (GIS) methods. Wang (2009) stated, although the AHP method is more widely used in building a decision-making system, but this method has drawbacks, namely not considering the uncertainty and doubts in decision making. Therefore Fenton & Wang (2006) argues fuzzy-set theory can be used to overcome the limitations of AHP. This study assessed that site selection with Fuzzy AHP and TOPSIS can reduce decision uncertainty. GIS is used to analyze and describe the real relationship between the points of piracy incidents that have occurred with the position of the surrounding Navy Base. This research can help determine the best Navy bases from several existing bases, especially those around the waters of the Strait of Malacca. This base will then be used as a base for KRI and personnel who are carrying out maritime security operations in order to handle piracy and piracy crimes. In the research area limited by sea map no. 2 production of Dishidros TNI AL, there are 7 Naval Bases that can be used as alternatives namely Lanal Batam, Lanal Tanjung Balai Karimun, Lanal Dabo Singkep, Lanal Dumai, Lanal Tanjung Balai Asahan, Lanal Lhokseumawe and Lanal Sabang. From the results of weighting and warkingan, Naval Base Batam was selected as the best aju base from a scale of 0-1, with a weight value of 0.8442.*

**Keywords:** Piracy, GIS, Fuzzy AHP

## 1. INTRODUCTION

Piracy and piracy incidents that often occur in Indonesian waters greatly affect the credibility and dignity of the Indonesian nation in the eyes of the international world. Based on existing data, piracy and piracy in Indonesian waters became the most in the world, especially in the waters of the Strait of Malacca. This condition certainly has a negative impact on the Indonesian government. Even the International Maritime Bureau (IMB) gave the title 'Black Area' in the waters of the Strait of Malacca. According to the IMB, the most piracy and piracy areas in the world include the Strait of

Malacca, the Bay of Bengal, the Indian Ocean, the Waters of the Indonesian Archipelago, East Africa, West Africa, South America, the Mediterranean Sea, the Black Sea and the South China Sea.

Piracy and piracy have increased drastically in recent years and are estimated to cost the global economy more than \$7 billion a year (Ploch 2010). This has caught the attention of the United Nations, thus giving an international statement that the main motivation of pirate attacks is the financial gain gained either through piracy and theft of cargo or ransom collected after the kidnapping of the ship and its crew (Hastings 2009).

A number of approaches to combat piracy have been implemented by various parties (Rengelink 2012). For example, an October 2008 U.N. Security Council resolution provided a legal basis for pursuing pirates into Somali territorial waters. U.N. sanctions in 2008 and a U.S. presidential decree in 2010 prohibited ransom payments to a list of individuals known to be involved in piracy. In August 2008, the Maritime Security Patrol Area (MSPA) was established in the Gulf of Aden and in February 2009 ships carrying out sailings in the Gulf of Aden were advised to sail on a predetermined channel. Although various efforts have been made to reduce piracy, observers state that such efforts have not provided evidence of success (Shortland & Vothknecht 2010). Fighting piracy is the duty of all walks of life. In 2010 the ship allocated to combat piracy was 30 ships, the number is too small if it has to secure an area of two million square miles (Chalk 2010). Thus, the ability to create new strategies aimed at reducing piracy and piracy crimes is indispensable.

So far, various efforts to counter piracy and piracy have been carried out by the Indonesian government, both repressive and preventive. However, efforts have not received maximum results because it has not been through good planning and only utilizes ships operating in the territorial waters. A reliable intelligence capability and support is required, both in terms of information accuracy and base readiness that will be used as a starting point for ship movement and personnel in maritime security operations.

A law enforcement operation at sea is said to be successful if the goal can be achieved with minimal losses on its own side. There are several Navy Bases that are located close to the Strait of Malacca, the bases are Lanal Batam, Lanal Tanjung Balai Karimun and Lanal Dabo Singkep. Each base has advantages and disadvantages related to the ability to provide support to KRI and personnel who are carrying out Maritime Security Operations activities.

In this study, the authors used methods to consider the selection of alternative Naval Bases that will be used as a base for based on qualitative and quantitative criteria. The combination model of Multi Criteria Decision Making used is weighting method with Fuzzy AHP (Analytical Hierarchy Process) and mode workingman with Technique For

Others Reference by Similarity to Ideal Solution (TOPSIS). While GIS (Geographic Information System) is used to analyze and describe the real relationship between the points of piracy events that have occurred with the position of the surrounding Navy Base.

## 1.2 Problem Formulation

Based on the identification of existing problems, the problem can be formulated as follows: "How to determine the navy base around the waters of the Strait of Malacca to be used as the best aju base. In this case to deal with piracy and piracy crimes based on the position of events that have existed"

## 1.3 Research Objectives

This research was conducted to achieve several objectives, namely:

- Determine the right criteria for the selection of Initial Naval Base.
- Create a hierarchical hierarchy process (AHP) hierarchical structure model for the selection of the Navy Base combined with the TOPSIS combat method.
- Determine the appropriate Navy Base to be used as an base in the framework of handling piracy and piracy crimes.
- Create an information map about the selected Navy Base using Geographic Information System (GIS) method.

