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# APPLICATION OF DECISION SUPPORT SYSTEM FOR DETERMINING AMPHIBIOUS LANDING BEACH IN WEST PAPUA INDONESIA

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**ABSTRACT**

*Determination of the landing beach becomes a must for the Marine Forces of the Indonesian Navy as an element of the landing forces in order to carry out the task of amphibious operations in particular to determine the ideal landing beach location for the successful implementation of the task. Requirements on the determination of ideal landing beaches should be in accordance with predetermined parameters and serve as an important component in determining the weighting value of landing beach selection criteria. This study aims to determine the location of landing beaches by using the Preference Ranking Method Method of Organization for Enrichment Evaluation (PROMETHEE) combined into the Borda method. The research stages started from determining the value of criterion preferences to the landing beach alternative options analyzed by PROMETHEE method then processed again in Borda method. The PROMETHEE method is used to analyze individual decisions of decision makers, while the Borda method is used to manage group decisions from the PROMETHEE method of ranking. The use of both methods is a solution to generate more objective group decisions so as to obtain a ranking result against the selection of logical amphibious landing beaches and have an objective value in accordance with accurate data and greatly assist decision-makers to solve multi-criteria problems. From the results of this study can be seen that the location of the selected beach is the most feasible to serve as the location of landing beaches in amphibious operations is Beach 3 with a weighted value of 0.389.*

***Keywords:*** *Amphibious operations, the landing beach, Decision Support Systems, PROMETHEE, Borda.*

## 1. INTRODUCTION.

Indonesia is one of the largest countries in the world with a total area 5.193.250 $\mathrm{km}^2$ covering land and sea areas. This places Indonesia as the world's seventh largest country after Russia, Canada, USA, China, Brazil and Australia (Putra, et al., 2017). In addition Indonesia is also the largest archipelagic country in the world with a vast maritime territory with a total coastline of about 81.000 $\mathrm{km}^2$ and has more than 17.000 islands and 5,8 $\mathrm{km}^2$ of sea area or about 70% of the total area of Indonesia (Putra, et al., 2017). As an archipelagic country, especially in the eastern part of Indonesia with its abundant natural resources, it has not been optimally utilized so that it is very vulnerable to regional violation activities, such as illegal fishing, illegal mining, illegal logging and other illegal activities (Headquarter, 2017). World Maritime Axis Policy issued by the President of the Republic of Indonesia demands that Indonesia should anticipate able to maintain security stability in the urisdiction of NKRI. For that reason it is necessary a thought that can answer the problems faced in the eastern of Indonesia (Headquarter, 2017).

The process of division of Papua region has contributed well to the plan of establishment of The Eastern Marine Area Command and the $3^{rd}$ of Marine Force in West Papua due to infrastructure development (Headquarter, 2017), facilities and infrastructure of the local area is getting better. In order to carry out the function of empowering the marine defense area requires the ability of sea defense and also the ability to maintain all the potential of natural resources in it (Brink, 2000).

Understanding deeply about the coastal characteristics of West Papua especially related to the determination of landing beach becomes a must for Pasmar as a landing troop element in order to carry out the task of amphibious operation especially to determine the ideal landing beach location (Headquarter, 2013) for the successful implementation of the task (Brink, 2000). Requirements on determining ideal landing beaches (Collins, 1998) must conform to predefined parameters (Brink, 2000). These parameters serve as an important component in the determination of the criterion preferences value of the selected alternative (Ronyastra, et al., 2015) ideal landing beach location.

In the case of the landing beach location selection the PROMETHEE method is used to make individual decisions. Individual decision making is done by each decision maker by giving input in the form of weighted value against the criteria used (Brans, et al., 1998). PROMETHEE method is used in this research because this method is good enough to take into account the characteristics of the data as well as provide many functions that can accommodate various kinds of data characteristics (Deshmukh, 2013). The Borda method uses a preferential calculation for ranking against inputs provided by decision makers with more than one alternative (Costa, 2017). The Borda method in this study is used to accommodate the decision of each decision maker (Mohajan, 2013) which results from the calculation of the PROMETHEE method. Calculations using the Borda method use the weights in each ranking of each decision maker (da Rocha, et al., 2016). The choice alternatives with the top-ranking positions produced by each decision maker are rated higher than the rank below (Saediman, 2015). Using the method, the resulting decision is wiser depending on the original rank.

By using PROMETHEE method combined into Borda method, the research stages are started from the determination of the criterion preferences value (Ronyastra, et al., 2015) to the alternative choice (Velazques & Hestler, 2013) landing beaches using PROMETHEE method analysis to find an alternative ranking value for each individual decision-maker, then the ranking result is processed again with Borda method that emphasizes on the weighting of all alternative ranking (Costa, 2017) which is generated in the previous process so it is expected to obtain the result of alternative ranking of the landing beach which is logical and has objective value according to accurate data and very help the decision makers to solve the problem which is multi-criteria (Velasquez & Hester, 2013).

The systematics of this study are as follows: Chapter 2 contains a review literature on the definition of Amphibious Operations, landing beaches and theories used as the basis for the use of PROMETHEE and Borda methods. In chapter 3 discussed the flowchart and the use of research methods in all stages of the study. In chapter 4 the results and discussion are presented and the last is chapter 5 conclusion.

## 1. 2. MATERIAL/METHODOLOGY.

### Amphibious Operations.

Amphibious Operation is an attack carried out from the sea by naval units of the Navy and landing troops loaded in ships and amphibious landing means (Brink, 2000) and landed on enemy shore and / or coastal potential enemy (Headquarter, 2013).

### The Landing Beach.

The landing beach is part of the coastline required for landing one Battalion of Landing Team or equivalent unit. Beach landing can also be part of the coastline that has tactical value (Brink, 2000), such as a bay beach that can be used to land a smaller unity of the Battalion of the Landing Team (Brink, 2000) (Headquarter, 2013). In landing beach selection, certain types of oceanographic data should be adequately considered so that the Marines can safely carry out their landing (Staff, 2014) (Brink, 2000). These types of data include the concept of landing troop operations, coastal capacity to maneuver amphibious landing troops, coastal approaches, coastal obstacles, coastal rear features, communications infrastructure including railroads and weather and other hydro-oceanographic data (Collins, 1998). An important aspect of the ideal landing zone selection criteria in amphibious operations should be in accordance with landing beach parameters (Collins, 1998) which has been determined in accordance with table 1.

