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Suitability analysis of spiny lobster mariculture zones in Sabang waters, Indonesia

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ABSTRACT

The lobster aquaculture industry has a high dependence on natural catch. Hence, lobster farming has become necessary. The waters in Sabang have the potential for developing lobster mariculture, but data is not yet available on the conditions of the aquatic environment that are suitable for lobster farming. This research aims to determine which locations are suitable for lobster mariculture activities in the waters of Sabang. The research parameters are divided into geographics, physicochemical, and supporting parameters. The geographical parameters group was collected through in-situ observations, and physicochemical parameters were measured in-situ and laboratory tests, supporting parameters through observations. Initial data analysis used the SAW (Simple Additive Weighting), AHP (Analysis Hierarchy Process) methods, and spatial analysis to determine the suitability of lobster cultivation zones with the Geographic Information System (GIS). From the observations of geographical parameters, the three locations of the observation station were in the very suitable category. The results of measuring physicochemical parameters group in three research locations were very suitable. Based on observations of other supporting parameters, Lhok Krueng Raya is very suitable for the cultivation zone, while Teupin Sirui and Lhok Weing are suitable. The findings of this research indicate that location protection, accessibility, DO, and COD are limiting parameters for selecting a suitable location for lobster mariculture in Sabang waters.

Introduction

Lobster (*Panulirus* sp.) is a high-value fishery commodity with high economic potential. Due to high domestic market demand and exports to countries such as China, Hong Kong, Singapore, and Taiwan, there has been increased pressure on natural lobster stocks. The lobster fishing industry currently still relies on catching lobsters from the wild because, until now, there has been no successful attempt to hatch lobsters to meet the demand (Musbir *et al.*, 2014).

The increasing demand for lobsters from China, especially pearl lobsters (*P. ornatus*), in the 1980s led to an increase in lobster fishing in Vietnam and Indonesia. However, overfishing of lobsters and a lack of management regulations have resulted in declining yields and size, especially in Vietnam. Indonesia can potentially develop marine cultivation, including lobster farming (Mustafa, 2013). Although lobster farming has started in various provinces in Indonesia since 2000, the progress has been slow due to challenges such as the high mortality rate of lobster seeds caused by environmental factors and predators.

One important factor in the success of lobster mariculture activities is choosing the right location. Water quality levels play an important role. Therefore, accurate data and information regarding water quality in lobster cultivation zones are needed (Junaidi *et al.*, 2018). Providing accurate and up-to-date data is important to increase the chances of success in developing lobster farming. Selecting a location for mariculture activities is crucial and must be done correctly (Mustafa *et al.*, 2018).

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Sabang is a coastal area and small islands consisting of five islands, namely Weh Island, Klah Island, Rubiah Island, Seulako Island, and Rondo Island. Besides having tourism potential, Sabang also has fishery potential, making it suitable for lobster farming and marine tourism. Lobster production in Sabang is quite large, and the lobster price tends to be stable. Based on initial observations, its aquatic environment is suitable for lobster habitat, so it has the opportunity to become a location for lobster mariculture.

Despite the potential, lobster farming in Sabang has not been optimized due to the lack of suitability studies and water quality assessments. Currently, the lobster fishery in Sabang is mostly reliant on capture fisheries, which poses long-term risks. Thus, there is an urgent need for studies related to zone suitability analysis to determine the optimal locations for lobster mariculture in Sabang.

Lobsters are hard-skinned animals belonging to the Arthropod class, with a segmented body, hard exoskeleton, and book-shaped protrusions (arthropod means 'book-footed'). The characteristics of arthropods are bilateral symmetry, and the body consists of a head, thorax, and abdomen, segmented, and each has hinge joints and opposing muscles (Campbell, 2012). Taxonomically, crayfish are divided into four groups, namely: true crayfish (true lobster; Homaridae), crayfish (spiny lobster, Palirunidae), stick shrimp (crayfish, Astacidae), and sand shrimp (Spanish lobster, Astacidae). Only three of the four types of lobster have been detected in Indonesian waters. The true lobsters are not found in Indonesian waters and are only found in subtropical waters (Harris and Rani, 2013).