## 1.4 Research Benefits

The benefits obtained from this study are:

- The results of this study can be used to facilitate the determination of areas most prone to piracy and piracy crimes.
- The results of this study can be used to select the Navy aju base to support the implementation of operations handling piracy and piracy crimes.

## 1.5 Research limitations

The limitations of research used in this study are:

- The research area is limited according to the area on the sea map no. 2 production of the Indonesian Navy which covers the waters of Sumatra-East Coast of Singapore to the Bangka Strait.
- This research is limited to piracy and piracy incidents that have occurred in the waters of the Strait of Malacca in the period

from 2009 to 2014.

3. Navy bases that are used as research objects are navy bases located around the waters of the Strait of Malacca, namely Lanal Batam, Lanal Tanjung Balai Karimun, Lanal Dabo Singkep, Lanal Dumai, Lanal Tanjung Balai Asahan, Lanal Lhokseumawe and Lanal Sabang.

## **2. LITERATURE REVIEW**

### **2.1 Terms of high sea piracy under the Geneva conventions of 1958 and the United Nations Law of the Sea Convention 1982**

Piracy on the High Seas has been regulated under international customary law, as it is considered to interfere with the smooth sailing and the country has the right to exercise jurisdiction under the applicable laws of its country. [Subroto, S. and Wahyono, 1983].

The Geneva Convention of 1958 in Article 15 formulates piracy at sea, namely that:

Piracy consists of one of the following actions:

- 1) Any illegal act of violence, detention or act of depreciation, committed for personal purposes by the crew or passengers of a private ship or private aircraft, and directed:
  - a) On the high seas, against other vessels or aircraft, or against persons or property on board or aircraft.
  - b) To a ship, aircraft, person or goods somewhere outside the jurisdiction of any Country.
- 2) Any act of voluntary participation in the operation of an aircraft by knowing the facts that make it a pirate-ship or aircraft.
- 3) Any act invites or intentionally assists the actions mentioned in subsection (1) or subparagraph (2) of this article.

### **2.2 Decision Making Theory**

This process is to determine and resolve organizational issues. The decision-making process in the human brain is basically choosing an alternative from many alternatives based on a number of criteria of a problem. There are several methods in decision making, among others:

1. Decision analysis – deterministic.
2. Multi Criteria Decision Making (MCDM).
3. Analytical Hierarchy Process (AHP).

4. Analytical Network Process (ANP).  
[Kadarsah Suryadi, 2000,138].

### **2.3 Base Selection**

Determination of a strategic base is expected to provide solutions in solving problems / obstacles faced in the current conditions. In this paper the author uses two models in solving in determining strategic location, namely Fuzzy AHP (Analytical Hierarchy Process) method of workingman with Technique For Others Reference by Similarity to Ideal Solution (TOPSIS) and Geographic Information System (GIS). It is intended that in the research conducted can be obtained maximum results. Given that each model has different functions in solving the problems that will be raised in solving this paper. GIS is used to determine the working area of the Navy Base located around the waters of the Strait of Malacca taking into account the points of piracy and piracy crimes. While the Fuzzy AHP and TOPSIS methods focus on the selection of alternative Navy Bases that can be used as the most effective initial base.

#### **2.3.1 Basic Geographic Information System (GIS) Theory**

Currently, the GIS-MCDM combination spreads to energy-related applications. In the state of Georgia (USA), [Defne et al. 2011;15] evaluates the possibility of plant tidal power installation by combining GIS and several criteria. In Oman, [Charabi and Gastli, 2011;36] studied the suitability of installing solar photovoltaic power plants by combining GIS and multi-criteria fuzzy. Geographic Information System (GIS) is an organized collection of computer hardware, software, geographic data, and personnel efficiently designed to obtain, store, update, manipulate, analyze, and display all forms of geographically differentiated information. GIS has the ability to analyze spatial and non-spatial data (attributes). Related to its capabilities, it is necessary to manage non-spatial databases that are correlated with spatial data.

Database design is central in GIS. Database design will determine the effectiveness and efficiency of GIS input, management and output processes. A database is a non-redundant data set that can be shared by application systems. In other words, a database is a non-redundant data set (file) that is interconnected with

each other (expressed by key attributes in its tables/data structures and relationships) in an attempt to form an important information building [Eddy Prahasta, 2005: 190].

### 2.3.2 Fuzzy Analytic Hierarchy Process (Fuzzy AHP)

According to Indradewi (2008), AHP fuzzy measures are:

a. Change the linguistic variable in the form of fuzzy numbers.

Questionnaire data in the form of linguistic variables is converted to fuzzy number form. An example of a fuzzy number for a triangular fuzzy number (TFN) is seen in Table 1 where linguistic variables are converted into three fuzzy levels, i.e. low (a); medium (b); and high (c).