**Table 1.** Parameter of criteria for ideal landing beach in amphibious operations (Collins, 1998).

| NO | CRITERIA | INFLUENCE IN AMPHIBIOUS OPERATIONS | IDEAL PARAMETER |
|---|---|---|---|
| 1 | **Type of Shorelines.**<br>a. Straight shoreline.<br>b.Convex shoreline.<br>c.Concave shoreline. | a. Influence on currents and waves.<br>b. Effect on the direction of the shot the opposing coastal defense. | Straight shoreline |
| 2 | **Composition of the seafloor.**<br>a. Sand.<br>b. Sand pabbles.<br>c. Muddy sand.<br>d. Rocky gravel. | Influence on surface manuver of landing troop & combat materials | Sand composition |
| 3 | **Coastal gradient.**<br>a. Steep (gradient 1:15)<br>b.Moderate (1:15 >gradient≥ 1:30)<br>c.Gentle (1:30 > gradient≥ 1:60)<br>d.Mild (1:60>gradient≥1:120)<br>e. Flat (gradient > 1:120) | a. Influence on determination of ship type & landing lifeboat.<br>b. Influence on type of break wave in shallow water area | a. Moderate gradient.<br>1:15 > gradient ≥ 1:30<br>b. Gentle gradient<br>1:30 > gradient ≥ 1:60 |
| 4 | **Physical hydro-oceanography**<br>a. Wave<br>b. Tidal<br>c. Current | a. Effect on landing lifeboat and amphibious vehicle.<br>b.To determinate type of lifeboat & amphibious vehicle to be used. | a. spilling wave type.<br>b.Semidiurnal and Mixed Semidiurnal tidal type<br>c. Current parallel shoreline velocity < 1 knots. |
| 5 | **Back area of beach** | a. Influence on manuver of troops & amphibious vehicles.<br>b. Defence area for protection after landing. | a. Flat with an elevated beach backdrop.<br>b. There is a ramp to the rear of the beach. |
| 6 | **Point of reference for landing beach.** | a. To help identification process about landing beach.<br>b. As a navigation mark when on sea surface. | Can be a known terrain sign for its position |
| 7 | **Obstacles on Littoral Area**<br>a. Natural obstacles<br>b. Artificial obstacles | a. Influence in motion power of combat materials and troops<br>b. Can make amphibious vehicle and lifeboat become broken. | The area which have minimum natural obstacle. |
| 8 | **Beach access** | Make easy to manuver for troops & vehicle on landing beach. | The area which have enough of total access. |

**Group Decision Support System.**

Decision Support Systems The group was very popular in the 1980s which was a tool in finding solutions to solve problems in workgroups (Manzini & Pareschi, 2012) so the system is usually called the group decision support system (Korhonen, et al., 1992). There are three important steps to solve the problem in this system:

a. Determination of criteria and alternatives.

b. Evaluate the value of criteria preference to alternative by the decision makers of each section.

c. Evaluate the weighted values collected into one group to determine the alternatives of group selection.

**PROMETHEE Method.**

PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation)
is a method for determining the order or priority of alternative options (Turcksin, et al., 2011) on issues that are multicriteria (Brans, et al., 1998) which offers a simple and flexible way (Rao & Rajesh, 2009) to the decision makers in order to find the right solution (Martin, et al., 2003) on multicriteria issues (Brans & Vincke, 1985). In this method the value of the criterion preferences for the alternative P (d) is grouped according to the six types of preference functions (Deshmukh, 2013) below:

a. Usual criterion.

$$P(d) = \begin{cases} 0, d = 0, \\ 1, d \neq 0. \end{cases} \quad (1)$$

In this case, $a$ and $b$ are said to be indifference if and only if $f(a) = f(b)$. If there is a difference (though very small) between the two alternatives then the decision maker gives immediate preference (Halouani, et al., 2009) strong for an alternative with a higher value (Brans & Vincke, 1985). The function P (d) is shown in Figure 1 below:

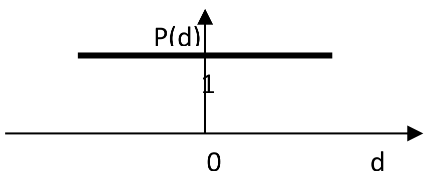


**Fig. 1** Usual criterion.

b. Quasi criterion:

$$P(d) = \begin{cases} 0, -q \leq d \leq q \\ 1, d < -q \cup d > q \end{cases} \quad (2)$$

Based on this criterion, the two alternatives are said to be no different as long as the value $d$ does not exceed the value of $q$, and if the d value exceeds the $q$ value then there is absolute preference (Brans & Vincke, 1985). This is shown in Figure 2 below:

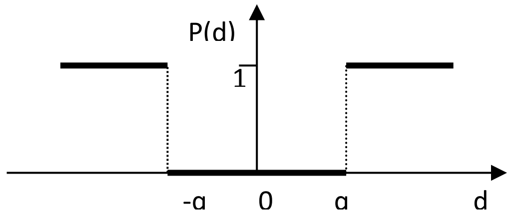


**Fig. 2** Quasi criterion.

If the decision maker decides to use the quasi criterion, then the value of $q$ should be determined (Deshmukh, 2013), where this value can explain the significant effect of a criterion (Macharis, et al., 2004). Thus it can be said that $q$ is the indifference threshold value, which is the largest $d$ value which still allows indifference between alternatives (Christian, et al., 2016).

c. Criterion with linear preference:

$$P(d) = \begin{cases} d/p, -p \leq d \leq p, \\ 1, d < -p \cup d > p. \end{cases} \quad (3)$$

In this criterion, decision-making preferences increase linearly as long as the value $d$ is still lower than $p$ (Vega, et al., 2013). And if $d$ exceeds p occurs absolute preference (Goumas & Lygerou, 2000). Here the decision maker must set the value of $p$ (threshold preference value), it's the lowest $d$ value that still results in a preference relationship between alternatives (Brans & Vincke, 1985).

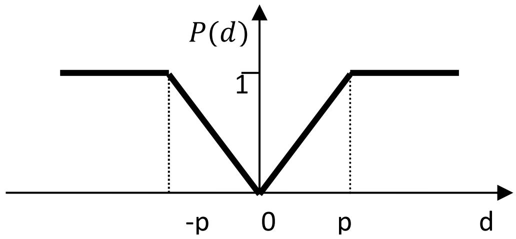


**Fig. 3** Criterion with linear preference.

d. Level criterion:

$$P(d) \; = \; \begin{cases} 0, \mathrm{I}d\mathrm{I} \le q, \\ 1/2, q < \mathrm{I}d\mathrm{I} \le p, \\ 1, p < \mathrm{I}d\mathrm{I}. \end{cases} \qquad (4)$$

Here, the indifference threshold value $q$ and the preference threshold $p$ are determined simultaneously (Briggs, et al., 1990). If d lies between $q$ and $p$ then there is a weak preference relationship ( $P(d)$=1/2 ) (Brans & Vincke, 1985).

