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Determining Tourism Area Using TOPSIS Analysis in the Dampier Strait Conservation Area

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Abstract: The Dampier Strait regional conservation area is one of the conservation areas included in the Raja Ampat Regency marine conservation area, which has high potential for developing tourism activities. The most important aspect in the use of natural resources for tourism purposes is their suitability to support tourism activities. The challenge faced is the difficulty if the potential for beach tourism, snorkeling and diving to be developed simultaneously. The aim of this research is to determine areas for ecotourism and recommend appropriate locations. Data analysis is determining ecotourism areas using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). TOPSIS is used because it is able to rank the selected alternatives that are closest to the positive ideal and furthest from the negative ideal solution. The criteria used are tourist carrying capacity, accommodation, accessibility, number of international tourists, number of domestic tourists and suitability area. The results of this TOPSIS analysis are that Sauwandarek, Marandanweser and Arborek are areas that can be used as an alternative area for carrying out beach tourism, snorkeling and diving activities. Areas that can be developed into ecotourism activities are Yeben Kecil and Tanjung Putus.

Keywords: Coast; Conservation area; Ecotourism; TOPSIS

Introduction

Indonesia's natural resources and environmental services are very potential in the sea, especially for tourism purposes (Yamin et al., 2021; Rizaldi et al., 2024). The development of tourism areas must be directed at comprehensively planned development so that the community can benefit by paying attention to its sustainability so that the resources owned can be enjoyed in the long term (D'Oria et al., 2021; Velenturf & Purnell, 2021; Kuhlman & Farrington, 2010). One form of management is the wise utilization of marine and coastal resource potentiall (Yuhandra et al., 2023; Basconi et al., 2023; Uktolseja, 2022; Eger et al., 2021). Coastal tourism plays an important role in the national economy as an archipelagic country, as long as it is managed well to maintain environmental quality and attract tourists (Lukman et al., 2022; Atika et al., 2024). Tourism activities in coastal areas generally prioritize economic benefits, namely how to attract as many tourists as possible without considering the environmental carrying capacity (Mira & Kurniawan, 2020; Insani et al., 2020; Metilelu et al., 2022).

If an area is no longer able to accommodate the number of tourists (exceeding the carrying capacity of the area) then there will be a decrease or degradation of environmental quality (Baños-Pino et al., 2024; Adrianto et al., 2021). The Dampier Strait Regional Marine Conservation Area (KKPD) is the second largest area in Raja Ampat, with an area of 353.53 ha. The Dampier Strait KKPD has the highest biodiversity of all areas in Raja Ampat, namely in coral reefs, seagrass beds and the largest mangrove forest in Raja Ampat (Yuanike et al., 2019). The Dampier Strait KKPD is a stopover for whales, dolphins and dugongs, as well as a gathering place for Manta Rays which are a tourist attraction

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(Mangubhai et al., 2012; Sari Hani, 2021). The Dampier Strait KKPD is an area with the highest number of visits in the Raja Ampat region. This can be seen in 2022, the number of tourist visits to Raja Ampat was 5.72 people, including 4.97 foreign tourists and 752 domestic tourists.

As an area that is very famous for the tourism sector, this is inseparable from management problems related to the use of tourism (Ineke et al., 2018), namely damage to coral reefs from tourism activities, the accumulation of visitors at several diving locations, the accumulation of visitors in several areas such as Arborek, garbage and wastewater due to the development of tourism infrastructure, there has been no determination of limited shipping routes for tourist ships, and the increasing number of tour guides from outside Raja Ampat who enter the Dampier Strait without knowing about conservation. Based on the background above, research was conducted with the aim of determining areas for ecotourism and recommending appropriate locations.