The natural habitat of lobsters varies by type, related to depth, currents, and water turbidity. Bamboo Lobster *(P. versicolor)* is found in coral reefs and rocky areas with sandy bottoms. It is active at night and, during the day, takes refuge in rock crevices and under coral reefs, living at depths of between 5-10 meters. Meanwhile, rock lobsters (*P. homarus*) are found in rocky areas and coral reefs at depths of 1-7 meters in murky waters and strong wavy currents (Mukminin *et al*., 2022).

Lobster is a fishery commodity with high economic value. However, its production still depends on capture fisheries. Lobster mariculture has not become the main choice for fishermen in Indonesia due to their lack of knowledge about ideal locations for mariculture, the technological systems used, and vulnerability to death due to disease and unsuitable waters (Prasetya and Hasidu, 2021). The low productivity of lobster farming is caused by various technical obstacles, which cause coastal communities to prefer selling their catch of clear lobster seeds directly to traders rather than growing lobsters to consumption size (Erlania *et al*., 2014).

One of the determining factors for the success of mariculture activities in waters is selecting the right location. The level of suitability and productivity of water is an important parameter that must be considered. For this reason, data and information regarding water quality are needed (Junaidi, 2018).

This research aims to determine the suitability of water zones for lobster mariculture using a spatial analysis approach, which includes assessing environmental conditions, water quality, temperature, salinity, and other relevant factors to determine whether the coastal area studied is suitable for lobster cultivation. The purpose of determining the suitability of lobster mariculture development zones is to increase the chances of successful lobster farming in Sabang waters.

Method

Location and time of research

This research was conducted in the coastal area of Sabang using the Purposive Sampling Method, namely selecting locations based on differences in the habitat characteristics of each station, including three research stations: Lhok Krueng Raya, Teupin Sirui, and Lhok Weng (Iboih).

The research lasted for five months from February to June 2023. The research was carried out in three stages, namely: (1) The initial research preparation stage in February, (2) The field data collection stage began in March 2023, and (3) The data analysis stage was carried out from April to June 2023.

Figure 1. Research sites, where Station 1 is Lhok Krueng Raya (Lat. 5.871127°; Long. 95.258133°), Station 2 is Teupin Sirui (Lat. 5.83997°; Long. 95.292887°), Station 3 is Lhok Weing (Lat. 5.864755°; Long. 95.265523°).

The distance between research stations is as follows: Lhok Krueng Raya to Teupin Sirui is 4 km (2.15 miles), Lhok Krueng Raya to Lhok Weing is 4.82 km (2.6 miles), and Teupin Sirui to Lhok Weing is 4.1 km (2.21 miles). These distances must be noted and considered when planning any research-related activities.

Parameter used for the suitability analysis of lobster mariculture

The parameters used to analyze the suitability of waters for lobster mariculture consist of geographical parameters, including location protection, depth, and physicochemical parameters of waters in the form of water quality. Important parameters to describe the quality of marine waters are temperature, salinity, dissolved oxygen, BOD, and COD. Measurement of temperature, salinity, and dissolved oxygen parameters are inseparable in any research at sea. The reason is that temperature, salinity, and dissolved oxygen play an important role in aquatic biota (Patty, 2013). Measurement and testing of water quality parameters are presented in Table 1.

Table 1. Water quality parameters

Parameter	Unit	Test Method	Test Equipment
Temperature	°C	SNI.06. 6989.23.2005	Thermometer
Salinity	‰	Refractory	Refractometer
pH	-	SNI. 06. 6989. 11. 2004	PH meter
Brightness	cm		Secchi Disk
DO	mg/L	SNI. 06. 6989. 14. 2004	DO Meter
BOD	mg/L	SNI. 06. 6989. 72. 2009	Winkler
COD	mg/L	SNI. 06. 6989. 15. 2004	Reflux Tool

Apart from geographical parameters and the physicochemical parameters of water, other supporting parameters in selecting a location for lobster mariculture are also considered. Other supporting parameters mentioned in this research are accessibility (ease of reaching the location), spatial location suitability parameters and information on spatial (water) use conflicts from each research location.