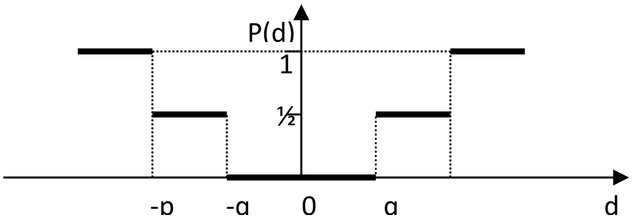


**Fig. 4** Level criterion.

e. Criterion with linear preference and indifferent area:

$$P(d) \; = \; \begin{cases} 0, \mathrm{I}d\mathrm{I} \le q, \\ (\mathrm{I}d\mathrm{I} - q)/(p - q), q < \mathrm{I}d\mathrm{I} \le p, \\ 1, p < \mathrm{I}d\mathrm{I}. \end{cases} \qquad (5)$$

Here the decision-making preference increases linearly from the indifference to the absolute preference in the area between $q$ and $p$ (Behzadian, et al., 2010).

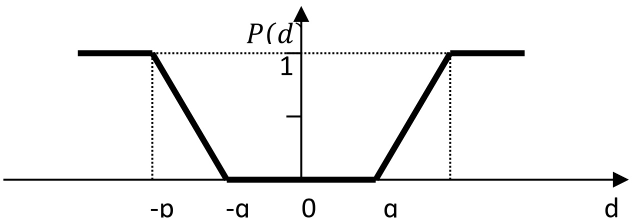


**Fig. 5** Criterion with linear preference and indifferent area.

f. Gaussian criteria:

$P(d) \; = \; 1 \; - \; exp\{-d2/2\sigma2\}$. (6)

Where $d$ is difference of criterion value, then it can be written $d = f_{(a)} - f_{(b)}$. Here it is only necessary to determine the value $\sigma$ which can be made based on the normal distribution of statistics (Martin, et al., 2003).

Graphically, this criterion can be seen in the following picture:

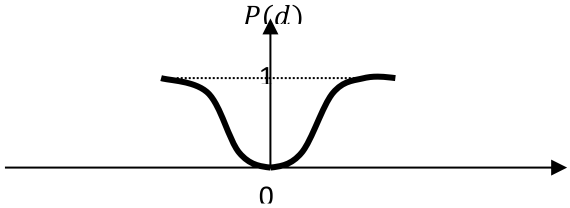


**Fig. 6** Gaussian Criteria

The stages of calculation by using PROMETHEE method is as follows (Vega, et al., 2013):

a. Specify some alternatives.

b. Specify some criteria.

c. Define the criteria weight.

d. Define the rating rules (maximum or minimum).

e. Determine the type of preference for each criterion based on data and judgments of decision makers. These types of preferences are Usual, Quasi, linear, quasi and Gaussian linear.

f. Calculates the preference index.

g. Calculating leaving flow, entering flow and net flow.

h. Determine the ranking of alternatives by creating a peraninga table (Brans & Vincke, 1985).

**Borda Method.**

Borda method proposed by the discoverer of Jean Charles de Borda in the 18th century is one of the methods used for the alternative purpose of some selected alternatives (Costa, 2017). Each alternate option will be judged on a weighted value and then sorted by rank (Vega, et al., 2013). The greatest weight is the best alternative for decision makers (Mohajan, 2012) (Costa, 2017). The privilege of this method can overcome the difficulties of other methods where people / things that are not in the first rank will be automatically eliminated (Ishida, 2017). The basic idea in Borda Method is by assigning weight to each of the first rank, second rank, and so on (Ishida, 2017).

Borda method is one method that can be used to accommodate the ranking of decision makers (Saediman, 2015). The calculation on this method uses the weight of each ranking position generated by the decision makers (Costa, 2017) (Mohajan, 2013).

**Flow Chart Diagram.**

In this study is divided into four stages of research activities are arranged in sequence starting from the stage of identification, data collection phase, analysis and data processing and conclusions and suggestions that can be seen as Figure 7. as follows:

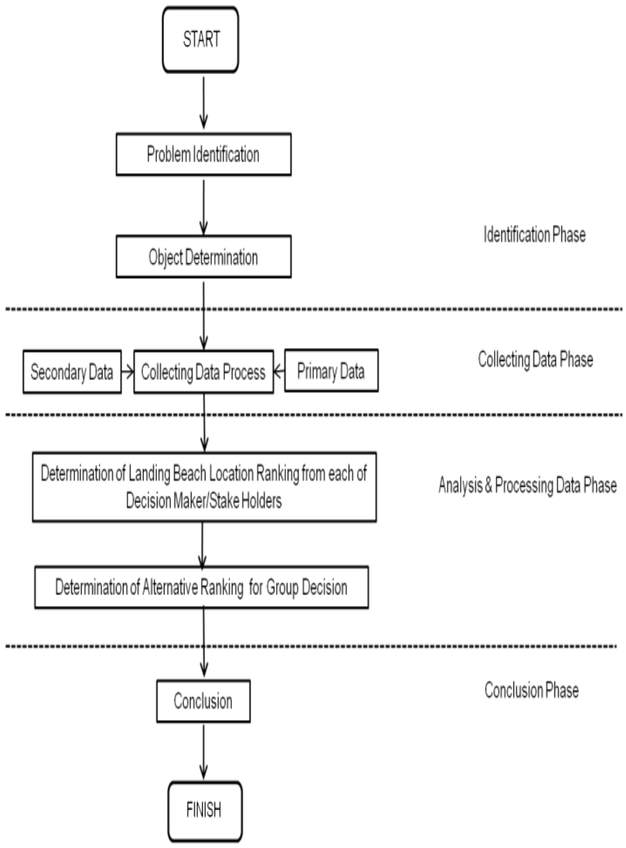


**Fig. 7** Flow chart diagram of research..

**Research Object.**

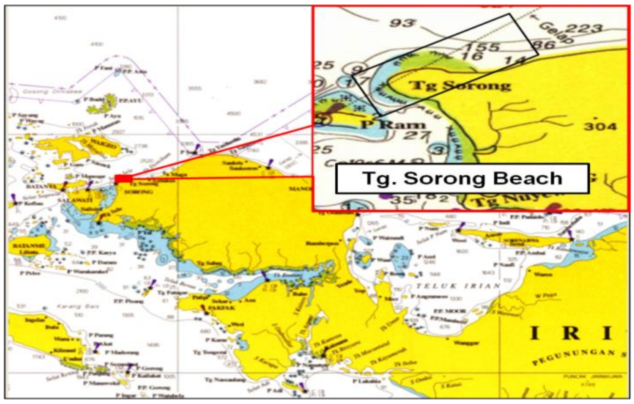


**Fig. 8** Research location map.


**Fig. 9** Alternative map of landing beach location.

**Research Stages.**

Stages of this study can be explained as follows:

a. Identification phase .