Method

Data Collection Method

Primary data is obtained from direct measurements and observations for tourism suitability parameters, including parameters for beach tourism, snorkeling tourism, and diving tourism. Secondary data is obtained from tourism associations, the Raja Ampat Tourism Office, and the Raja Ampat BLUD UPTD. Secondary data obtained are in the form of accommodation, accessibility, number of foreign tourists, and number of domestic tourists

Data Analysis

TOPSIS analysis is carried out by determining the criteria used as points to find the best solution (Dutta et al., 2019). Criteria are factors that influence decision making. The criteria used are carrying capacity, accommodation, accessibility, number of foreign tourists, number of domestic tourists, and total area of tourism suitability. TOPSIS is one method that can help the decision-making process optimally to complete decisions practically (Kelemenis & Askounis, 2010). This is because the concept is simple and easy to understand and is able to measure the relative performance of decision alternatives. In addition, this method can provide solutions from several alternatives by comparing each alternative with the best alternative and the worst alternative. The steps used in finding a solution with the TOPSIS method are through the following stages (Rahim et al., 2018; Chakraborty, 2022): Determine the criteria used to determine whether an option is the best option. Build a normalized decision. Use the following equation:

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

Where:
r_{ij} = R decision matrix normalization results;
i = 1, 2, 3,,,,,m;
j = 1, 2, 3,,,,,,m

Weighting the criteria. At this stage, the criteria that influence decision making are given a weight value based on the importance of the criteria; Building a weighted normalized decision matrix as shown in the following equation:

$$V = \begin{bmatrix} w_1 r_{11} & \cdots & w_n r_{1n} \\ \vdots & \ddots & \vdots \\ w_1 r_{m1} & \cdots & w_n r_{mn} \end{bmatrix} \quad (2)$$

Determine the negative ideal solution and positive ideal solution shown in the following equation:

$$A^+ = \{(\max V_{ij})(\min V_{ij} | j \in J'), i = 1,2,3, \dots,, m\} = \{V1^+, V2^+, \dots, Vm^+\}$$
$$A^- = \{(\max V_{ij})(\min V_{ij} | j \in J'), i = 1,2,3, \dots,, m\} = \{V1^-, V2^-, \dots, Vm^-\} \quad (3)$$

Calculating separation, it is a way to calculate or measure the distance between alternative solutions and positive ideal solutions or negative ideal solutions shown in the following equation:

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij-} v_j^+)^2}$$
$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij-} v_j^-)^2} \quad (4)$$

with i = 1,2,3,...,n;
Calculate the relative closeness to the optimal solution shown in the following equation

$$Ci^+ = \frac{S_i^-}{S_i^- + S_i^+} \quad (5)$$

with 0<C<1 dan i=1,2,3,...,n;
Provides alternative rankings that can be sorted based on the Ci+ value from largest to smallest.

Result and Discussion

Determination of Criteria

The criteria used in this study are coastal carrying capacity (C1), snorkeling carrying capacity (C2), diving carrying capacity (C3), accommodation (C4), accessibility (C5), number of foreign tourists (C6),

number of domestic tourists (C7), total coastal suitability area (C8), total snorkeling suitability area (C9), and total diving suitability area (C10). Accommodation data is the number of lodgings in the area and accessibility is the availability of ports or bridges so that tourists can reach the area. The research area includes Yeben Kecil (1), Yeben Besar (2), Waiweser (3), Yef Adoak (4), Marandanweser (5), Dayan (6), Arborek (7), Sauwandarek (8), Yenbekwan (9), Friwen (10), and Tanjung Putus (11). The amounts of criteria to be calculated can be seen in Table 1.

Table 1. Criteria Matrix

Location	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
1	38	0	0	0	0	0	0	3628	0	0
2	82	1	1	5	1	14	31	7920	918	1132
3	477	7	0	2	0	14	31	8541	9602	0
4	131	2	1	6	1	14	31	5402	2621	1495
5	636	2	0	6	1	28	61	8916	3050	0
6	15	1	2	5	0	21	46	1412	785	2689
7	36	1	1	9	1	35	77	3417	1873	1099
8	189	3	0	8	1	35	77	18190	4455	0
9	711	0	1	0	1	0	0	17080	0	1128
10	97	1	1	2	0	14	31	9327	839	1233

a. Making a normalized decision

Calculations to obtain normalized matrix values using the formula

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x^2 ij}}$$

$$r_{ij}\ \frac{38}{1103{,}54} = 0.034 \quad (6)$$

Based on these calculations, the normalized matrix value for coastal bearing capacity in Yeben Kecil is 0.034. Other calculation results can be seen in Table 2.

