Determination of the Best Location for Freshwater Fish Ponds in South Aceh Districts by Using Multi Criteria Analysis

Meraty Ramadhini1* and Arnold Rikardo Sihombing1
1Industrial Engineering, Politeknik Aceh Selatan, Aceh, 23711, Indonesia

*Corresponding author: meraty.ramadhini@yahoo.com

Abstract. South Aceh is one of the areas in the development of freshwater cultivation. The purpose of this study was to determine the values and factors for freshwater fish ponds using multi criteria analysis using the Analytical Hierarchy Process (AHP) method in South Aceh District. Criteria consist of ecological and socio-economic, assessment is carried out on the level of scoring and weighting factors of each parameter. The results of the analysis of ecological answer factor indicate that slope factors, soil types and rainfall must be anticipated in choosing a location for freshwater cultivation, because these three factors get the same weight and highest of the other factor is 0.2900. The results of the factor analysis of socio-economic criteria indicate that the distance factor from the road gets the highest weight of 0.4100, and this needs attention because it relates to economic principles, such as the distance of the marketing location to the location of cultivation.

Keywords: Multi criteria analysis, Freshwater cultivation, Soil type, Slope factor

1. Introduction

The sea waters of South Aceh are part of the Indian Ocean with a coastline reaching 140 km which has very large and abundant fish resource potential. In addition, the waters of South Aceh also have good potential for fish farming, the potential area for aquaculture in South Aceh Regency is also quite large both in fish cultivation in ponds, public waters and in fish farming in the Minapadi system. Overall the potential of freshwater fish farming is estimated to be 20,156 Ha. However, the utilization has reached 48.67 Ha with a production of 265.97 tons / year [1].

The potential for developing brackish water cultivation (ponds) reaches 4,000 Ha in 9 (nine) districts, namely Trumon District, Bakongan, North Kluet, South Kluet, Pasie Raja, East Labuhan Haji, Labuhan Haji, and Samadua. However, the new community has cultivated 17.50 Ha of the potential of the existing land with the level of application of simple technology with a production of only 5.75 tons, this is a huge potential to advance fisheries and marine affairs.

One of the factors to achieve a successful pond culture business, in addition to the investment costs, quality, and specific character of cultivated biota, operator discipline, cultivation methods with applied technologies such as design, layout and construction, as well as production levels, must also be consider the biophysical characteristics of locations such as biology, hydrology, meteorology, quality of soil, and water that are in accordance with the environmental carrying capacity of the region [2].

One method for selecting the location of the cultivation of freshwater fish ponds is through multi-criteria analysis. The purpose of this study was to determine the weight and location factors for
freshwater fish ponds in South Aceh Regency. The results of this study are expected to be the basis for further planning in fisheries development in South Aceh Regency.

2. Material
This research was carried out in the district of Southern Aceh, Aceh Province. South Aceh Regency has an area of 384200 ha with 18 districts. The data used in this study is primary data, primary data was obtained through interviews with five respondents and filling out questionnaires for three farmers per district.

Analytical Hierarchy Process (AHP) is applied to set goals and criteria for this research. This research used two criteria, namely ecological criteria and socio-economic criteria. Ecological criteria consists of four factors; slope, soil texture, rainfall and distance from the river while socio-economic criteria consists of three factors, namely the distance from road, distance from settlements and current land use.

Site selection is a very important step in determining the success of aquaculture business since its ecological and socio-economic should be taken into considerations. Technically, if the location of the fish pond is good it will influences the construction of the fish pond to be built and the operational costs of its maintenance. In this case, the calculation of important values in the AHP analysis will produce a weighted value for each criterion, where the weight value produced is then used as a priority sequence that affects the final focus set in the form of potential fisheries for freshwater fish ponds. Table 1 shows the suitable criteria for ponds.

| Table 1. Land suitability criteria for ponds. |
|---------------------------------------------|
| Criteria | Factor | 1 | 2 | 3 | 4 |
| Ecology | Slope (%) | 0-3 | >3-8 | >3-8 | >8 |
| | Type of soil | loamy/sandyclay | Sandy clay | Sand |
| | Rainfall (mm thn⁻¹) | <1,000 | >1,000-2,000 | >2,000-2,500 | >2,500 |
| Socio- | Distance from river (m) | <500 | >500-1,000 | >1,000-1,500 | >1,500 |
| | Distance from road (m) | <500 | >500-1,000 | >1,000-1,500 | >1,500 |
| | Distance from the settlement | <400 | >400-800 | >800-1,200 | >1,200 |
| | Land Use | Pond | Field | Garden | Shrubs |

Source: Cahyaningrum, dkk (2014)

2.1. Analytical Hierarchy Process (AHP)
AHP is a decision support model developed by Thomas L. Saaty. This decision support model will describe complex multi-factor or multi-criteria problems into a hierarchy, according to [3], hierarchy is defined as a representation of a complex problem in a multi-level structure where the first level is the goal, followed by factor level, criteria, sub criteria, and so on down to the last level of alternatives.