Table 1. TFN Scale in Linguistic Variables  
Source: (Firdolas et al (2006) in Indradewi (2008)

| Linguistic Scale                                                  | AHP Firm Value | FUZZY TFN Scale (a, b, c) | Inverse           |
|-------------------------------------------------------------------|----------------|---------------------------|-------------------|
| Both elements are equally important                               | 1              | (1,1,1+Δ)                 | (1,1,1/1+Δ)       |
| One element approaches a little more important than the other     | 3              | (3-Δ,3,3+Δ)               | (1/3+Δ,1/3,1/3-Δ) |
| Elements that one approaches are more important than the other    | 5              | (5-Δ,5,5+Δ)               | (1/5+Δ,1/5,1/5-Δ) |
| One approaching element is absolutely more important than another | 7              | (7-Δ,7,7+Δ)               | (1/7+Δ,1/7,1/7-Δ) |
| One element is absolutely essential than another                  | 9              | (9-Δ,9,9)                 | (1/9,9,1/9-Δ)     |
| The value between two adjacent considerations                     | 2,4,6,8        |                           |                   |

b. Develop a comparison matrix in pairs

between all elements / criteria in the dimension of the hierarchical system based on the assessment of variable linguistic.

$$\tilde{A} = \begin{pmatrix} 1 & \tilde{a}_{12} & \dots & \tilde{a}_{1j} \\ \tilde{a}_{21} & 1 & \dots & \tilde{a}_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{i1} & \dots & \dots & 1 \end{pmatrix} = \begin{pmatrix} 1 & \tilde{a}_{12} & \dots & \tilde{a}_{1j} \\ 1/\tilde{a}_{21} & 1 & \dots & 1/\tilde{a}_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{a}_{i1} & \dots & \dots & 1 \end{pmatrix} \dots (2.1)$$

$$\tilde{a}_{ij} = \begin{matrix} \tilde{1}, \tilde{3}, \tilde{5}, \tilde{7}, \tilde{9} & \text{Criteria } i \text{ are relatively important to } j \\ 1 & \text{Criteria } i \text{ are equally important to } j \\ \tilde{1}^*, \tilde{3}^*, \tilde{5}^*, \tilde{7}^*, \tilde{9}^* & \text{Criteria } i \text{ less important to } j \end{matrix}$$

c. Calculate the geometric average of respondents' assessments

The next step is to take the assessment results of all respondents and calculate the geometric average of the lower limit value (c); middle value (a); upper limit value (b) of the entire respondent. Here's a formula used to calculate geometric averages.

$$c = \sqrt[n]{c_1, c_2, \dots, c_n} \quad (2.2)$$

$$a = \sqrt[n]{a_1, a_2, \dots, a_n} \quad (2.3)$$

$$b = \sqrt[n]{b_1, b_2, \dots, b_n} \quad (2.4)$$

d. Defuzzification

After calculating the geometric average, the result is defuzzification to obtain the crisp value of the geometric mean of the fuzzy number to be reprocessed in AHP. One of the defuzzification techniques is the Centre Of Gravity (COG). The formula of defuzzification is as follows:

$$COG = \frac{\frac{1}{(a-c)} \left[ \frac{1}{3} x^3 - \frac{c}{2} x^2 \right]_c^a + \frac{1}{(a-b)} \left[ \frac{1}{3} x^3 - \frac{b}{2} x^2 \right]_c^b}{\frac{1}{(a-c)} \left[ \frac{1}{3} x^2 - cx \right]_c^a + \frac{1}{(a-b)} \left[ \frac{1}{3} x^3 - bx^2 \right]_c^b} \quad (2.5)$$

e. Calculate weight with AHP

Weight calculation is performed if the questionnaire results prove consistent, i.e. if the Consistency Ratio (CR) value < 0.1. To get cr done consistency index (CI) calculation first. Here's the formula for calculating CI:

$$CI = \frac{\lambda_{maks} - n}{n - 1} \quad (2.6)$$

Where:

$\lambda_{maks}$  = maximum eigen value

n = matrix size

CI = Consistency Index

The CI value is compared to the Ratio Index (RI) value in accordance with the matrix size so that consistency ratio (CR) value is obtained. The matrix is declared consistent if the CR value is not greater than 0.1. Table 2. Ratio Index (RI)

|                    |   |   |      |     |      |      |      |      |      |      |
|--------------------|---|---|------|-----|------|------|------|------|------|------|
| n (ukuran matriks) | 1 | 2 | 3    | 4   | 5    | 6    | 7    | 8    | 9    | 10   |
| RI (Ratio Index)   | 0 | 0 | 0,58 | 0,9 | 1,12 | 1,24 | 1,32 | 1,41 | 1,45 | 1,49 |

### 2.3.3. Technique For Others Reference by Similarity to Ideal Solution (TOPSIS)

The steps of the TOPSIS method are as follows:

a. Create a normalization matrix

The  $r_{ij}$  elements resulting from the normalization of the R matrix are:

$$r_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^m X_{ij}^2}} \quad (2.7)$$

b. Calculate the weight of the normalization matrix

With the weight of  $W = (w_1, w_2, \dots, w_n)$ , the normalization of the weight of matrix V is:

$$V = \begin{pmatrix} w_1 r_{11} & w_2 r_{12} & \dots & w_n r_{1n} \\ w_1 r_{21} & w_2 r_{22} & \dots & w_n r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ w_1 r_{m1} & w_2 r_{m2} & \dots & w_n r_{mn} \end{pmatrix}$$

c. Determine the ideal solution and the negative ideal solution.

