Analysis of Floating Net Cage Based on Geographic Information System in Lembeh Island

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Abstract. This study aims to assess the suitability and distribution of aquaculture with the KJA system on Lembeh Island. The method used in this research is quantitative research with the spatial analysis used in Geographic Information Systems supported by primary and secondary data to obtain information on the suitability of aquaculture land with the KJA system on the Lembeh Island. The results of the analysis of the suitability level of KJA aquaculture in Lembeh Island with a total area of observation area of 2395.38 ha. The results of the study show the suitability level of the KJA system aquaculture are Suitable (S1), covering 227.81 ha located in the South Lembeh sea waters covering 101.48 ha while in the North Lembeh sea waters covering 126.34 ha. Suitable needs (S2) covering an area of 1161.75 ha, which is located in the waters of the South Lembeh sea waters area of 774.51 ha while in the waters of the North Lembeh sea waters covering is 387.25 ha. Unsuitable (N) covering an area of 1005.81 ha located in the South Lembeh sea waters area of 245.54 ha and the North Lembeh sea waters covering an area of 760.28 ha.

Keywords: Aquaculture, floating net cages, Lembeh Island

1. Introduction
Bitung City has the most significant contribution to fisheries production in North Sulawesi Province [1]. This support by the extent of waters and adequate fisheries facilities. The results of fisheries production in the city of Bitung showed a positive trend, wherein 2004 the total fishery production in PPS Bitung was around 131,000.07 tons, in 2009 it increased to 142,000.72 tons with an average of 1.4% per year during the period 2004 – 2009 [2], [3]. Production Bitung fisheries 99.3% come from fish catches in the sea; the rest comes from aquaculture [4]. Bitung City fisheries production still relies on excessive exploitation of fish [1]; this will cause an imbalance of marine resources [4]. For marine resources to be sustainable and fisheries production to increase [5], [6], there needs to be a breakthrough, namely, to start conducting aquaculture development activities both at sea and on land [1], [7], [8]. Lembeh Island [9] can be used as an alternative in the development of marine culture [10], especially floating net cages [11]. Judging from the geographical position, partly territorial waters in the strait, where the area is an area that protects from the force of the waves besides water conditions, are still preserved [1], [12], [13]. Aquaculture with the KJA system [14] has begun to be developed but has not seen tangible production results [15]. This problem often experienced by fishermen on Lembeh Island [10] is impoverished data and information
about the location of aquaculture with the KJA system, so fishers in determining the location of cultivation are still based on experience and intuition [14]. The development of KJA aquaculture needs analysis in determining the appropriate location and suitable seawater data [14]. According to [16], several considerations need to consider in determining the location of KJA, namely physical, chemical, and biological and non-technical parameters in the form of a nation's market, security, and human resources. To find out information about the suitability of the aquaculture land with the KJA system can be done by spatial analysis [16], [17]. This method can combine some data and information about aquaculture in the form of layers which can later be overlapped with other data, to produce a new output in the form of a thematic map that has a reasonably high level of efficiency and accuracy [16], [18]–[20]. This study aims to assess the suitability and distribution of aquaculture with the KJA system on Lembeh Island.

2. Research Methods

2.1 Research Location
Administered, Lembeh Island Bitung is located within the city of North Sulawesi province is divided into two sub-districts Lembeh territory of North and South Lembeh. In North Lembeh subdistrict, it is divided into 10 territories, namely Batu Kota Kelurahan, Binuang Kelurahan, Motto Kelurahan, Lirang Kelurahan, Pintu Kota Kelurahan, Gunung Woka Kelurahan, Posokan Kelurahan, Posokan Kelurahan, Mawali Kelurahan, Nusu Kelurahan, Binuang Kelurahan, and Kareko Kelurahan, while the District of Lembeh Selatan divided into 7 urban areas, namely Batu Lubang Village, Doorbolaang Village, Papusungan Village, Pasir Panjang Village, Kelapa Dua Village, Pancuran Village and Paudean Village. Seen from the astronomical location of Lembeh Island which is at 1° 15´-1°25´LU and 125º 06´-125º 72´BT (Figure 1).

![Figure 1. Map of research location](image)

2.2 Research Tools and Materials
As for the equipment used in this study as follows: Hardware in the form of personal computers for data processing; Global Positioning System (GPS) that used to take position coordinates of the observation point; Digital cameras used as documentation tools during field surveys; Software in the form of ArcGIS 10.6.1, and Microsoft Excel 365 is used for data analysis; Thermometer is used to measure the temperature of seawater; Floating Drodge is used to measure the current velocity and Secchi Disk is used to measure water clarity. While the research materials used are as follows: Landsat 8 Satellite Imagery OLI (https://earthexplorer.usgs.gov/) acquisition 20 August 2019 was used to identify the protected area of KJA fisheries cultivation; Map of the Indonesian Aquatic Environment Scale 1: 50,000 sheets 2417-07 Bitung (BAKOSURTANAL and DISHIDROS 1st edition 1991); Dissolved Oxygen-Do, pH, Nitrate,
Phosphate (results of a 2012 survey of the Bitung City Maritime Service); Digital Map of P3GL Watershed Substrate in 1991.