According to previous study by Saaty, for various information, a scale of 1 to 9 is the best scale in interviews [4]. Each paired comparison is evaluated in the author scale 1-9 as follows;

| Most Important | Neutral | Most Important |
|----------------|---------|----------------|
| Element A | 9 7 5 3 1 3 5 7 9 | Element B |

The value and definition of qualitative opinions from the Saaty comparison scale can be seen in the following table 2.
Table 2. Pairwise comparative assessment scale.

| Interest Intensity | Information                                                                 |
|--------------------|------------------------------------------------------------------------------|
| 1                  | Both elements are equally important (equal Importance)                        |
| 3                  | One element is slightly more important than the other (Slightly more Importance) |
| 5                  | One element is more important than the other (Materially more Importance)    |
| 7                  | One element is clearly more important than other elements (Significantly more Importance) |
| 9                  | One element is absolutely important than other elements (Compromise values)   |
| 2,4,6,8            | Values between two values of consideration are close together (Compromise values) |

Source: Saaty, T. Lorrie. 1990

2.2. Test Index Consistency and Ratio

Determination of the consistency of the matrix is based on the maximum eigen value, obtained by the following equation (1):

\[
\text{Consistency Index (CI)} = CI = \frac{\lambda_{\text{max}} - n}{n-1}
\]

(1)

Where CI is deviation ratio consistency index, \(\lambda_{\text{max}}\) is eigen value maximum from an ordered matrix \(n\), \(n\) is matrix order \(n\).

If the CI value is zero, then the matrix pairwise comparison that consistent. Limitation of consistency (inconsistency) determined by Thomas L. Saaty determined using the Consistency Ratio (CR), namely comparison consistency index with Random Index (RI) value. Consistency Ratio can be formulated in equation (2) as follows:

\[
\text{Consistency Ratio (CR)} = \frac{CI}{RI}
\]

(2)

where RI is a Random Consistency Index. If the Consistency Ratio (CR) \(\leq 0.1\), then the results of the data assessment can be justified / consistent and if not then the assessment needs to be repeated. The results of data calculations can be justified/consistent. List of RI can be seen in table 3.

Table 3. Random index.

| n   | RI    |
|-----|-------|
| 1   | 0.00  |
| 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  | 1.48  |

Source: Saaty, T. Lorrie. 1993

3. Results and Discussion

3.1. Weighting Criteria with AHP Method

Criteria weighting is done to determine the highest value and the lowest value of ecological criteria and socio-economic criteria from several factors in increasing productivity and quality of freshwater fish ponds. The results of the weighting criteria analysis obtained can be seen in table 4 below.

| Ecological Criteria (0.39996) | Factor    | Weight | Socio-economic Criteria (0.29900) | Factor    | Weight |
|-------------------------------|-----------|--------|----------------------------------|-----------|--------|
| Slope                         | 0.2900    |        | Land use                         | 0.3300    |        |
| Type of soil                  | 0.2900    |        | Distance from road               | 0.4100    |        |
| Rainfall                      | 0.2900    |        | Distance from the settlement     | 0.2600    |        |
| Distance from the river       | 0.1400    |        | Amount                           | 1.0000    |        |
| Amount                        | 1.0000    |        | Amount                           | 1.0000    |        |

Source: Saaty, T. Lorrie. 1993
Analysis of ecological criteria indicates that slope, soil type and rainfall have the same and highest weight of 0.2900. Slope is the height of the place / location of the pool to the surface of the sea, the location of the pond is good if the location is located between the highest tide and the lowest tide. Soil acts to hold water during the fish cultivation process, this type of soil greatly determines the success factor of freshwater cultivation, soil types that are good for freshwater cultivation are types of clay. Rainfall that tends to be high is a problem for farmers, rainwater has a level of acidity that can harm fish cultivators, the cultivator has not taken anticipatory measures to free the pond from the acidity of rainwater.

Socio-economic factor analysis shows that the distance factor from the road currently obtains the highest weight of 0.4100. This is related to economic principles, such as far from the marketing location with the location of fish farming.

### 3.2. Consistency Test Result

What is measured in AHP is Consistency Ratio by looking at the Consistency Index. The expected consistency is near perfect to produce decisions that are close to valid. Although it is difficult to achieve the perfect, the expected consistency ratio is less than or equal to 10%.

| Criteria          | $\lambda_{max}$ Value | CI Value | CR Value |
|-------------------|------------------------|----------|----------|
| Ecological        | 4.0009                 | 0.0003   | 0.00033  |
| Socio-economic    | 3.0537                 | 0.0270   | 0.0465   |

Based on table 5. It can be concluded that Consistency Ratio (CR) ≤ 0.1, then the results of data calculation can be justified/consistent.

### 4. Conclusion

Based on the data shown above, it can be concluded that:

1. Ecological criteria have a greater weight than socio-economic criteria, this can improve the quality of freshwater fish ponds better, because it is related to the distance of water sources. The farther away with the water source, the more the cost of procuring water for cultivation.

2. Factor analysis including ecological criteria shows that slope, soil type and rainfall have the highest weight, this indicates slope related to the height of the place / location of the pool to the surface of the sea, the type of soil that cannot store water and high rainfall.

3. Analysis of factors including socio-economic criteria shows that the distance from the road has the highest weight, this factor can increase productivity and quality of fishery products, because it is associated with easier / affordable accessibility.

4. Ecological criteria can be set as the top priority for ponds development, because in this criterion there are still many inhibiting factors in the coastal areas of South Aceh Regency to be used as ponds land, related to slope, type of soil and rainfall.

### References

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