1) Problem identification.

Before decision support systems are built, the problems in the research must be properly defined so that the results obtained match the problems at hand.

2) Object Determination.

Determination of research objectives is done based on a problem that is defined as something that must be solved.

b. Collecting data phase.

Data collection was obtained by conducting literature studies on PROMETHEE and Borda methods used in the study, as well as the determinant variables and criteria of ideal landing beach parameters from several literature such as journals, books and other relevant scientific sources relevant to the study.

c. Analysis and processing data phase.

Determination of landing beach location ranking from each decision maker/stake holder. In this phase, ranking is done by PROMETHEE method to generate individual location ranking by decision makers. The sequence of activities undertaken is as follows:

a) Determine the criteria value against the alternatives.

The criteria assessment of alternatives is implemented by decision makers in accordance with predetermined assessment rules.

b) Determine the preference value $H(d)$.

In this case the type of preference used is the type of linear preference with the consideration that the decision maker will assign the value of the criterion preferences to each alternative on the condition that if $d \leq 0$ then $H(d) = 0$ and if $d > 0$ then $H(d) = 1$, the calculation of preference values is determined by the formula (Ronyastra, et al., 2015):

$$P[f(a), f(b)] = P[f(a) - f(b)]$$

In order to indicate any differences in values between environments, it can be written by the formula (Brans, et al., 1998) (Brans & Vincke, 1985):

$$d = f(a) - f(b)$$

Where:

$P$ : preference.

$d$ : difference of criterion value

$f(a)$ : preference value $a$.

$f(b)$ : preference value $b$.

c) Determine the preference index value $H(d)$.

After the criterion preferences value for each individual alternative has been obtained, the next step is to determine the preference index value (Brans & Vincke, 1985) by the formula (Brans, et al., 1998):

$$\pi(a,b) = \frac{1}{k}\sum_{h=1}^{k} P_h(a,b)$$

Where:

$\pi(a,b)$= index preference $a, b$.

$k$ = total of criteria.

$h$ = preference group $1,2,3, \ldots, k$.

The function of this index value is to measure the decision maker's preferences in order to answer the question of whether the alternative $a$ is better than alternative $b$ taking all the criteria into account simultaneously (Brans & Vincke, 1985) (Deshmukh, 2013). This value is between 0 and 1 with conditions if $\pi(a,b)$=0 then it shows weak preference for alternative $a$ better than $b$ in all criteria (Martin, et al., 2003). And if $\pi(a,b)$=1 then it strong preference for alternative $a$ better than $b$ in all criteria (Brans, et al., 1998).

d) Calculate leaving flow ($\Phi^+$ ).

Leaving flow function is to measure the level of dominance of alternative $a$ to other alternatives (Brans, et al., 1998) with the following formula (Brans & Vincke, 1985):

$$\emptyset^+(a) = \frac{1}{n-1}\sum_{x \in k} \pi(a,x)$$

Where:

$\emptyset^+$ : leaving flow

$a$ : alternative

$n$ : total of alternative

$k$ : criteria

$\pi(a,x)$ : preference outgoing flow for each node a.

e) Calculate entering flow ($\Phi^-$),

Entering flow is to measure how big an alternative is dominated by other alternatives (Brans, et al., 1998) with the following formula (Brans & Vincke, 1985):

$$\emptyset^{-}(a) = \frac{1}{n-1}\sum_{x \in k} \pi(x,a)$$

Where:

$\emptyset^{+}$ : leaving flow

$a$ : alternative

$n$ : total of alternative

$k$ : criteria

$\pi(x,a)$: preference incoming flow for each node a.

f) Calculate net flow (Φ ).

Net flow is calculated based on the difference between leaving flow and entering flow in order to determine an alternate ranking (Brans, et al., 1998) by formula (Brans & Vincke, 1985):

$$\emptyset(a) = \emptyset^{+}(a) - \emptyset^{-}(a)$$

Where:

$\emptyset(a)$ : net flow

$\emptyset^{+}(a)$ : leaving flow

$\emptyset^{-}(a)$ : entering flow

2) Determination of alternative ranking for group decision.

In this phase, to determinate alternative ranking for group decision use Borda method where the rank of landing beaches are resulted by that count. We can see on this phase below:

a) Create a ranking table from the all decision maker.

The ranking table is created base on PROMETHEE process result before, and then entered in matrix form.

b) Determination alternative value.

From table 3, we do the assessment by giving the value for the first rank with the value of $n-1$ where n is the number of alternatives (Mohajan, 2012). Each decision maker assigns a $n-1$ value for the first choice alternative, $n-2$ for the second option, $n-3$ for the third option and so on up to 0 for the last choice criterion or alternative (Ishida, 2017).

c) Determination ratio value for all weighted ranking of alternative (Costa, 2017) with formula below (Ishida, 2017):

$$R_1 = \sum_{j=1}^{n} R_{ij}$$

d) Determination of the weight value of each alternative $(W_1)$ (Ishida, 2017):

$$W_1 = \frac{R_1}{\sum_{i=1}^{m} R_1}$$

Where:

$R_1$: the sum of all rankings is weighted for all criteria 1.

$R_{ij}$: the rankings are evaluated by *j* for criteria 1.

$W_1$: criteria weight 1 for evaluator *n*.

In this case, all alternatives are calculated on the basis of their respective weights and then the results are divided by the ratio value to get the alternative value. The alternative with the highest value is the choice.

## 3. RESULT AND DISCUSS.

**Data Alternatives.**

From the data acquisition results about the characteristics of each alternative beach that will be selected as the location of amphibious landing beach obtained data. There are four alternatives to be considered in the selection process with data summarized in table 2.