2.3 Data Collection Techniques

The data used in this study about the suitability of the aquaculture land with the floating net cage system were obtained in two ways, namely [21], [22]:

a) Primary Data, data in the form of field survey results (ground check) of the parameters of current speed, water clarity, temperature, salinity, and protection. Field surveys are intended to obtain a visual and direct picture of the physical conditions in the field.

b) Secondary data, data obtained from the collection of literature studies such as reports on survey results, and other publications and maps relating to the research object, collected from various agencies and related institutions. Data collected in the form of dissolved oxygen data (Dissolved Oxygen-Do), water-based substrate, pH, nitrate, and phosphate.

2.4 Data analysis technique

The data obtained in this study, both primary and secondary, are processed and analyzed spatially with the Geographic Information System on the parameters of the suitability of aquaculture with KJA [21]. The data analysis stages are as follows:

a) Thematic Map, data obtained from the results of field surveys and library studies, will be processed, analyzed and arranged in the form of thematic map layers. Dissolved Oxygen-DO, pH, nitrate and phosphate measurement data, have coordinate positions based on observation points then, are analyzed based on their parallel location using the interpolation kriging method in ArcGis 10.6.1. The analysis will produce data in the form of the raster, which will then be converted using convert to a polygon to create thematic maps. Determination of protected areas through visual interpretation of the Landsat 8 OLI satellite imagery in 2020. Furthermore, protected areas divided into three classes, namely, protected, entirely protected, and open. The protected class is an area that is in the strait and the bay, for a sufficiently protected class, it is in a reef-scorched area, and an open course is an area of water that faces directly with the open sea that has no barriers.

b) KJA Suitability Classification, the parameters used for the analysis of the suitability aquaculture with a floating net cage system are divided into two categories, and the first is the physical parameters which include; the settings of protection, bottom waters, brightness and speed of currents, while the second are chemical parameters including; Dissolved Oxygen (DO) parameters, pH, salinity, nitrate, and phosphate. These parameters are used to scale the assessment and weighting of the suitability of aquaculture with KJA. Settings that provide a more robust influence as a limiting factor for aquatic organisms are given a higher weight, a total weight of 100. Each limiting factor in the land suitability matrix [22] column is made a rating scale with the numbers S1 (suitable), S2 (suitable needs), and N (unsuitable). According to [22], [23], quantitative analysis to determine the suitability of fish culture in KJA uses the "scoring" method with the following approach:

\[
Y = \sum a_i \cdot X_n
\]

where:
- \(Y\) = final value;
- \(a_i\) = weighting factor;
- \(X_n\) = value of land suitability level.

The criteria used in preparing the suitability and weighting matrix for determining the feasibility of fish farming land in the KJA are as shown in the following Table 1.
Table 1. Land Suitability Matrix for Fish Culture in KJA.

| No | Parameter          | Class        | Value | Weight |
|----|--------------------|--------------|-------|--------|
| 1  | Protected          | Protected    | 3     | 20     |
| 2  | Dissolve Oxigen (mg/l) | 6 – 8     | 3     | 20     |
|    |                    | 3 – 5       | 2     |        |
|    |                    | < 3         | 1     |        |
| 3  | Bottom substrate   | Sand         | 3     | 15     |
|    |                    | Coral        | 2     |        |
|    |                    | Mud          | 1     |        |
| 4  | Current speed (cm/dt) | 5 – 15    | 3     | 10     |
|    |                    | 16 – 30     | 2     |        |
|    |                    | < 5         | 1     |        |
| 5  | Water Clarity (m)  | > 3         | 3     | 10     |
|    |                    | 2           | 2     |        |
|    |                    | < 2         | 1     |        |
| 6  | Temperature (°C)   | 28 – 31     | 3     | 5      |
|    |                    | 26 – 27     | 2     |        |
|    |                    | < 26; > 31  | 2     |        |
| 7  | pH                 | 8,0 – 8,2   | 3     | 5      |
|    |                    | 7,5 – 7,9   | 2     |        |
|    |                    | < 7,5; > 8,5| 1     |        |
| 8  | Salinity (°/00)    | 30 – 35     | 3     | 5      |
|    |                    | 25 – 29     | 2     |        |
|    |                    | < 25; > 35  | 1     |        |

Source: I. N. Radiarta, A. Saputra, and B. Priono (2017)

To get an interval of values in each category is determined based on the percentage value of the calculation results in Table 2.