Use of geographic information systems

Geographic Information System (GIS) technology is the right solution for research on determining the suitability of lobster cultivation development zones. Remote sensing can monitor large areas periodically and can observe objects at any distance. GIS is a means of collecting, combining, and processing data for each required parameter. The existence of GIS makes it easier to process large amounts of data with complex structures efficiently. GIS can help make decisions in a timely and accurate manner (Samad, 2020).

The GIS technology can also be used to facilitate analysis of selecting suitable locations for placement of floating net cages based on measurement data of geographical, physical, and chemical parameters of waters and other supporting parameters. This method has now been developed and used worldwide to determine the suitability of cultivation zones (Purnawan *et al*., 2015).

The method used in this research was to compare potential locations for lobster mariculture. Furthermore, an analysis was carried out using data and information about environmental parameters supporting mariculture in the form of layers which then be overlaid with each other and produce a new thematic map regarding the suitability of water locations for the development of lobster mariculture.

Analysis of the suitability of lobster farming locations in Sabang waters was carried out by preparing a base map, which became a reference for entering spatial and attribute data, and processes using ArcGIS 10.8 tools. The base maps used were Ikonos satellite image data, administrative maps of Sabang at a scale of 1:100,000, and other thematic maps at a scale of 1:65,000 obtained from the Geospatial Information Agency and field data collected in March 2023.

After the data was collected, a database was prepared, the second step in implementing the GIS. The database contains a collection of data originating from various sources and types of data, both spatial and attributed. Compilation of the suitability map with the GIS application, the biophysical data of the waters obtained from measurements in the field are entered into a database format. This data was generally in the form of coordinate points with the X and Y axes area that do not have length and area dimensions.

Data from environmental parameter measurements and other data are formed into a layer that would be included in the base map. Table attribute data was compiled using ©Microsoft Excel software before being entered into the ArcGIS database. After the database was formed, the existing digital map was converted into a transverse Mercator projection system with a Universal Transverse Mercator (UTM) grid. After the thematic map for

each parameter was formed, it was combined or overlaid with ArcGIS 10.8 software regarding the suitability parameters for lobster cultivation zones in the Sabang waters.

Method of collecting data

The data collected in this research consisted of primary data and secondary data. Primary data includes (i) geographical data, physicochemical data of the research location's waters, and (ii) interview data from the community (cultivator) of lobster mariculture in Sabang, which includes socio-economic-technical problems of lobster mariculture.

Primary data was obtained through field observations, parameter measurements at the research location, and interviews with the cultivators. Data collection was carried out in March 2023. Meanwhile, secondary data in this research includes supporting literature and other supporting data. Secondary data collection was carried out to provide input to the geographic information system, both spatial and attribute data.

The geographical parameters referred to in this research include protectability parameters, and types of bottom-water substrate were carried out by direct observation at the location and interviews with local fishermen. In contrast, depth parameters were measured directly at the location after marking the location points with a Global Positioning System (GPS) device. Depth and location protection observations were conducted before water quality measurements and sampling.

Water quality parameters collected include temperature, salinity, pH, brightness, dissolved oxygen (DO), BOD, and COD. Water quality sample data was taken from three specified locations (purposive sampling). Coordinate positions are determined for each observation and sampling station using the GPS at potential locations for developing floating net cages for lobster mariculture. The temperature, salinity, pH, DO, and brightness parameters were measured directly in the field using a refractometer, pH meter, oximeter, and seiche disk. At the same time, COD and BOD data were carried out in the water sample testing process at the BARISTAND Laboratory (Industrial Research and Standardization Center) Banda Aceh.