**Table 2** Data summarized of the landing beach alternatives

| Alternatives Data | Beach 1 (A) | Beach 2 (B) | Beach 3 (C) | Beach 4 (D) |
|---|---|---|---|---|
| Area (km²) | 0,5049 | 0,6603 | 1,0027 | 0,9078 |
| Depth (m) | 2,8 | 3,4 | 3,1 | 3,7 |
| Facility Object | Road access | Road access | Road access | Road access |
| | Goverment office | Goverment office | Fishing port | Fishing port |
| | School building | Public transport terminal | Wirehouse | |
| | Sport field | Shops | | |
| Usage | Resort home | Commersial area | Commersial area | Commersial area |
| | Tourism destination | Tourism destination | Adventure center | Industrial |
| | Villas | Villas | Fishing area | mining |

**Determination landing beach location ranking from each decision maker/stake holder.**

In the selection process, the decision makers are considering to use eight criteria, They are type of shoreline, hydro-oceanography, coastal gradient, composition of seafloor, ponit of reference, back area of beach, obstacles of littoral area and beach access. After analyzing preference value for the degree of importance of each criteria. In the following tables a preference rating of eight criteria for four A, B, C and D alternatives of each decision maker with value 1 is feasible, value 2 is moderate and value 3 is less feasible. The weights assigned using PROMETHEE method and data summarized in table 3, 4 and 5.

**Table 3.** Table of assessment from decision maker 1

| NO | CRITERIA | ALTERNATIVE | | | |
|---|---|---|---|---|---|
| | | A | B | C | D |
| 1 | TYPE OF SHORELINE | 2 | 1 | 2 | 3 |
| 2 | HYDRO-OCEANOGRAPHY | 1 | 1 | 1 | 3 |
| 3 | COASTAL GRADIENT | 1 | 3 | 3 | 2 |
| 4 | COMPOSITION OF SEAFLOOR | 2 | 1 | 2 | 1 |
| 5 | POINT OF REFERENCE | 3 | 2 | 1 | 2 |
| 6 | BACK AREA OF BEACH | 2 | 3 | 2 | 3 |
| 7 | COASTAL OBSTACLES | 2 | 2 | 2 | 3 |
| 8 | BEACH ACCESS | 2 | 2 | 1 | 3 |

**Table 4.**Table of assessment from decision maker 2

| NO | CRITERIA | ALTERNATIVE | | | |
|---|---|---|---|---|---|
| | | A | B | C | D |
| 1 | TYPE OF SHORELINE | 2 | 1 | 1 | 2 |
| 2 | HYDRO-OCEANOGRAPHY | 1 | 1 | 3 | 1 |
| 3 | COASTAL GRADIENT | 2 | 1 | 3 | 2 |
| 4 | COMPOSITION OF SEAFLOOR | 3 | 3 | 2 | 1 |
| 5 | POINT OF REFERENCE | 3 | 2 | 2 | 2 |
| 6 | BACK AREA OF BEACH | 2 | 3 | 2 | 2 |
| 7 | COASTAL OBSTACLES | 1 | 2 | 2 | 1 |
| 8 | BEACH ACCESS | 2 | 3 | 3 | 3 |

**Table 5.** Table of assessment from decision maker 3

| NO | CRITERIA | ALTERNATIVE | | | |
|---|---|---|---|---|---|
| | | A | B | C | D |
| 1 | TYPE OF SHORELINE | 1 | 2 | 2 | 1 |
| 2 | HYDRO-OCEANOGRAPHY | 2 | 1 | 3 | 2 |
| 3 | COASTAL GRADIENT | 2 | 2 | 2 | 3 |
| 4 | COMPOSITION OF SEAFLOOR | 3 | 2 | 3 | 2 |
| 5 | POINT OF REFERENCE | 2 | 1 | 1 | 2 |
| 6 | BACK AREA OF BEACH | 1 | 3 | 1 | 1 |
| 7 | COASTAL OBSTACLES | 2 | 2 | 1 | 3 |
| 8 | BEACH ACCESS | 2 | 2 | 1 | 3 |

From the above assessment results then proceed with determining the value of preference of each decision maker or stake holder. At this stage, all values are processed to get the value $H(d)$ so the result of calculation to each preference value is like in table 6,7 and 8.

**Table 6.** Preference value from decision maker 1

| No | Criteria (F) | Calculation Result of Preference Values [H(d)] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | F1: Type of Shoreline | | F1 (A,B) | F1 (A,C) | F1 (A,D) | F1 (B,A) | F1 (B,C) | F1 (B,D) | F1 (C,A) | F1 (C,B) | F1 (C,D) | F1 (D,A) | F1 (D,B) | F1 (D,C) |
| | | d | 1 | 0 | -1 | -1 | -1 | -2 | 0 | 1 | -1 | 1 | 2 | 1 |
| | | H(d) | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| 2 | F2: Hydro-Oceanography | | F2 (A,B) | F2 (A,C) | F2 (A,D) | F2 (B,A) | F2 (B,C) | F2 (B,D) | F2 (C,A) | F2 (C,B) | F2 (C,D) | F2 (D,A) | F2 (D,B) | F2 (D,C) |
| | | d | 0 | 0 | -2 | 0 | 0 | -2 | 0 | 0 | -2 | 2 | 2 | 2 |
| | | H(d) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 3 | F3: Coastal Gradient | | F3 (A,B) | F3 (A,C) | F3 (A,D) | F3 (B,A) | F3 (B,C) | F3 (B,D) | F3 (C,A) | F3 (C,B) | F3 (C,D) | F3 (D,A) | F3 (D,B) | F3 (D,C) |
| | | d | -2 | -2 | -1 | 2 | 0 | 1 | 2 | 0 | 1 | 1 | -1 | -1 |
| | | H(d) | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| 4 | F4: Composition of Seafloor | | F4 (A,B) | F42 (A,C) | F4 (A,D) | F4 (B,A) | F4 (B,C) | F4 (B,D) | F4 (C,A) | F4 (C,B) | F4 (C,D) | F4 (D,A) | F4 (D,B) | F4 (D,C) |
| | | d | 1 | 0 | 1 | -1 | -1 | 0 | 0 | 1 | 1 | -1 | 0 | -1 |
| | | H(d) | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 5 | F5: Point of Reference | | F5 (A,B) | F5 (A,C) | F5 (A,D) | F5 (B,A) | F5 (B,C) | F5 (B,D) | F5 (C,A) | F5 (C,B) | F5 (C,D) | F5 (D,A) | F5 (D,B) | F5 (D,C) |
| | | d | 1 | 2 | 1 | -1 | 1 | 0 | -2 | -1 | -1 | -1 | 0 | 1 |
| | | H(d) | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 6 | F6: Back Area of Beach | | F6 (A,B) | F6 (A,C) | F6 (A,D) | F6 (B,A) | F6 (B,C) | F6 (B,D) | F6 (C,A) | F6 (C,B) | F6 (C,D) | F6 (D,A) | F6 (D,B) | F6 (D,C) |
| | | d | -1 | 0 | -1 | 1 | 1 | 0 | 0 | -1 | -1 | 1 | 0 | 1 |
| | | H(d) | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 7 | F7: Coastal Obstacle | | F7 (A,B) | F7 (A,C) | F7 (A,D) | F7 (B,A) | F7 (B,C) | F7 (B,D) | F7 (C,A) | F7 (C,B) | F7 (C,D) | F7 (D,A) | F7 (D,B) | F7 (D,C) |
| | | d | 0 | 0 | -1 | 0 | 0 | -1 | 0 | 0 | -1 | 1 | 1 | 1 |
| | | H(d) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 8 | F8: Beach Access | | F8 (A,B) | F8 (A,C) | F8 (A,D) | F8 (B,A) | F8 (B,C) | F8 (B,D) | F8 (C,A) | F8 (C,B) | F8 (C,D) | F8 (D,A) | F8 (D,B) | F8 (D,C) |
| | | d | 0 | 1 | -1 | 0 | 1 | -1 | -1 | -1 | -2 | 1 | 1 | 2 |
| | | H(d) | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |

**Table 7.** Preference value from decision maker 2

| No | Criteria (F) | Calculation Result of Preference Values [H(d)] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | F1: Type of Shoreline | | F1 (A,B) | F1 (A,C) | F1 (A,D) | F1 (B,A) | F1 (B,C) | F1 (B,D) | F1 (C,A) | F1 (C,B) | F1 (C,D) | F1 (D,A) | F1 (D,B) | F1 (D,C) |
| | | d | 1 | 1 | 0 | -1 | 0 | 0 | -1 | 0 | -1 | 0 | 1 | 1 |
| | | H(d) | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 2 | F2: Hydro-Oceanography | | F2 (A,B) | F2 (A,C) | F2 (A,D) | F2 (B,A) | F2 (B,C) | F2 (B,D) | F2 (C,A) | F2 (C,B) | F2 (C,D) | F2 (D,A) | F2 (D,B) | F2 (D,C) |
| | | d | 0 | -2 | 0 | 0 | -2 | 0 | 2 | 2 | 2 | 0 | 0 | -2 |
| | | H(d) | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 3 | F3: Coastal Gradient | | F3 (A,B) | F3 (A,C) | F3 (A,D) | F3 (B,A) | F3 (B,C) | F3 (B,D) | F3 (C,A) | F3 (C,B) | F3 (C,D) | F3 (D,A) | F3 (D,B) | F3 (D,C) |
| | | d | 1 | -1 | 0 | -1 | -2 | -1 | 1 | 2 | 1 | 0 | 1 | -1 |
| | | H(d) | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 |
| 4 | F4: Composition of Seafloor | | F4 (A,B) | F42 (A,C) | F4 (A,D) | F4 (B,A) | F4 (B,C) | F4 (B,D) | F4 (C,A) | F4 (C,B) | F4 (C,D) | F4 (D,A) | F4 (D,B) | F4 (D,C) |
| | | d | 0 | 1 | 2 | 0 | 1 | 2 | -1 | -1 | 1 | -2 | -2 | -1 |
| | | H(d) | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 5 | F5: Point of Reference | | F5 (A,B) | F5 (A,C) | F5 (A,D) | F5 (B,A) | F5 (B,C) | F5 (B,D) | F5 (C,A) | F5 (C,B) | F5 (C,D) | F5 (D,A) | F5 (D,B) | F5 (D,C) |
| | | d | 1 | 1 | 1 | -1 | 0 | 0 | -1 | 0 | 2 | -1 | 0 | 0 |
| | | H(d) | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6 | F6: Back Area of Beach | | F6 (A,B) | F6 (A,C) | F6 (A,D) | F6 (B,A) | F6 (B,C) | F6 (B,D) | F6 (C,A) | F6 (C,B) | F6 (C,D) | F6 (D,A) | F6 (D,B) | F6 (D,C) |
| | | d | -1 | 0 | 0 | 1 | 1 | 1 | 0 | -1 | 0 | 0 | -1 | 0 |
| | | H(d) | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | F7: Coastal Obstacle | | F7 (A,B) | F7 (A,C) | F7 (A,D) | F7 (B,A) | F7 (B,C) | F7 (B,D) | F7 (C,A) | F7 (C,B) | F7 (C,D) | F7 (D,A) | F7 (D,B) | F7 (D,C) |
| | | d | -1 | -1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | -1 | -1 |
| | | H(d) | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| 8 | F8: Beach Access | | F8 (A,B) | F8 (A,C) | F8 (A,D) | F8 (B,A) | F8 (B,C) | F8 (B,D) | F8 (C,A) | F8 (C,B) | F8 (C,D) | F8 (D,A) | F8 (D,B) | F8 (D,C) |
| | | d | -1 | -1 | -1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| | | H(d) | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |

