Combined Method to Determine Shrimp Pond Cultivation Land

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Abstract: Shrimp farming has begun to be cultivated in several parts of Indonesia and it is expected to attract some investments. One of the factors that influence the success of a shrimp pond business is the location of shrimp pond which must be based on several criteria. This study aims to provide alternative decisions about appropriate and safe land used as shrimp ponds by taking into account several criteria such as soil texture, soil pH, water pH, rainfall, beach bottom type, distance and coastline, labour, affordability, security and marketing the shrimp pond harvest. The method used is a combination of decision-making methods, the analytical hierarchy process and the technique for order preference by similarity to an ideal solution, while the system development method is a user-centred design where the system created is tailored to user needs. The results of this study are a decision support system that provides recommendations for the area that is suitable for use as a shrimp pond with the highest weight value.

1 INTRODUCTION

The Ministry of Maritime Affairs and Fisheries through the 2014-2019 strategic plan states the vision and mission in increasing domestic fisheries productivity to make Indonesia as a producer of marine products and to prosper the community through the improvement offishery products. Exports of fishery products in 2014 reached USD 4.64 billion. The achievement of the export value was dominated by the export value of shrimp commodities which reached USD 2.09 billion and was followed by the *tuna tongkol cakalang* (TTC) commodity of USD 0.69 billion in 2014 (Peraturan Menteri Kelautan Dan Perikanan Republik Indonesia, 2017).

The large market demand for fish products, namely fish, shrimp, and seaweed and the higher selling prices make this business increasingly attract some people. This is the reason why the products of the ponds to be one of the fishery commodities which gives a big profit. It is also what makes the potential of the business opportunities for aquaculture pond products greater (Andriyanto et al., 2013). To meet the growing market demand, it is necessary to accelerate the production of sustainable aquaculture ponds. The development of aquaculture ponds must be able to utilize cultivation technology in a sustainable manner by utilizing the potential of coastal resources through the feasibility of existing cultivation lands (Hidayat et al., 2014). Sustainable aquaculture farming is an environmentally friendly aquaculture activity that takes into account and considers biophysical conditions in accordance with the environmental support in the region (Kusuma, W A; Prayitna, 2017).

Determination of the appropriate coastal areas used as shrimp farming land must consider several factors such as demographic, biological, social and economic factors (Hasnawi, 2009). Analysis of these factors is used to get the right area to open the shrimp farms with maximum profit and minimize the impact on the surrounding environment (Hakim, L; Supono;

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Waluyo, S; Adiputra, 2018), (Prakesakwa et al., 2019). In determining the appropriate area by taking into account these factors, a decision support system is needed by considering each region and selecting the region with the highest value (Yesmaya et al., 2018), (Yuwono et al., 2015).

Decision support systems have been implemented to provide recommendations for decisions on a problem (L. et al Wanti, 2020), (Kholidasari et al., 2019), (Azlan et al., 2020), (Linda Perdana Wanti et al., 2020). Various methods are used such as analytical hierarchy process in (Kar, 2015), (Balubaid & Alamoudi, 2015), (Mubarok & Maldina, 2017), (Mamat et al., 2019), simple additive weighting in (Vafaei et al., 2018), technique for order preference by similarity to ideal solution (TOPSIS) method in (Rakhshan, 2017), (Sun et al., 2018), hybrid methods of AHP and TOPSIS in (Reddy et al., 2019), (Pramanik et al., 2017), (Wedagama, 2010).

Combined method in this research are used to provide recommendations for areas that have the potential to be used as aquaculture pond. The steps in the AHP (Analytical Hierarchy Process) method are used to determine the alternative chosen based on the weights value of each criterion used because in the AHP method there isa paired comparison matrix used to test consistency and rank the alternatives used (Balubaid & Alamoudi, 2015), (Benmoussa et al., 2019). While the TOPSIS method is used to alternative selection chosen based on value of a negative ideal solution and value of a positive ideal solution (Wedagama, 2010). The criteria used in this study are soil texture symbolized by C1, rainfall with C2, bottom type of beach with C3, distance and coastline with C4, labour with C5, affordability with C6, security with C7 and marketing of shrimp farm yields with C8. The alternatives selected were 6 areas in the Cilacap area. The results of this study are recommendations for areas that have the potential to be used as shrimp farms with a weighting value of the intervention which has the closest distance to the value of Di^+ and the farthest distance to the value of a Di^-.