Data analysis

Data were analyzed using the Analytical Hierarchy Process (AHP) to determine the weight values among parameter groups and between parameters within each group. In contrast, the score values were analyzed using the criteria for the suitability of water zones for developing lobster mariculture. The criteria for the suitability of aquatic zones for mariculture are a matrix compiled based on the results of previous studies (Fatmawati and Baharuddin, 2021), (Ghani *et al.*, 2015) and (Lesmana, 2022). Meanwhile, the Simple Additive Weighting (SAW) method is often used to analyze the suitability area for lobster cultivation zones.

Each parameter group is given a weight value based on its contribution to the suitability of the lobster cultivation location as follows:

1. Geographic parameters weigh 35.24%
2. Physicochemical parameters weigh 29.52%
3. Other supporting parameters weigh 35.24%

(Based on the AHP analysis)

Water zone suitability analysis

The criteria for suitability of the water zone used for lobster cultivation in this study used two criteria: (1) Suitability criteria for geographic and physicochemical parameters and (2) Suitability criteria for other supporting parameters. Criteria for Suitability of geophysical and physicochemical parameters can be seen in Table 2.

Table 2. Criteria for suitability of lobster cultivation zones on geophysical and physicochemical parameters.

Parameter	Suitability Criteria			
	Very suitable	Suitable enough	Conditionally suitable	Not suitable
Protection	Very protected	Protected	Expose	Expose, extreme
Depth (m)	5-20	21-25	26-35	<5 and >35
Type of Substrate	Sandy, Coral Fragments	Coral	Muddy Sand	Mud
Water temperature (^{0} C)	27-32	25-27	32-34	<25 and >34
Brightness (%)	78.5-100	65-78.4	49.2-64	<49.1
Salinity (‰)	27-32	32-35	20-27	<20 and >35
pH	>7	6-7	4-6	<4
DO (mg/L)	> 7	5-7	3-5	<3
BOD (mg/L)	<20	20-25	25-30	>30
COD (mg/L)	<20	20-50	50-100	>100

Modification from Fatmawati and Baharuddin (2021).

Another group of supporting parameters in this research are other parameters that also determine

whether a water zone is suitable to be used as a mariculture location based on considerations of ease of accessing the location, suitability of the location regarding freshwater input, sources of pollution and conflicts over the utilization or use of water location space. The criteria used for the suitability of other supporting parameter groups can be seen in Table 3.

Table 3. Criteria for suitability of lobster cultivation zones and other supporting parameters

Parameter	Suitability Criteria			
	Very suitable	Suitable enough	Conditionally suitable	Not suitable
Accessibility	very easy to reach	reachable	hard to reach	very difficult to reach
Location suitability	no freshwater input, not near sources of pollution	There is freshwater input, not near sources of pollution	no freshwater input, near sources of pollution	There is freshwater input, close to the source of pollution
Conflict over space use	There is no conflict in space use	conflict occurs, <3 groups of space users	There is a conflict over the use of space >3 groups of space users	There was conflict over the use of space in 3 groups, acute and recurrent scale

Modification from Lesmana *et al.* (2022).

Results

Geographic parameters

The geographical parameters used in this research are location protection parameters, depth, and type of bottom substrate. These parameters are included in the category of physical geography (Geophysics). Based on the results of observations and measurements at the three research stations, the following results were obtained in the Table 4.

Based on the geophysical parameter suitability category in Table 2, the location protection parameters indicate that the first station, *Lhok Krueng Raya*, is semi-enclosed waters. It is calm and clear, has two entrances, and is protected by Klah Island, so it is included in the Very Suitable category. The second station, *Teupin Sirui,* is Conditionally Appropriate, considering that this location is exposed to much wind in the east season, while the last station, *Lhok Weing*, is Suitable because it is in a bay with one inlet/outlet from the northeast and still exposed to the east wind. This is particularly in line with the opinion of Sulistijo (2002) *in* Schaduw and Ngangi (2015), which states that mariculture locations in the sea must be protected from waves and strong winds.

Table 4. Results of grouping geographic parameters at the research location.