The positive ideal solution is notified with  $(A^+)$ , while the negative ideal solution is notified with  $(A^-)$  :

$$A^+ = \{(\max v_{ij} \mid j \in J), (\min v_{ij} \mid j \in J'),$$

$$i = 1, 2, 3, \dots, m\} = \{v_1^+, v_2^+, \dots, v_n^+\}$$

$$A^- = \{(\min v_{ij} \mid j \in J), (\max v_{ij} \mid j \in J'),$$

$$i = 1, 2, 3, \dots, m\} = \{v_1^-, v_2^-, \dots, v_n^-\}$$

d. Calculating separation

The alternative distance of the ideal positive solution ( $S_i^+$ ) and the negative ideal solution ( $S_i^-$ ) is defined as:

$$S_i^+ = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^+)^2}, \text{ dengan } i = 1, 2, 3, \dots, m \quad (2.8)$$

$$S_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^-)^2}, \text{ dengan } i = 1, 2, 3, \dots, m \quad (2.9)$$

e. Calculate proximity relative to the ideal solution

$$A = \frac{S_i^-}{S_i^+ + S_i^-}, 0 < A < 1 \text{ dan } i = 1, 2, 3, \dots, m \quad (2.10)$$

f. Ranging Alternatives

Alternatives can be ranked in the order of A, therefore, the best alternative is one that is the shortest distance to the ideal positive solution and is furthest away with the ideal negative solution. Basically TOPSIS does not have a specific input model in the settlement of a case, TOPSIS uses an adapted input model from other methods (eg: AHP, ELECTRE, etc.).

### 2.3.4. Basic Theory of Geographic Information System (GIS)

Operations on the use of GIS require components in the form of:

a. Hardware, in the form of computers and equipment needed to run the system.

b. Software, is a system module that serves to enter, store, and extract the necessary data.

c. Geographic Information System (GIS) can collect and store the necessary data and information either directly or indirectly.

d. Management or brain ware, human ability to manage and utilize GIS effectively. As shown in Figure 1

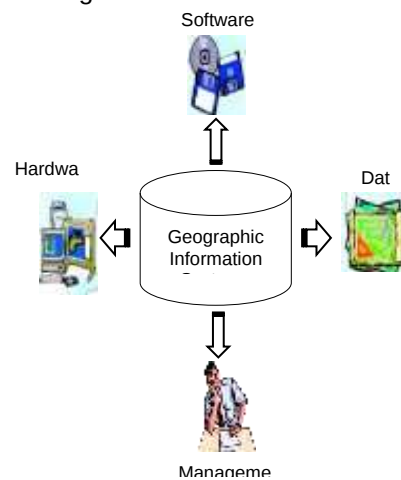


Figure 1. Geographic Information System

Geographic Information System (GIS) has the ability to analyze spatial and non-spatial data (attributes). Related to its capabilities, it is necessary to manage non-spatial databases that are correlated with spatial data

### c. RESEARCH METHODOLOGY

Research method is the first step, so that the research carried out becomes more targeted. It was previously given an initial hypothesis for the framework for research. To minimize the mistakes that occur and get results that are in accordance with the goals that have been set, a research method is needed. Types of data collected in the form of qualitative and quantitative data consisting of primary and secondary data. The primary data was obtained from Koarmabar operations staff, Koarmabar intelligence staff, and data from the Regional Analysis of Operations (ADO) of the Navy base around the waters of the Strait of Malacca