**Table 8.** Preference value from decision maker 3.

| No | Criteria (F) | Calculation Result of Preference Values [H(d)] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | F1: Type of Shoreline | | F1 (A,B) | F1 (A,C) | F1 (A,D) | F1 (B,A) | F1 (B,C) | F1 (B,D) | F1 (C,A) | F1 (C,B) | F1 (C,D) | F1 (D,A) | F1 (D,B) | F1 (D,C) |
| | | d | -1 | -1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | -1 | -1 |
| | | H(d) | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| 2 | F2: Hydro-Oceanography | | F2 (A,B) | F2 (A,C) | F2 (A,D) | F2 (B,A) | F2 (B,C) | F2 (B,D) | F2 (C,A) | F2 (C,B) | F2 (C,D) | F2 (D,A) | F2 (D,B) | F2 (D,C) |
| | | d | 1 | -1 | 0 | -1 | -2 | -1 | 1 | 2 | 1 | 0 | 0 | -1 |
| | | H(d) | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 3 | F3: Coastal Gradient | | F3 (A,B) | F3 (A,C) | F3 (A,D) | F3 (B,A) | F3 (B,C) | F3 (B,D) | F3 (C,A) | F3 (C,B) | F3 (C,D) | F3 (D,A) | F3 (D,B) | F3 (D,C) |
| | | d | 0 | 0 | -1 | 0 | 0 | -1 | 0 | 0 | -1 | 1 | 1 | 1 |
| | | H(d) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 4 | F4: Composition of Seafloor | | F4 (A,B) | F42 (A,C) | F4 (A,D) | F4 (B,A) | F4 (B,C) | F4 (B,D) | F4 (C,A) | F4 (C,B) | F4 (C,D) | F4 (D,A) | F4 (D,B) | F4 (D,C) |
| | | d | 1 | 0 | 1 | -1 | -1 | 0 | 0 | 1 | 1 | -1 | 0 | -1 |
| | | H(d) | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 5 | F5: Point of Reference | | F5 (A,B) | F5 (A,C) | F5 (A,D) | F5 (B,A) | F5 (B,C) | F5 (B,D) | F5 (C,A) | F5 (C,B) | F5 (C,D) | F5 (D,A) | F5 (D,B) | F5 (D,C) |
| | | d | 1 | 1 | 0 | -1 | 0 | -1 | -1 | 0 | -1 | 0 | 1 | 1 |
| | | H(d) | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 6 | F6: Back Area of Beach | | F6 (A,B) | F6 (A,C) | F6 (A,D) | F6 (B,A) | F6 (B,C) | F6 (B,D) | F6 (C,A) | F6 (C,B) | F6 (C,D) | F6 (D,A) | F6 (D,B) | F6 (D,C) |
| | | d | -2 | 0 | 0 | 2 | 2 | 2 | 0 | -2 | 0 | 0 | -2 | 0 |
| | | H(d) | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | F7: Coastal Obstacle | | F7 (A,B) | F7 (A,C) | F7 (A,D) | F7 (B,A) | F7 (B,C) | F7 (B,D) | F7 (C,A) | F7 (C,B) | F7 (C,D) | F7 (D,A) | F7 (D,B) | F7 (D,C) |
| | | d | 0 | 1 | -1 | 0 | 1 | -1 | -1 | -1 | -2 | 1 | 1 | 2 |
| | | H(d) | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 8 | F8: Beach Access | | F8 (A,B) | F8 (A,C) | F8 (A,D) | F8 (B,A) | F8 (B,C) | F8 (B,D) | F8 (C,A) | F8 (C,B) | F8 (C,D) | F8 (D,A) | F8 (D,B) | F8 (D,C) |
| | | d | 0 | 1 | -1 | 0 | 1 | -1 | -1 | -1 | -2 | 1 | 1 | 2 |
| | | H(d) | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |

From the calculation of the above preference values has been obtained a value of of $H(d)$ for all criteria on all landing beach alternatives. Then the results of the assessment are processed again to determine a value of $\pi$ as an alternative preference value index of landing beach location choice on each decision maker. The calculation result of index value $\pi$ for each decision maker can be seen in table 9, 10 and 11.

**Table 9.** Calculation result of the preference index value from decision maker 1.

| Index | A | B | C | D |
|---|---|---|---|---|
| A | 0 | 0,375 | 0,25 | 0,25 |
| B | 0,25 | 0 | 0,375 | 0,125 |
| C | 0,125 | 0,25 | 0 | 0,25 |
| D | 0,75 | 0,5 | 0,75 | 0 |

**Table 10.** Calculation result of the preference index value from decision maker 2.

| Index | A | B | C | D |
|---|---|---|---|---|
| A | 0 | 0,375 | 0,375 | 0,25 |
| B | 0,5 | 0 | 0,25 | 0,375 |
| C | 0,5 | 0,25 | 0 | 0,625 |
| D | 0,125 | 0,25 | 0,125 | 0 |

**Table 11.** Calculation result of the preference index value from decision maker 3.

| Index | A | B | C | D |
|---|---|---|---|---|
| A | 0 | 0,375 | 0,375 | 0,125 |
| B | 0,25 | 0 | 0,375 | 0,25 |
| C | 0,25 | 0,25 | 0 | 0,375 |
| D | 0,375 | 0,5 | 0,5 | 0 |

After the preference index value in each decision maker has been obtained, then the next step is to determine the value of leaving flow $(\emptyset^{+})$, entering flow $(\emptyset^{-})$ dan net flow $(\emptyset)$ to know the acquisition of the ratings of all the alternative landing beach options in each decision maker that we can see in tables 12, 13 and 14.

**Table 12.** Calculation result of leaving flow, entering flow and net flow from decision maker 1.

| Alternative | Leaving Flow ($\Phi^{+}$) | Entering Flow ($\Phi^{-}$) | Net Flow ($\Phi$) | Alternative Ranking |
|---|---|---|---|---|
| A | 0,292 | 0,375 | -0,083 | 4 |
| B | 0,250 | 0,375 | -0,125 | 3 |
| C | 0,208 | 0,458 | -0,250 | 2 |
| D | 0,667 | 0,208 | 0,458 | 1 |

**Table 13.** Calculation result of leaving flow, entering flow and net flow from decision maker 2.

| Alternative | Leaving Flow ($\Phi^{+}$) | Entering Flow ($\Phi^{-}$) | Net Flow ($\Phi$) | Alternative Ranking |
|---|---|---|---|---|
| A | 0,333 | 0,375 | -0,042 | 3 |
| B | 0,375 | 0,292 | 0,083 | 2 |
| C | 0,458 | 0,250 | 0,208 | 1 |
| D | 0,167 | 0,417 | -0,250 | 4 |

**Table 14.** Calculation result of leaving flow, entering flow and net flow from decision maker 3.

| Alternative | Leaving Flow ($\Phi^{+}$) | Entering Flow ($\Phi^{-}$) | Net Flow ($\Phi$) | Alternative Ranking |
|---|---|---|---|---|
| A | 0,292 | 0,292 | 0 | 2 |
| B | 0,292 | 0,375 | -0,083 | 4 |
| C | 0,292 | 0,417 | -0,125 | 3 |
| D | 0,458 | 0,250 | 0,208 | 1 |

From the calculation of the value of leaving flow, entering flow and net flow above we can see the difference of the ranking of the alternative to the alternative on each decision maker. In the decision maker 1 shows the alternative D in the order of 1 with the net value of 0.458 followed by alternative C in the order of 2 with the net value of -0.25, the alternative B in the order of 3 with net flow -0.125 and the last alternative A in fourth place with net flow -0.083. While the ranking in decision maker 2 shows the alternative C in the first sequence with net flow 0.208, alternate B in second with net flow 0.083, alternative A in third with net flow -0,042 and alternative D in fourth with net flow -0, 25. While for decision maker 3 produce alternative D in the first sequence with net flow 0,208, alternative A in second with net flow 0, alternative C in third with net flow -0,125 and alternative B in fourth with net value -0,083.