Parameter	Lhok Krueng Raya	Score	Teupin Sirui	Score	Lhok Weing	Score
Protection	Very Suitable, very protected	4	Conditionally suitable Expose	2	Suitable Enough, Protected	3
Depth	Very Suitable, (8-12m)	4	Very Suitable, (5-10m)	4	Very Suitable, (5-7m)	4
Type of Substrate	Very suitable, sand and coral	4	Very suitable, sand and coral	4	Very suitable, sand and coral	4

The depth parameters at the three research stations display varying results. The first station with a depth of around 10-12 meters. The second station is between 5-10 meters, and the last station with a depth of 5-7 meters. These results align with Mustafa's (2013) assessment, which states that the minimum depth requirement for mariculture with floating net cages is 6–20 meters at the lowest low tide. Appropriate water depth provides opportunities for smooth water exchange, especially at the bottom of the net. The lowest tides are used as a reference in aquaculture activities to minimize the risk of friction with the bottom of the water. The depth of the water is also helpful for avoiding the buildup of food waste, disturbance of bottom organisms, and lobster droppings at the bottom of the net. According to Junaidi (2018), the distance from the bottom of the cage net to the bottom of the water at low tide is at least 1 meter, while for lobster cultivation, the height of the cage is at least 3 meters, so the ideal water depth is at least 4 meters.

Observation of bottom substrate type parameters shows that the three research stations have similarities in the form of sand and coral, so they are included in the Very Suitable category. The lobster cultivation zone categories can be seen in the suitability criteria table (Table 2).

Physicochemical parameters

The physical and chemical parameters of the waters have a significant influence in determining the lobster cultivation zone. Good water quality can support the growth of aquatic organisms, including cultivation (Lestari *et al.,* 2018). The physical parameters of the waters tested in this study include temperature and

brightness, while the chemical parameters include salinity, pH, dissolved oxygen (DO), BOD, and COD. Reducing the concentration of O^2 will reduce the physiological metabolism of living creatures in the water (Tahir, 2016). The average value of the results of measurements and laboratory tests of the physicochemical parameters of water at the research location can be seen in Table 5.

Table 5. Results of physicochemical parameters of water*.

No	Parameter	Unit	Lhok Krueng Raya	Teupin Sirui	Lhok Weing	Quality standards **	Score ***
1	Temperature	°C	29.33	28.73	28.50	28 -30	4
2	Brightness	%	94.58	92.50	100	49.2 - 78.4	4
3	Salinity	‰	27.67	28.90	28.95	20-35	4
4	pH	-	7.51	7.57	7.40	7-8.5	4
5	DO	mg/L	6.11	6.30	5.66	> 5	3
6	BOD	mg/L	0.96	1.00	1.34	<20	4
7	COD	mg/L	55.43	74.13	68.80	<100	2

Information:
*) Measurements were carried out at depths of 3 meters, 5 meters, and 8 meters at each location (except Lhok Weing station because the depth was inadequate).
**) Sea water quality standards refer to Government Regulation Number 22 of 2021 concerning the Implementation of Environmental Protection and Management (Appendix VIII).
***) Suitability score criteria refer to Table 2.

This research found that DO and COD parameters are the main factors that limit the suitability of lobster cultivation zones in Sabang from the aspect of water quality. COD levels are associated with increased organic matter and nutrient content in water, which causes a decrease in dissolved oxygen levels and increases the potential for stress on aquatic organisms (Lein *et al.*, 2022). Guidelines for Good Fish Farming Practices emphasize the need to monitor and maintain water quality to support the growth and health of cultivators and minimize environmental impacts. It is recommended to apply suitable lobster mariculture methods and reduce the intake of domestic liquid waste from surrounding settlements.

Supporting parameters

Parameters supporting the suitability of lobster mariculture were analyzed based on observations and interviews and using standard suitability criteria in Table 3. The results of these parameter groups are presented in Table 6.

Analysis of the suitability of group parameters

The values in each parameter group are then subjected to weighting, scoring analysis, and classification using the Flag Analysis Method. The results of the group suitability analysis of geographic parameters are presented in Table 7.

Table 6. Supporting parameter analysis results.