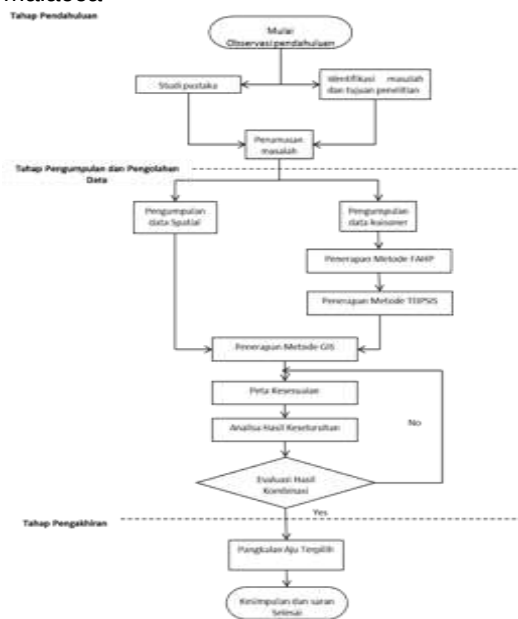


Figure 2. Research Flow Chart

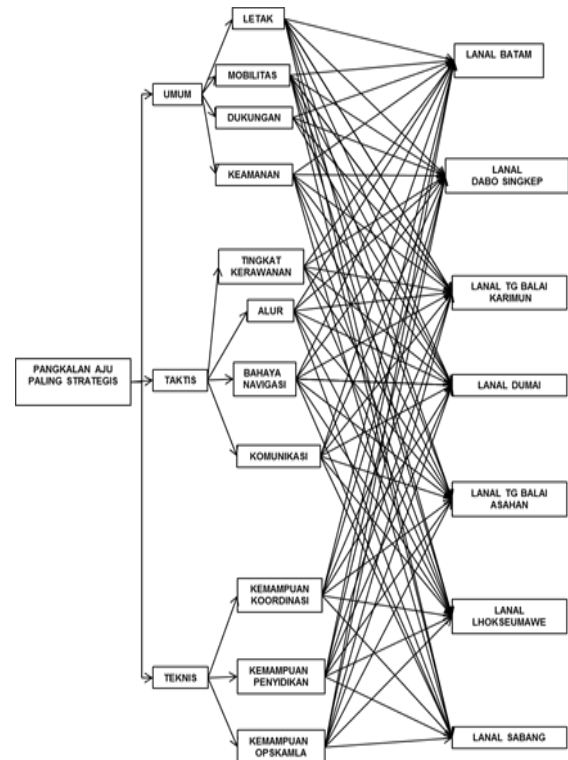


Figure 3. Development of hierarchy model in AHP

## 4. DATA COLLECTION AND PROCESSING

### 4.1 Fuzzy AHP Method

#### a. Data Collection

Questionnaire data is the main input used as a calculation input to know the priority of the Navy Base in Koarmabar work area that will be used as an base to carry out operational tasks using the Fuzzy Analytical Hierarchy Process (FAHP) method. These respondents have had the competence of expertise from academic provision and more than enough experience of the ministry, especially regarding the handling of piracy crimes.

#### b. Data Processing

1). Compile questionnaire data in the form of AHP paired comparison matrix

Table 3. Examples of paired comparison matrices

| Perbandingan ANTAR KRITERIA |       |      |        |        |
|-----------------------------|-------|------|--------|--------|
|                             | Baris | Umum | Taktis | Teknis |
| Kolom                       |       |      |        |        |
| Umum                        |       | 1    | 1/5    | 1/8    |
| Taktis                      |       | 5    | 1      | 1/3    |
| Teknis                      |       | 8    | 3      | 1      |

2). Change the linguistic variable in the form of fuzzy numbers

Table 4. Example of TFN value comparison matrix

| Perbandingan ANTAR KRITERIA |       |      |     |     |        |     |        |     |
|-----------------------------|-------|------|-----|-----|--------|-----|--------|-----|
| Kolom                       | Basis | Umum |     |     | Taktis |     | Teknis |     |
| Umum                        |       | 1    | 1/5 | 1/5 | 1/4    | 1/9 | 1/8    | 1/7 |
| Taktis                      |       | 4    | 5   | 6   | 1      | 1/4 | 1/3    | 1/2 |
| Teknis                      |       | 7    | 8   | 9   | 2      | 3   | 4      | 1   |

3). Calculate the geometric average of respondents' assessments

Table 5. Examples of geometric average data of all respondents

| Perbandingan ANTAR KRITERIA |       |      |      |      |        |      |        |      |
|-----------------------------|-------|------|------|------|--------|------|--------|------|
| Kolom                       | Basis | Umum |      |      | Taktis |      | Teknis |      |
| Umum                        |       | 1.00 | 1.36 | 1.68 | 2.10   | 1.14 | 1.43   | 1.78 |
| Taktis                      |       | 0.48 | 0.60 | 0.73 | 1.00   | 0.61 | 0.70   | 1.32 |
| Teknis                      |       | 0.56 | 0.70 | 0.88 | 1.15   | 1.43 | 2.49   | 1.00 |

4). Defuzzification

Table 6. Examples of defuzzification results

| Antar Kriteria |      |        |        |
|----------------|------|--------|--------|
|                | Umum | Taktis | Teknis |
| Umum           | 1,00 | 0,30   | 0,28   |
| Taktis         | 0,21 | 1,00   | 0,26   |
| Teknis         | 0,23 | 0,31   | 1,00   |

5). Calculating weights with AHP

Table 5. Results of Weighting Criteria and Alternatives

| Peringkat | Subkriteria | Bobot  |
|-----------|-------------|--------|
| 1         | KOORDINASI  | 0,1206 |
| 2         | LETAK       | 0,1156 |
| 3         | OPSKAMLA    | 0,1074 |
| 4         | PENYIDIKAN  | 0,1046 |
| 5         | KERAWANAN   | 0,1016 |
| 6         | DUKUNGAN    | 0,0988 |
| 7         | MOBILITAS   | 0,0980 |
| 8         | BHY NAV     | 0,0819 |
| 9         | ALUR        | 0,0816 |
| 10        | KOMUNIKASI  | 0,0464 |
| 11        | KEAMANAN    | 0,0434 |
| Jumlah    |             | 1,0000 |