Table 2. Normalized Decision Matrix

Location	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
1	0.03	0	0	0	0	0	0	0.10	0	0
2	0.07	0.10	0.30	0.30	0.40	0.20	0.20	0.30	0.80	0.30
3	0.40	0.80	0	0.10	0	0.20	0.20	0.30	0.80	0
4	0.10	0.20	0.30	0.40	0.40	0.20	0.20	0.20	0.20	0.40
5	0.60	0.20	0	0.40	0.40	0.40	0.40	0.30	0.30	0
6	0.01	0.10	0.60	0.30	0	0.30	0.30	0.10	0.10	0.70
7	0.03	0.10	0.30	0.50	0.40	0.50	0.50	0.10	0.20	0.30
8	0.20	0.40	0	0.50	0.40	0.50	0.50	0.60	0.40	0
9	0.60	0	0.30	0	0.40	0	0	0.60	0	0.30
10	0.10	0.10	0.30	0.10	0	0.20	0.20	0.30	0.10	0.30
11	0.10	0.10	0.30	0	0	0	0	0.30	0.10	0.30
√x2	1104	8.40	3.20	17	2.40	68	147	31317	11677	4000

Weight Value of Each Criterion

Weight is defined with a value of 1 = not important, 2 = less important, 3 = moderate, 4 = important, and 5 = very important. So, the weight distribution is as follows: 5 (Very Important), Accommodation, Accessibility, Number of Foreign Tourists, Number of Domestic Tourists 4 (Important). Coastal Carrying Capacity, Snorkeling Carrying Capacity, Diving Carrying Capacity, Total Beach Suitability Area, Total Snorkeling Suitability Area, Total Diving Suitability Area. The results of the criteria weighting calculation can be seen in Table 3.

Table 3. Criteria Weighting Results

Location	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
1	0.14	0	0	0	0	0	0	0.46	0	0
2	0.30	0.47	1.26	1.51	2.05	1.05	1.06	1.01	3.20	1.12
3	1.73	3.32	0	0.60	0	1.05	1.06	1.09	3.29	0
4	0.47	0.95	1.26	1.81	2.05	1.05	1.06	0.69	0.87	1.48
5	2.30	0.95	0	1.81	2.05	2.10	2.08	1.14	1.04	0
6	0.05	0.47	2.53	1.51	0	1.57	1.57	0.18	0.27	2.68

Location	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
7	0.13	0.47	1.26	2.71	2.05	2.62	2.62	0.44	0.64	1.08
8	0.68	1.42	0	2.41	2.05	2.62	2.62	2.32	1.52	0
9	2.58	0	1.26	0	2.05	.0	0	2.18	0	1.12
10	0.35	0.47	1.26	0.60	0	1.05	1.06	1.19	0.28	1.20
11	0.33	0.47	1.26	0	0	0	0	1.12	0.54	1.08

Determining negative ideal solution and positive ideal solution

The positive ideal solution is obtained from the sum of the best values on each criterion, and the negative ideal solution is obtained from the lowest value on each criterion (Resmi & Defriani, 2022; Effatpanah et al., 2022; Kurniawan et al., 2020). The positive ideal solution value is obtained from the maximum value and the negative ideal solution value is obtained from the minimum value of the criteria weighting table. These values can be seen in Table 4.

Table 4. Positive and Negative Solution Values

Criteria	Min	Max
C1	0.05	2.57
C2	0	3.32
C3	0	2.52
C4	0	2.71
C5	0	2.04
C6	0	2.62
C7	0	2.62
C8	0.18	2.32
C9	0	3.28
C10	0	2.68

Calculating Separation

Calculating the distance to the positive and negative ideal solutions of each existing alternative.