Parameter	Lhok Krueng Raya	Score	Teupin Sirui	Score	Lhok Weing	Score
Accessibility	very suitable, very easy to reach,	4	Suitable enough. reachable	3	Suitable enough. reachable	3
Location suitability	Suitable enough, there is freshwater input, far from sources of pollution	3	Suitable enough, there is freshwater input, far from sources of pollution	3	Very Suitable, no freshwater input, far from sources of pollution	4
Space use conflicts	Suitable enough, conflict occurs, <3 space user groups	3	Suitable enough, conflict occurs, <3 space user groups	3	Suitable enough, conflict occurs, <3 space user groups	3

Table 7. Analysis of the suitability of geographic parameters group.

Parameter	Lhok Krueng Raya			Teupin Sirui			Lhok Weing		
	W	S	V	W	S	V	W	S	V
Location Protection	52.38	4	209.52	52.38	2	104.76	52.38	3	157.14
Depth	26.19	4	104.76	26.19	4	104.76	26.19	4	104.76
Type of Substrate	21.43	4	85.71	21.43	4	85.71	21.43	4	85.71
Total	100		400			295.24			347.62
Suitability			**209.52**			**154,65**			**82.09**

Information:
W = Weight, S = Score, N = Value
Parameter group weight 52.38%
Suitability value = 52.38/100 total parameter value

Suitability classification:	Very suitable	Suitable enough	Conditionally suitable	Not suitable
Value	>118-82	96.67-118.82	74.53-96.66	<74.53

Analysis of the suitability of geographic parameter groups shows that the three research stations are classified as **Very Suitable** categories for the lobster cultivation zone. The location protection parameter is a limiting factor at station two due to the conditions of the waters exposed to winds during the east monsoon. The results of the spatial analysis of the suitability of geophysical parameters can be seen in Figure 2.

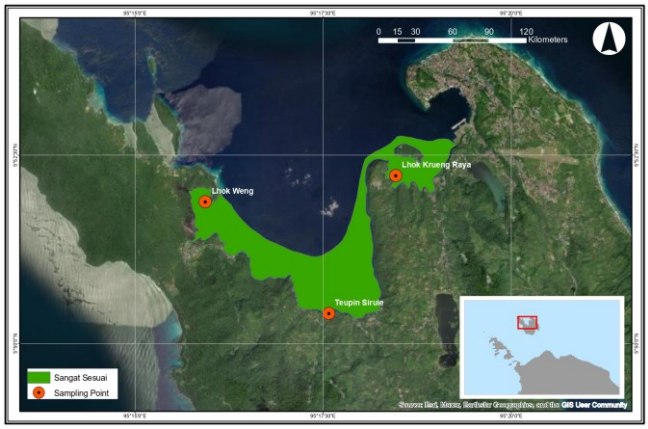

Figure 2. Spatial analysis of geophysical parameters of the lobster cultivation zone.

Analysis of the suitability of the physicochemical parameters of the waters as a lobster cultivation zone can be seen in Table 8.

Table 8. Analysis of the suitability of aquatic physicochemical parameters group.

Parameter	Lhok Krueng Raya			Teupin Sirui			Lhok Weing		
	W	S	V	W	S	V	W	S	V
Temperature	7.01	4	28.03	7.01	4	28.03	7.01	4	28.03
Brightness	7.01	4	28.03	7.01	4	28.03	7.01	4	28.03
pH	11.46	4	45.85	11.46	4	45.85	11.46	4	45.85
Salinity	11.46	4	45.85	11.46	4	45.85	11.46	4	45.85
DO	21.02	3	63.06	21.02	3	63.06	21.02	3	63.06
BOD	21.02	4	84.08	21.02	4	84.08	21.02	4	84.08
COD	21.02	2	42.04	21.02	2	42.04	21.02	2	42.04
Total	100		336.94			336.94			336.94
Suitability			**88.25**			**88.25**			**88.25**

Information:
W = Weight, S = Score, N = Value
Parameter group weight 26.19%
Suitability value = 26.19/100 total parameter value

Suitability classification:	Very suitable	Suitable enough	Conditionally suitable	Not suitable
Value	>85.12	65.47-85.11	45.83-65.46	<45.83

By referring to the standard category of suitability for lobster cultivation in terms of geophysical and physicochemical water parameters (Table 2), the results of the suitability analysis show that the three research stations are classified as **Very Suitable** as lobster cultivation zones. The results of the spatial suitability analysis of the physicochemical parameters of water can be seen in Figure 3.