Sumber: Pengolahan data

| PANGKALAN             | BOBOT  | PERINGKAT |
|-----------------------|--------|-----------|
| BATAM                 | 0,2660 | 1         |
| TANJUNG BALAI KARIMUN | 0,2056 | 2         |
| DUMAI                 | 0,1718 | 3         |
| SABANG                | 0,0961 | 4         |
| TANJUNG BALAI ASAHAN  | 0,0918 | 5         |
| DABO SINGKEP          | 0,0911 | 6         |
| LHOKSEUMAWE           | 0,0776 | 7         |

Sumber: Pengolahan data

## 4.2 TOPSIS Method

a. Determining the ideal solution and the ideal negative solution:

|    |        |        |        |        |        |        |        |        |        |        |
|----|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| A+ | 0,2961 | 0,2960 | 0,2726 | 0,2804 | 0,2962 | 0,3560 | 0,3300 | 0,3409 | 0,3225 | 0,2883 |
| A- | 0,3467 | 0,3386 | 0,3416 | 0,3426 | 0,3403 | 0,3452 | 0,3655 | 0,3541 | 0,3515 | 0,3453 |

b. Calculate the ideal alternative distance

| ALTERNATIF | Si+     | Si-     |
|------------|---------|---------|
| BATAM      | 1,44387 | 7,82407 |
| DABO       | 7,32869 | 1,81136 |
| KARIMUN    | 3,75735 | 5,54414 |
| DUMAI      | 4,50833 | 4,71899 |
| ASAHAN     | 7,42772 | 1,80355 |
| LHOK       | 8,13271 | 0,81909 |
| SABANG     | 7,20275 | 1,88159 |

c. Creating Alternate Battles

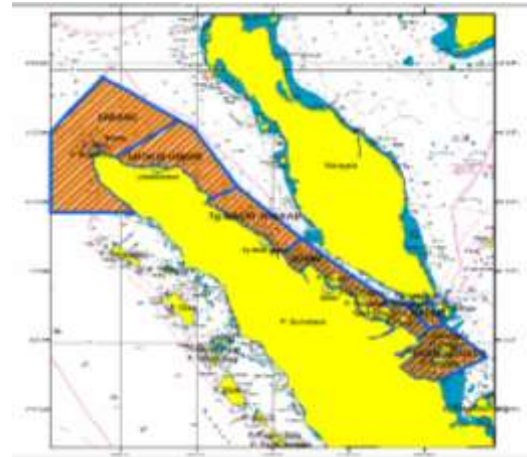
| PANGKALAN             | BOBOT  | PERINGKAT |
|-----------------------|--------|-----------|
| BATAM                 | 0,5442 | 1         |
| TANJUNG BALAI KARIMUN | 0,2791 | 2         |
| DUMAI                 | 0,5114 | 3         |
| SABANG                | 0,2036 | 4         |
| DABO                  | 0,1932 | 5         |
| TANJUNG BALAI ASAHAN  | 0,1954 | 6         |
| LHOK                  | 0,1915 | 7         |

## 4.3 Geographic Information System (GIS) Method

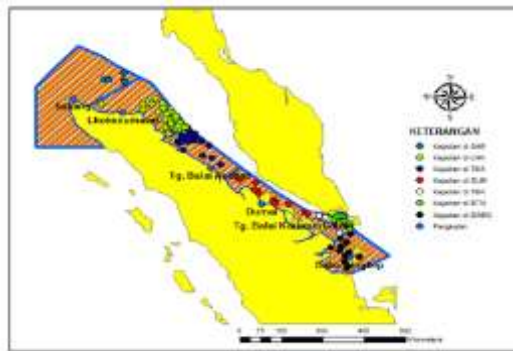
a. Data Collection

The data was obtained from Dishidros TNI AL and Koarmabar as well as other references that support this research. The data needed in this study include: Sea Map no. 2 production of Dishidros TNI AL, spatial data on piracy and piracy, spatial data and data of the Navy Base in the research area.

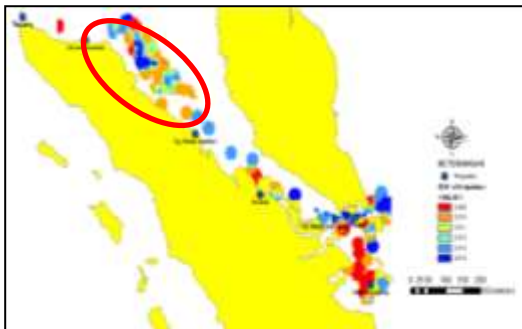
1) Position 7 (seven) Alternative Navy Base and Its Working Area



2) Data on Piracy and Piracy Insecurity in the working area of the Navy Base



Sumber: Pengolahan Data dengan Arcgis 9.3



#### 4.4 Fuzzy AHP, TOPSIS and GIS Combination

Based on the results obtained from the collection and processing of data by Fuzzy AHP, and GIS methods. This combination is done by entering the weight values produced in fuzzy AHP and TOPSIS processing into ArcGIS Software 9.3, thus creating a new literary map and making it easier for users to know the selected Navy Base with data and visuals.