2 RESEARCH METHOD

The system development method used in this study is user centred design, where all user needs are mapped into the system design (Schnall et al., 2016), (Luna et al., 2017), (Linda Perdana Wanti, Azroha, et al., 2019). Figure 1 explains the research method in which the system is made oriented to the user in all stages of the process (Abd Rahman et al., 2020), (Kautonen & Nieminen, 2018). It starts with defining the system user context, defining all user requirements, creating user interface design solutions and evaluating the system with regard to user feedback (Georgsson et al., 2019), (Linda Perdana Wanti, Laksono, et al., 2019). With the evaluation, the system improvement will be done in accordance with the feedback from the user until all user needs are defined and there are no more repairs to be done (Liu et al., 2016). We strongly encourage authors to use this document for the preparation of the camera-ready. Please follow the instructions closely in order to make the volume look as uniform as possible (Moore and Lopes, 1999).

AHP method implementation uses 8 criteria, C1 to C8 namely soil texture,rainfall, beach bottom type, distance and coastline, labour, affordability, safety and marketing of shrimp pond harvests with 6 alternatives, A1 to A6, namely the Teluk Penyu coastal area symbolized by A1, Binangun beach area with A2, Selok beach area with A3, Menganti beach area with A4, Widara Payung beach area with A5 and Logending beach with A6.

The method used is AHP and TOPSIS, with the aim of combining the decision-making steps available in AHP and TOPSIS, as well as providing recommendations for the most potential areas to be

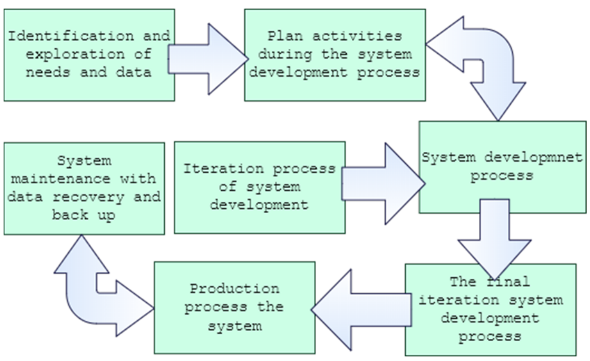

Figure 1: Research Model Stages.

used as shrimp farming land. Analytical hierarchy process methods provide systematic solutions and minimize the inconsistency or subjectivity of decision makers in valuation (Chourabi et al., 2019), (Mamat et al., 2019). In decision making, it is important to know how good the consistency is because it is not necessary to make decisions based on considerations with low consistency (L P Wanti et al., 2020). Therefore, it is necessary to check the consistency of the hierarchy in the decision tree. If the value is more than 10%, then the judgment assessment must be corrected. However, if the consistency ratio (CR) is less or equal to 0.1. Then the calculation results are declared correct (Yu et al., 2020).

Table 1: Random Index List Consistency.

Matrix Size	*Ri*
1,2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49
11	1.51
12	1.48
13	1.56