From the results of observations on other supporting parameter groups, suitability analysis was then carried out using the weighting and scoring method and classification using the Flag Analysis method (Table 9).

Based on the suitability category for lobster cultivation standards for supporting parameters (Table 3). The research results show that Station 1 (Lhok Krueng Raya) is classified as **Very Suitable** as a lobster cultivation zone, while Station 2 (Teupin Sirui) and Station 3 (Lhok Weing) are classified as **Suitable Enough**. The results of the spatial suitability analysis of other supporting parameters can be seen in Figure 4.

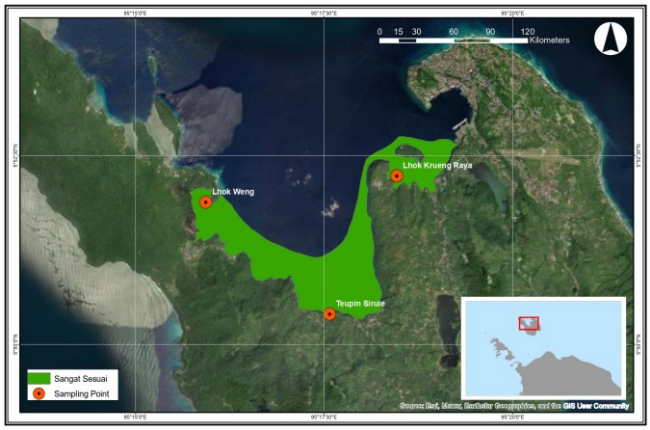

Figure 3. Spatial analysis of the physicochemical conditions of the waters for the lobster cultivation zone.

Table 9. Analysis of Suitability of other supporting parameter groups.

Parameter	Lhok Krueng Raya			Teupin Sirui			Lhok Weing		
	W	S	V	W	S	V	W	S	V
Accessibility	62.32	4	249.29	62.32	3	186.97	62.32	3	186.97
Location suitability	23.95	3	71.85	23.95	3	71.85	23.95	4	95.80
Space use conflicts	13.73	3	41.19	13.73	3	41.19	13.73	3	41.19
Total	100		362.32			300.00			323.95
Suitability Value			**77.64**			**64.29**			**69.42**

Information:
B = Weight, S = Score, N= Value
Parameter group weight 21.43%
Suitability value = 21.43/100 total parameter value

Suitability classification:	Very suitable	Suitable enough	Conditionally suitable	Not suitable
Value	>69.64	53.57-69.64	37.50-53.56	<37.50

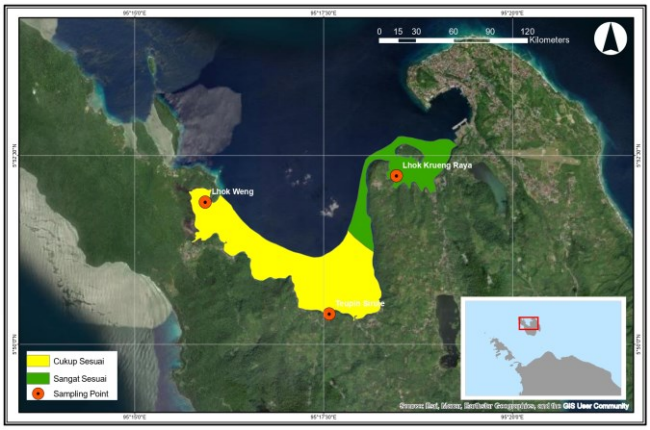

Figure 4. Spatial analysis of supporting parameters for lobster cultivation zones.