Table 6. of Sub criteria Weights on each Criterion

| PANGKALAN | UMUM   |        |        |        |        | TAKTIS |        |        |        | TEKNIK |        |
|-----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|           | K1     | K2     | K3     | K4     | K5     | K6     | K7     | K8     | K9     | K10    | K11    |
| BATAM     | 0.1959 | 0.2369 | 0.3400 | 0.0984 | 0.1984 | 0.1206 | 0.0950 | 0.3300 | 0.3426 | 0.2225 | 0.2362 |
| DABO      | 0.0911 | 0.0785 | 0.0680 | 0.2729 | 0.0420 | 0.2200 | 0.0935 | 0.0489 | 0.0635 | 0.0564 | 0.0719 |
| KARIMUN   | 0.0991 | 0.2216 | 0.1679 | 0.1101 | 0.2414 | 0.1467 | 0.1030 | 0.2255 | 0.2065 | 0.2200 | 0.2591 |
| DUMAI     | 0.2145 | 0.1939 | 0.1895 | 0.1739 | 0.1124 | 0.2392 | 0.1930 | 0.1592 | 0.1500 | 0.1742 | 0.1596 |
| ABAHAN    | 0.1029 | 0.1011 | 0.0684 | 0.1992 | 0.0920 | 0.1291 | 0.1280 | 0.0705 | 0.0655 | 0.0840 | 0.0805 |
| LHOK      | 0.0467 | 0.0280 | 0.0416 | 0.0429 | 0.2824 | 0.0452 | 0.0540 | 0.0499 | 0.0541 | 0.0915 | 0.0480 |
| SABANG    | 0.0549 | 0.0723 | 0.1075 | 0.1469 | 0.0469 | 0.0960 | 0.1591 | 0.1220 | 0.1212 | 0.1090 | 0.0959 |
| Jumlah    | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

Sumber: Pengolahan Data

The Navy base chosen to be the aju base. From the results of data processing with Fuzzy AHP

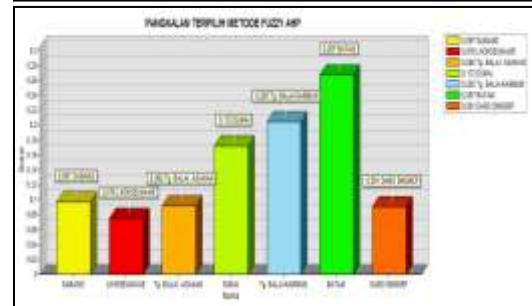
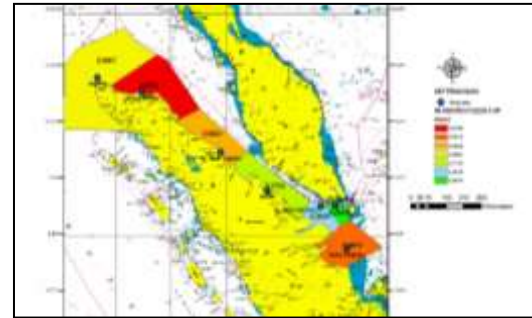


Figure 4. Weighting chart using ArcGIS Software 9.3

Then to integrate the value of the result of the working on the TOPSIS method, it is done how to import the data generated by the TOPSIS method into a GIS application namely Arcgis 9.3. The use of this application is to provide convenience to the user in understanding the data generated in the form of numbers and images

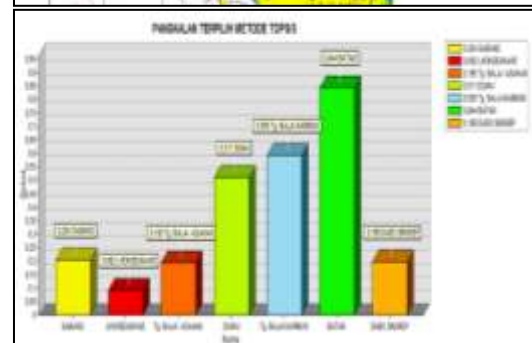
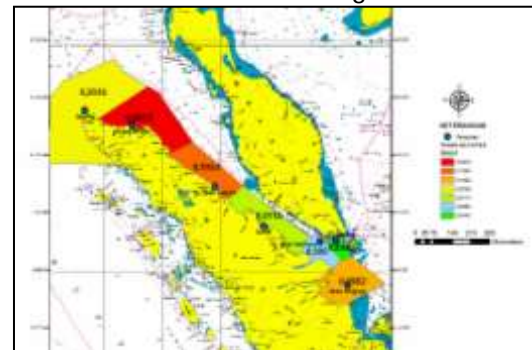