The stages of the AHP method (Kar, 2015), namely:

a. Determine the final goal of the decision to be taken.
b. Develop criteria and alternatives used in the decision making process.
c. Make a pairwise comparison matrix for each element involved by selecting the weight of each criterion oriented to the final goal.
d. Determine the value of the eigenvector vector and its total using the results of the pairwise comparison matrix. It starts with normalizing each column j in matrix A:

$$\sum_i a(ij) = 1 \quad (1)$$

e. Calculate the average value of each row i in matrix A:

$$Wi = \sum_i n\,(ij) \quad (2)$$

f. Evaluate each alternative used based on its weighted value by checking the consistency of the AHP process hierarchy (Mamat et al., 2019). Calculate the consistency value of a weight vector:

$$(A)(W^T) = (n)(W^T) \quad (3)$$

g. Calculate the consistency index:

$$Ci = \frac{t-n}{n-1} \quad (4)$$

h. Calculate the consistency ratio:

$$CR = \frac{Ci}{(Ri)(n)} \quad (5)$$

The value positive ideal solution and value negative ideal solution only exist in TOPSIS method is used to select alternatives (Budhi & Wardoyo, 2017). The stages in the TOPSIS method (Sun et al., 2018), namely:

a. For the first step is normalize the decision matrix
b. For second step is normalize a weighted decision matrix where an alternative performance rating of Ai on each normalized Cj is calculated using the formula:

$$rij = \frac{Xij}{\sqrt{\sum_i=1(_{ij})^2}} \quad (6)$$

c. For the third step is determine Di+ matrix and Di-matrix that is determined based on the normalized weight rating (yij), is calculated using the formula:

$$yij = (wi)(rij) \quad (7)$$

With i=1,2,…,n
And j=1,2,…,m

$$A^+ = y1^+, y2^+, y3^+, \ldots, yn^+ \quad (8)$$

$$A^- = y1^-, y2^-, y3^-, \ldots, yn^- \quad (9)$$

Where

y^+ = {max yij with j is profit attribute
{min yij with j is cost attribute

y^- = {min yij with j is profit attribute
{max yij with j is cost attribute

d. For the fourth step is calculate the distance between the values of A1 until A6 with Di+ matrix and Di- matrix.
The distance between the alternative Ai and the positive ideal solution is formulated as:

$$Di^+ = \sqrt{\sum_{j=1}^{n} (y^+ - y_j)^2} \quad (10)$$

The distance for negative ideal solution is formulated as:

$$Di^- = \sqrt{\sum_{j=1}^{n}(y_j^- - y_j)^2} \quad (11)$$

e. The final step is determine the preference value for each alternative (Vi), where a larger value (Vi) indicates that alternative Ai is preferred, Vi value is calculated using the formula:

$$Vi = \frac{Di}{Di^- + Di^+} \quad (12)$$

Figure 2 shows the hierarchy of the AHP process where the final goal of this decision support system is the recommendation of a region that has the potential to be a shrimp farm.

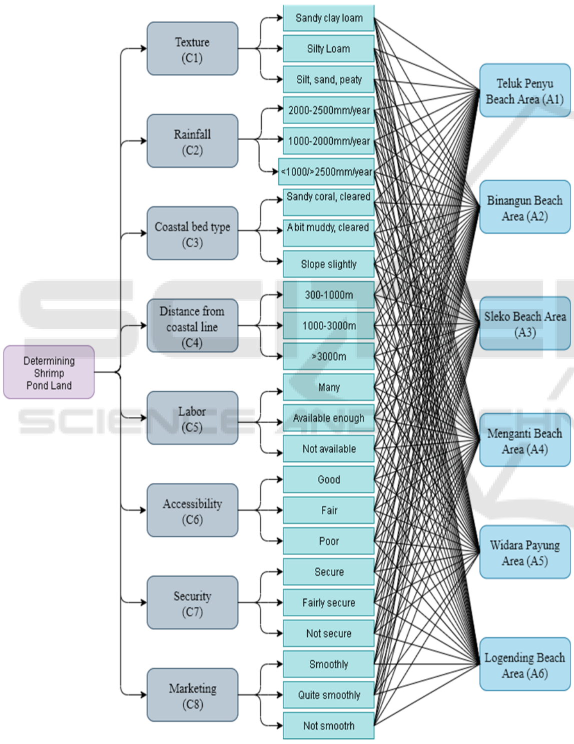

Figure 2: Hierarchy of AHP Process.