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The results of the analysis of the suitability of lobster cultivation zones from three groups of parameters were then continued with analysis using the GIS method and expressed in the form of a map of the suitability of lobster cultivation zones. The analysis map of the suitability of lobster cultivation zones in the waters of Sabang can be seen in Table 10 and Figure 5.

Table 10. Analysis of the suitability of lobster cultivation zones in the waters of Sabang.

Research Location	Parameter Group			Suitability Score
	Geographical	Physics-chemical	Supporting parameter	
Lhok Krueng Raya	4	4	4	4,0
Teupin Sirui	4	4	3	3.7
Lhok Weing	4	4	3	3.7

Information :
Suitability score = the average score of all parameter groups

Suitability classification:	Very suitable	Suitable enough	Conditionally suitable	Not suitable
Suitability Score	3.25-4	2.5-3.24	1.75-2.4	<1.75

Figure 5. Results of analysis of the suitability of lobster cultivation zones in the waters of Sabang.

Discussion

Lobster farming is a promising source of income for coastal community groups. However, this activity requires precise calculations based on adequate data and information to determine the appropriate location for lobster cultivation. This research found that the parameters of protection, accessibility, and COD were limiting factors for determining the suitability of lobster cultivation locations in Sabang. This finding aligns with the statement of Anuraj *et al.* (2022) who argue that these three factors must be considered when selecting aquaculture locations in the sea, especially those using floating net cages. Keeping these limiting factors in mind is critical to the success of lobster farming operations. Choosing the right location can help ensure business sustainability and profitability while minimizing environmental impact.

Aquatic environmental conditions influence lobster growth. Suitable water conditions will accelerate the growth rate of lobsters (Suhermat *et al.*, 2021). In addition, responsible farming practices can increase the sustainability of lobster mariculture businesses.

Aquaculture is vulnerable to environmental factors such as storms, strong currents, and extreme temperature fluctuations. Selecting locations that are protected by natural barriers (e.g., bays, straits, or other protected coastal areas) helps reduce the risk of damage to infrastructure and cultivated organisms (Sjahman *et al.*, 2020; Amin *et al.*, 2022; Sutaman *et al.*, 2023). This aligns with the principle of placing aquaculture facilities in areas that are safe from physical disturbances.

Accessibility is very important in selecting an aquaculture location. Ease of access to the cultivation site is critical for efficient operations, routine monitoring and maintenance tasks. Difficult-to-reach aquaculture facilities can result in increased transportation costs, logistical challenges, and delays in responding to emergencies. The existing theory emphasizes the importance of choosing a location by considering transportation access and good infrastructure to ensure smooth operations.

Water quality is a fundamental factor in the success of any fisheries cultivation business, including lobster cultivation. Existing theory recognizes that high organic and chemical pollution, indicated by low DO levels and high COD levels, can harm cultivated species (Putra and Dedi, 2022). Increased COD levels are associated with increased organic matter and nutrient content in water, causing a decrease in dissolved oxygen levels and increasing the potential for stress on aquatic organisms. Cultivation guidelines emphasize monitoring and maintaining good water quality to support cultivar growth and minimize environmental impacts. Avoiding locations with high COD levels is in line with this principle.

Conclusion

The results of the suitability analysis for the lobster cultivation zone in Sabang Waters, considering the geophysical, physicochemical, and other supporting parameters, show that the three study sites covering an area of 467 hectares are

classified as very suitable for lobster cultivation. Further research is needed by including current velocity, tides, nitrate, nitrite, and TSS content as test parameters for water quality aspects. Identification of other potential locations for lobster cultivation zones and maintenance of water quality, especially locations where lobster seeds, are needed in the future for the development of lobster cultivation in Sabang. The findings of this research indicate that the limiting factors for the suitability of lobster cultivation zones in Sabang Waters are location protection, accessibility, and COD levels. These parameters are important aspects of fish farming. Applying the principles of responsible and sustainable aquaculture can help lobster cultivators increase the chances of the success of the aquaculture business while maintaining environmental sustainability.

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