Figure 5. Weighting Chart of Selected Navy Base

## 5. RESULT AND DISCUSSION

### 5.1 Navy Bases Selected based on Criteria and Sub criteria.

From the results of data processing using fuzzy AHP method, then analyzed in accordance with the hierarchy structure produces the following weights:

a. Based on data collected from all respondents, the General Criteria had the highest weight rating (0.3868), the second rank of Technical Criteria (0.3183) and the third rank of Tactical criteria (0.2949). Factors of base position, mobility, ability to provide support and security from the monitoring of piracy actors are seen by respondents as factors that are very influential in the implementation of Opskamla. So for the selection of alternative Navy Bases that will be used as a base aju must pay attention to these factors.

b. Based on the processing of questionnaire data obtained the results of sub criteria weights based on their respective criteria, namely General Criteria of Sub criteria Location (0.2103), Mobility (0.2179), Support (0.3377) and Security (0.2341). Tactical Criteria, Sub criteria Level of Insecurity (0.3935), Groove (0.1706), Navigational Hazards (0.1858) and Communications (0.2501). Technical Criteria, Sub criteria of Coordination Capability (0.4559), Investigative Capability (0.1876) and Capability (0.3565). Sub criteria Support on general criteria, subcriteria Level of insecurity on tactical criteria and sub criteria coordination capabilities on technical criteria each ranked 1st for the selection of aju bases tni al. If seen from the results of weighting above, to accommodate the other criteria it appears that the selection of the navy base is expected to pay attention to the factors of location, level of insecurity and coordination ability.

c. Based on the results of data processing, the final weight value of subcriteria as a whole is ranked 1 Coordination ability (0.1344), 2. Support (0.1306), 3. Insecurity (0.1253), d. Opskamla Capability (0.1051), 5. Security (0.0906). 6. Mobility (0.0834), 7. Location (0.0813), 8. Communications (0.0794), 9. Navigation Hazards (0.0591), 10. Investigative capabilities (0.0553) and 11. Groove (0.0543).

### 5.2. Alternative Navy Bases Selected by Rank

From the results of data processing using fuzzy AHP method, then done warkingan using TOPSIS method, obtained the following results:

a. For alternative results, the selected Navy Bases are Batam Navy Base (0.8419), Tanjung Balai Karimun Navy Base (0.5891), Dumai Navy Base (0.5092), Sabang Navy Base (0.5891), Sabang Navy Base (0.5891). 0.2003), Dabo Singkep Base (0.1964), Tanjung Balai Asahan Navy Base (0.1961) and Lhokseumawe Navy Base (0.0894). Pangkalan TNI AL Batam was chosen as an adju base for the handling of piracy and piracy crimes. This is because of the 11 subcriterias used, Lanal Batam ranks 1st in 7 subcriterias namely mobility, support, navigation hazards, communication, coordination capabilities, investigation capabilities and opskamla capabilities. So as to make Lanal Batam as an adju base in the handling of piracy and piracy, the 7 subcriteria can be a top priority in improving its quality.

b. In the sensitivity analysis to find out the change in the rank of the alternative in case of weight change in the criteria, it was obtained that the critical criteria of weight change are the position criteria (at the change of weight + 0.5) and the safety criteria (on the change + 0.5). The change in weight on both criteria resulted in changes in ranks 5 and 6, namely at the Dabo Singkep Navy Base and Tanjung Balai Asahan Navy Base.

### 5.3 Creation of Geographic Information Maps

The creation of geographical information begins with the registration of sea map no. 2 production of Dishidros TNI AL, using Global Mapper software. Registration is done with the aim of adjusting the geodetic projection of the sea map to be used, in this study is the World Geodetic System (WGS) 1984

## 6. CONCLUSIONS

a. There are 3 (three) criteria and 11 (eleven) subcriteria used to determine the Navy Base to be used as Initial Base.

b. The results of the interview and identification of the next problem are carried out the preparation of the hierarchy. The first level is the goal to be achieved, the second level is the criteria that are the determining factors in the process of determining the base, while at the next level is subcriteria. At the last level is an alternative Navy Base to be chosen. To rank each alternative, the TOPSIS method is used using the principle that the selected alternative must have the closest distance from the positive ideal solution and the furthest from the negative ideal solution from a geometric point of view. A positive ideal solution is defined as the sum of all the highest values that can be achieved for each criterion, while a negative ideal solution consists of all the lowest values achieved for each criterion.

c. There are 7 (seven) Navy Bases along the Strait of Malacca that are used as alternative aju bases namely Lanal Batam, Lanal Dabo Singkep, Lanal Tanjung Balai Karimun, Lanal Dumai, Lanal Tanjung Balai Asahan, Lanal Lhokseumawe and Lanal Sabang. Pangkalan TNI AL Batam has the highest rating based on the overall criteria with a value of 0.8842, so it is appropriate to use as an adju base for the handling of piracy and piracy crimes. The resulting weight in data processing against the seven bases has a significant difference in ratings 1 to 4. As for the ranking of 5 to 7 the resulting difference is relatively small.

d. Map Information produced can provide convenience to the user to know the information contained in it. The resulting information includes the position of the Navy Base, the position of piracy events, the working area of each Navy Base and the final weight of the data processing results. The weights shown on each base include the rating weight based on each sub criteria and the final weight of the selected Navy Base.

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