Table 5. Separation Results

Location	Negative	Positive
Yeben Kecil	0.29	7.92
Yeben Besar	4.71	5.04
Waiweser	5.29	5.41
Yef adoak	3.94	5.12
Marandanweser	4.91	4.24
Dayan	4.58	6.00
Arborek	5.26	5.36
Sauwandarek	5.74	4.89
Yenbekwan	4.17	6.85
Friwen	2.64	6.38
Tanjung Putus	2.05	7.18

Based on the results of the separation calculation, the largest positive ideal solution value was obtained in Yeben Kecil. The positive ideal solution value indicates that the area maximizes the benefits of each criterion (Krohling & Pacheco, 2015; Hassan et al., 2023; Akbar et al., 2023; Lamrini et al., 2023). This is in line with the real conditions in Yeben Kecil which have not yet been utilized for tourism activities. The largest negative ideal solution is in Sauwandarek.

Calculating Proximity to the Optimal Solution

Searching for the relative proximity value of each criterion to the ideal solution.

Table 6. Optimal Solution Results

Location	Ci
Yeben Kecil	0.03
Yeben Besar	0.48
Waiweser	0.49
Yef adoak	0.43
Marandanweser	0.53
Dayan	0.43
Arborek	0.49
Sauwandarek	0.5
Yenbekwan	0.37
Friwen	0.29
Tanjung Putus	0.22

Based on the table above, the results of the calculation of the largest optimal solution are in Sauwandarek with a value of 0.54. This indicates that Sauwandarek can be used as an alternative destination for beach tourism, snorkeling and diving (Karima et al., 2022).

Providing Alternative Rankings

Ordering the relative proximity values that have been calculated.

Table 7. Alternative Rankings

Location	Ranking
Sauwandarek	1
Marandanweser	2
Arborek	3
Waiweser	4
Yeben Besar	5
Yef adoak	6
Dayan	7
Yenbekwan	8
Friwen	9
Tanjung Putus	10
Yeben Kecil	11

The final result of the TOPSIS calculation is the ranking of areas that can be used as alternative areas for tourism activities. Sauwandarek is the main alternative area for tourism (Sisriany & Furuya, 2024), because the area is suitable for beach and snorkeling tourism

activities, has accommodation for tourists, has a port or bridge for ships carrying tourists to dock, there is a dive shop to support snorkeling and diving tourism activities, and low carrying capacity for beach and diving tourism activities (Naranjo-Arriola, 2021; Zhang et al., 2016). In addition to Sauwandarek, Marandanweser and Arborek can be used as alternative areas. Low carrying capacity can be utilized to develop beach, snorkeling and diving tourism in order to attract the attention of tourists (Haribudiman et al., 2023). However, the development of areas for tourism activities must pay attention to the environment (De Zoysa, 2022), so that there is no decline or degradation of environmental quality, but must provide sustainable benefits (Cheng et al., 2023; Hariram et al., 2023; Wu & Tham, 2023).

Conclusion

Based on the results and discussions carried out, it can be concluded that Sauwandarek, Marandanweser and Arborek are the right location recommendations as alternative areas for tourism activities. Meanwhile, the areas that can be developed for ecotourism activities are Yeben Kecil and Tanjung Putus. Tourism development also requires areas that are still untouched by human activities. There are still some areas that can be developed into ecotourism areas such as Yeben Kecil and Tanjung Putus. These two areas can still be developed into ecotourism-based tourism so that they can be used as alternative areas for tourism activities.

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Conceptualization; A. K. Z.; methodology.; Y.; validation; F. formal analysis; A. H.; investigation.; A. K. Z; resources; Y, data curation: F.; writing—original draft preparation, A. H; writing—review and editing: A. K. Z.; visualization: Y. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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