Table 2. Scoring the suitability of aquaculture with the KJA system

| Total Score | Suitable Levels | Remarks |
|-------------|-----------------|---------|
| 255 – 300   | Suitable (S1)   | This area has the potential to be developed for aquaculture with a floating net cage system because it can meet the minimum requirements for KJA cultivation. |
| 151 – 254   | Suitable needs (S2) | This area is quite useful for developing aquaculture with the KJA system. However, this area has a limiting factor that requires special treatment to improve its capabilities. |
| ≤ 150       | Unsuitable (N)   | Areas that are included in this category cannot be cultivated for fish culture in the KJA. |

Source: I. N. Radiarta, A. Saputra, and B. Priono (2017)

c) Suitability Determination KJA Aquaculture System, the next process is overlapping thematic maps to produce the suitability of the aquaculture land with the KJA. In the GIS process, the thematic plan of each physical-chemical parameter is classified and weighted based on the relevance of
cultivated land with KJA. In determining the appropriateness of aquaculture land with the KJA system is limited only to areas that have a level of protection. Open waters are considered inappropriate despite having a high score. The results of the overlay are intersected with a thematic map of the depth of the seas to get the location of the floating net cages. From the results of this GIS analysis, a thematic map of the suitability of the physical land of the waters for fish culture with KJA is produced [22], [23].

3. Results and Discussion
3.1. Physical and Chemical Parameters
The parameters that support in the analysis of aquaculture suitability models floating net system as visualized in the following maps (Figure 2).
3.2. Determination of Suitability of Aquaculture with KJA
The decision of the suitability of the aquaculture land with the floating net cage system is carried out overlapping with all the physical and chemical parameters that have been classified and weighted based on the suitability of the KJA Cultivation class. Furthermore, in determining the appropriateness of the aquaculture land with the KJA system is limited to areas that have the right level of protection. Open waters are considered inappropriate despite having a high score. The results of these overlays are intersected with thematic maps of water depth. And for the boundaries of the observation area ranges from water depths between 1 to 25 meters. The depth range is within the potential to be developed for various marine aquaculture methods. Based on the results of scoring and weighting of physical and chemical parameters which are only limited to protected areas and intersect with water depth maps, the results of maps of the suitability level of aquaculture with the floating net cage system are divided into 3 classes of suitability namely: S1 (suitable), S2 (suitable needs) and N (unsuitable). The map of the suitability of aquaculture with the KJA system on Lembeh Island can be seen in Figure 3. For suitability classes, suitable (S1) is presented in green, for suitable needs (S2) presented in yellow and for unsuitable shown in the color red. For more information, see the following picture.
Figure 3. KJA Aquaculture Suitability Map

The results of the analysis of the suitability level of KJA aquaculture in Lembeh Island with a total area of observation area of 2395.38 ha. While the results of calculations for the suitability level are: Suitable (S1) covering an area of 227.81 ha located in the waters of the South Lembeh District area of 101.48 ha while in the waters of the North Lembeh District area of 126.34 ha. For the Suitable conditional needs (S2) covering an area of 1161.75 ha, which is located in the waters of the South Lembeh District area of 774.51 ha while in the waters of the North Lembeh District area is 387.25 ha. For the suitability class, it is Unsuitable (N) covering an area of 1005.81 ha located in the South Lembeh District area of 245.54 ha and for the waters of the North Lembeh District covering an area of 760.28 ha. For more information, see the following Table 3.

Table 3. Suitability of Aquaculture with KJA

| Suitable Levels          | District   | Area      | Percentage |
|--------------------------|------------|-----------|------------|
| Suitable (S1)            | Lembeh Utara | 126.34     | 5.27%      |
|                          | Lembeh Selatan | 101.48     | 4.27%      |
| Suitable needs (S2)      | Lembeh Utara | 387.25     | 16.17%     |
|                          | Lembeh Selatan | 774.51     | 32.33%     |
| Unsuitable (N)           | Lembeh Utara | 760.28     | 31.74%     |
|                          | Lembeh Selatan | 245.54     | 10.25%     |
| Jumlah                   |             | 2395.38    | 100%       |

4. Conclusions
The results of the analysis of the parameters of protection, dissolved oxygen, bottom substrates, current velocity, water clarity, temperature, pH, salinity, nitrate, and phosphate show that almost all physical and chemical parameter values, in Lembeh Island meet the requirements for aquaculture activities with the KJA system. Analysis of the suitability level of aquaculture in KJA on Lembeh Island are classified as follows: Suitable (S1) covering 227.81 ha, Suitable needs (S2) covering 1161.75 ha and unsuitable (N) covering 1005.81 ha.

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