Figure 3 explains hybrid model to determining the opening of a shrimp farm. Determination of the final decision, namely the selection of shrimp farming areas begins by determining the criteria and alternatives used. Then give weight to each criterion (Nasution & Bazin, 2018). Still using the AHP method, the next step is to determine a pairwise comparison matrix for each alternative involved. The next step using the TOPSIS method is determining alternative performance ratings on each criterion followed by determining positive and negative ideal solution matrix. After knowing positive and negative ideal matrices, then still using the TOPSIS method, the distance between the values of each alternatives and the matrix is determined. For final step in TOPSIS is to determine the preference value for each area of shrimp farming. The alternative with the preference value which has the closest distance to Di^+ and the farthest distance to Di^- is chosen as a feasible and potential area to be used as a shrimp farm.

3 RESULT AND ANALYSIS

This study uses a combination of TOPSIS and AHP methods. The result of combination two methods is a recommended area that is feasible and has the potential to be used as shrimp farming land. Starting by weighting the criteria shown in table 2 and table 3. Table 2 is the result of weighting the criteria using the analytical hierarchyprocessmethodwhichconsistsof 8 (eight) criteria used to select areas that could potentially be used as shrimp farms. The priorities for each criterion are explained, as follows:

a. Soil texture (C1) is less important than beach bottom type (C3) and distance from coastline (C4)

b. Rainfall (C2) is more important than soil texture (C1)

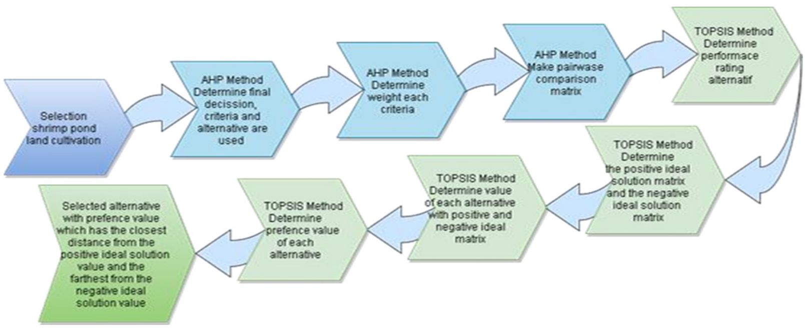

Figure 3: Combined Method for Determination of Shrimp Pond Cultivation Land.

c. The beach bottom type (C3) is as important as the distance from the coastline (C4)

d. Rainfall (C2) is more important than the beach bottom type (C3) and the distance from the coastline (C4)

e. Labor (C5) is less important than affordability (C6) and marketing (C8)

f. Security (C7) is more important than workforce (C5)

g. Affordability (C6) is as important as marketing (C8)

h. Security (C7) is more important than affordability (C6) and marketing (C8)

i. Security (C7) is equally important as rainfall (C2)

j. Rainfall (C2) is slightly more important than labor (C5), affordability (C6), marketing (C8)

k. Security (C7) is slightly more important than soil texture (C1), beach bottom type (C3), distance from coastline (C4)

l. The beach bottom type (C3) and distance from the coastline (C4) are as important as affordability (C6) and marketing (C8)

m. Labor (C5) is less important than beach bottom type (C3) and distance from coastline (C4)

The criteria that have been weighted and normalized with the final total weighted value per criterion using the analytical hierarchy process method then ranked. Ranking of A1 until A6 with the TOPSIS method using normalized criteria and using the analytical hierarchy process method. Table 3 shows the weighted normalized matrix using the TOPSIS method, where the value of each alternative per criterion is multiplied by the weight or value of the eigen vector values calculated using the AHP method.

Table 2: Pairwise Comparison Matrix of Criteria.

Criteria	c1	c2	c3	c4	c5	c6	c7	c8
c1	1	0.2	3	3	1	3	0.2	3
c2	5	1	0.14	0.14	0.33	0.33	1	0.33
c3	0.33	7	1	1	0.33	1	0.33	1
c4	0.33	7	1	1	0.33	1	0.33	1
c5	1	3	3	3	1	0.33	0.2	0.33
c6	0.33	3	1	1	3	1	7	1
c7	5	1	3	3	5	0.1	1	0.14
c8	0.33	3	1	1	3	1	7	1

Table 3: Normalized Matrix with Final Weight Value.