**Determination of alternatif ranking for group decision.**

From the results of individual decisions resulting from each decision maker, then performed the processing using Borda method. This Borda calculation is used to manage group decisions from the rankings generated by each appraiser so that the resulting decision has a more objective value. Alternative landing beach ranking results from each decision maker as assessors can be seen in table 15.

**Table 15.** Ranking result from each assessor.

| Alternative | PROMETHEE Ranking | | |
|---|---|---|---|
| | Expert 1 | Expert 2 | Expert 3 |
| Beach 1 | 4 | 3 | 2 |
| Beach 2 | 3 | 2 | 4 |
| Beach 3 | 2 | 1 | 3 |
| Beach 4 | 1 | 4 | 1 |

At this stage, the ranking of the alternatives of each decision maker was re-processed as the material for determining the ranking of landing beach alternatives using the Borda method in order to obtain group decision results. The calculation of Borda is done by giving a value to the $n-1$ alternative for the first rank, $n-2$ for second rank, $n-3$ for third rank and $n-4$ for fourth rank, where in this case the alternative number is four landing beach options so the value given for the first rank is 3 and so on up to the value 0 for the last ranking. The results of the assessment process on the landing beach alternative can be seen in table 16.

**Table 16.** Calculation result of alternatif value.

| Alternative | PROMETHEE Ranking | | | Alternative Value | | |
|---|---|---|---|---|---|---|
| | Expert 1 | Expert 2 | Expert 3 | Value 1 | Value 2 | Value 3 |
| Beach 1 | 4 | 3 | 2 | 0 | 1 | 2 |
| Beach 2 | 3 | 2 | 4 | 1 | 2 | 0 |
| Beach 3 | 2 | 1 | 3 | 2 | 3 | 1 |
| Beach 4 | 1 | 4 | 1 | 3 | 0 | 3 |

The results of the calculation of the above alternative values shown in the column value 1, value 2 and value 3 further determined the ratio value $(R_1)$ for all weighted ranking values of all alternatives in accordance with Borda calculations with the result $R_1 = 18$. Based on the $R_1$, all alternatives are calculated on the basis of their respective weights and then the results are divided by the ratio value to get the alternate value. From the resulting alternative value that can be known the overall ranking ranking of the landing beach alternative to be selected. In table 17 is the result of the calculation of Borda method which shows the ranking of alternative based on the value of alternative generated. While in Figure 10 shows the graph of alternative ranking result which compiled based on result of calculation of alternative value.

**Table 17.** Alternative ranking result.

| Alternative | Weight Code | Weight Value (W) | Ratio ($R_1$) | Value ($W/R_1$) | Level |
|---|---|---|---|---|---|
| Beach 1 | $W_1$ | 1 | 18 | 0,056 | 4 |
| Beach 2 | $W_2$ | 4 | 18 | 0,222 | 3 |
| Beach 3 | $W_3$ | 7 | 18 | 0,389 | 1 |
| Beach 4 | $W_4$ | 6 | 18 | 0,333 | 2 |

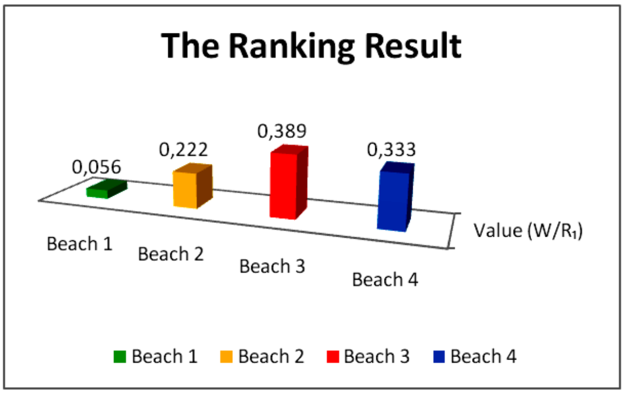


**Fig. 10.** The ranking result graph.

From the final result of the calculation it can be seen that the group decision making using the Borda method resulted in Beach 3 with an alternative value of 0.389 as the main priority to be chosen as landing beach, then in the other priority order, second to fourth respectively is Beach 4 with value 0,333, Beach 2 with value 0,222 and Beach 1 with value 0,056.

## 4. CONCLUSION.

Based on the results of research conducted to obtain the following conclusions:

1. In determining ideal landing beaches to carry out amphibious operations in the coastal waters of West Papua requires the ability of analysis of the components to be used as the

main criterion of selection and alternative landing coastal beaches that are multi-criteria. This is important because the selection of the right coastal location will determine the success in the implementation of amphibious operations, especially on the mastery of the beach.

2. Needed a right decision-making method to apply to this problem with reference to group decision support system that is integration between PROMETHEE and Borda method, where in this research PROMETHEE method is used to generate individual decision from each decision maker while method Borda serves to establish the results of group decisions on an alternative landing beach to be selected.

3. The result of analysis with PROMETHEE method to determination of alternative rank of landing beach in order to know the result of individual decision from each decision maker can be known that there are different preference about alternative appraisal on each decision maker. The result of individual decision on decision maker 1 shows that alternative D (Beach 4) becomes first rank with net value 0,458. In decision maker 2, alternative C (Beach 3) was chosen to be the first rank with net flow 0.208. As for decision maker 3 produces alternative D (Beach 4) in the first sequence with net flow 0.208.

4. From result of analysis with Borda method can be known that Beach 3 with value 0,389 chosen as first order, while for second to fourth is Beach 4, Beach 2 and Beach 1. The result of this calculation is result of group decision so Beach 3 is considered most feasible for chosen to be the location of the amphibious landing beach.

5. The integration between PROMETHEE and Borda method is very suitable to solve the problem of landing beach location selection in amphibious operation, where the result of PROMETHEE method can give input as alternative preference value which can then be processed in an integrated manner with Borda method analysis according to each process stage so that the result of the resulting group decision is logical and objective.

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