Criteria	c1	c2	c3	c4	c5	c6	c7	c8	Eigen Vector Value
c1	0.075	0.008	0.228	0.228	0.071	0.387	0.012	0.385	0.174
c2	0.375	0.040	0.011	0.011	0.024	0.043	0.059	0.042	0.075
c3	0.025	0.278	0.076	0.076	0.024	0.129	0.019	0.128	0.094
c4	0.025	0.278	0.076	0.076	0.024	0.129	0.019	0.128	0.094
c5	0.075	0.119	0.228	0.228	0.071	0.043	0.012	0.042	0.102
c6	0.025	0.119	0.076	0.076	0.214	0.129	0.410	0.128	0.147
c7	0.375	0.040	0.228	0.228	0.357	0.013	0.059	0.018	0.165
c8	0.025	0.119	0.076	0.076	0.214	0.129	0.410	0.128	0.147

Table 4: Normalized Weight Rating.

Alternative	Criteria							
	c1	c2	c3	c4	c5	c6	c7	c8
a1	0.029	0.015	0.019	0.007	0.016	0.027	0.018	0.021
a2	0.044	0.008	0.019	0.015	0.024	0.027	0.037	0.032
a3	0.029	0.008	0.019	0.022	0.024	0.013	0.037	0.021
a4	0.029	0.008	0.019	0.015	0.016	0.040	0.018	0.021
a5	0.029	0.015	0.009	0.015	0.016	0.013	0.037	0.032
a6	0.015	0.023	0.009	0.022	0.008	0.027	0.018	0.021

The next step is to determine Di^+ matrix and Di^- matrix using equations (8) and (9). After determining it, for next step is determine the distance of 6 (six) alternative areas of shrimp farms with a positive and negative ideal solution matrix. Determination the distance of six alternative is carried out with the normalized matrix using equations (10) and (11). Preference values indicate alternatives that have the closest distance to Di^+ and the furthest distance to Di^-. From the appraisal value, it obtained an alternative ranking of a suitable area and has the potential to become shrimp farming land. From the ranking of preference values obtained A2, namely Binangun beach area with a value of 0.0473, the highest among the other alternatives. This means that the Binangun coastal area, based on calculations using the AHP method and the TOPSIS method, is a feasible area and has the potential to be used as a shrimp farm. The value of the positive ideal solution and the value of the negative ideal solution along with the distance of each alternative and the preference value are shown in Figure 4 in the form of the following diagram. The value Di^+ shows the distance of alternative values with positive ideal solution values, Di^- shows the distance of alternative value with negative ideal solution values, then V shows the preference values of each alternative from A1 to A6.

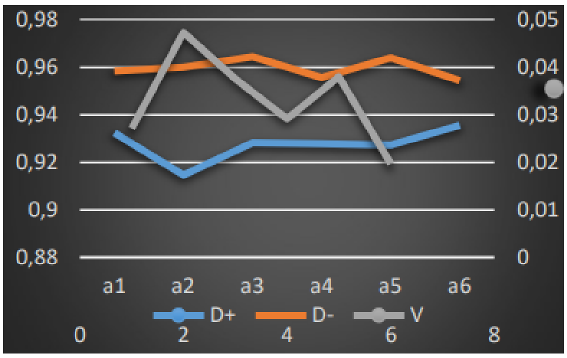

Figure 4: Final Results of Shrimp Pond Farming Land Ranking.

4 CONCLUSIONS

Areas that are feasible and potentially used as shrimp ponds have been successfully determined using a decision support system with a combination of two methods namely the analytical hierarchy process method and the TOPSIS method. The final results show that an alternative with A2 code, namely the Binangun beach area, was selected with the highest preference value of 0.0473.

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