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Research article

Spatial distribution and habitat suitability of seaweed on West Simeulue Island, Aceh Province, Indonesia

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Abstract

Seaweed is an important biological resource for human life, serving essential ecological functions, including providing shelter and feeding grounds for marine biota. Seaweed can be found in several Indonesian waters, growing naturally or through cultivation, including in the waters around Simeulue Island. This study aimed to assess the distribution of seaweed in relation to land suitability, using oceanographic parameters in Simeulue Island waters. The research was conducted at five stations within the West Teupah District, South Teupah District, and Alafan District. In situ measurements were taken to evaluate land suitability for seaweed growth based on oceanographic parameters such as current speed, depth, substrate type, salinity, temperature, pH, and dissolved oxygen. Results indicated that seaweed in Simeulue Island waters is distributed along the coastline and attached to coral reefs and rocks at depths of 2-5 meters. The total area of seaweed distribution is approximately 351.83 hectares along a coastline of 206.12 km. The measured parameters of seaweed habitats include a pH of 7.7 to 7.9, salinity of 31-35.3 ppt, temperature of 20-30 °C, dissolved oxygen levels of 3-4.8 mg/L, depth of 2-5 meters, current speed of 0.10 to 0.60 m/s, and a sandy coral substrate. Based on these water quality and substrate parameters, the seaweed habitats in Simeulue Island are classified as highly suitable, with suitability values ranging from 64 to 82. The recorded environmental conditions collectively support optimal seaweed growth.

Keywords: Seaweed, suitable area, water quality, geographic information system

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Introduction

Indonesia has 95,181 km of coastline and 5.8 million square kilometers of marine waters. As an archipelago, Indonesia has potential biological resources that can be optimally utilized, including seaweed. Seaweed is one of the macroalgae marine plants that requires the medium to grow by adhering and living at depths that can still be reached by light. This plant has many benefits because it has nutrients, food fiber, and several bioactive components, such as phenolic compounds, flavonoids, and chlorophyll (Lomartire et al., 2021; Salido et al., 2024). Seaweed has also been studied as a functional food, which is a food that has health benefits, including antioxidant, immunomodulatory, anti-diabetic, and antibacterial properties (Erniati et al., 2018; Peñalver et al., 2020).

Seaweed is commonly found in several areas of Indonesian waters, including the waters of Simeulue Island. Simeulue Regency is located in the southwest part of Aceh Province, which is approximately 150 km off the coast and has an area of 1,838.09 km^2 or 183,809 ha. Simeulue Regency has an archipelago of 147 islands, such as Siumat Island, Panjang Island, Batu Berlayar Island, Teupah Island, and Mincau Island.

There are three main classes of seaweed, namely Chlorophyceae (green seaweed), Phaeophyceae (brown seaweed), and Rhodophyceae (red seaweed) (Pangestuti & Kim, 2011). All three types of seaweed have been reported to grow well on the Aceh Coast, either naturally grown or cultivated (Diansyah et al., 2018). Several previous studies have also shown that seaweed grows naturally or through cultivation processes, such as on the coast of Lhokbubon in West Aceh, Simeulue District, and South Aceh Bay (Fitria et al., 2019). However, no information is available that describes explicitly the extent of seaweed distribution in the waters of Simeulue Island. The seaweed distribution can be visualized using Geographic Information Systems (GIS). The picture is useful as a database for exploring seaweed optimally. Therefore, this research is needed.

Methods

This research was carried out on Simeulue Island, Aceh Province, from October to November 2021 in the waters of Simeulue Island (Figure 1). The method used in data collection is guided classification, which is combined with field surveys to increase the accuracy of the research. The determination and sampling method was conducted using purposive sampling. The selected observation stations are Station I in Lubuk Baik Village, Alafan Subdistrict, stations II-IV in West Teupah Subdistrict, namely in Angkeo Village, Inor Village, and Maudil Village, while Station V in Labuhan Bakti Village, South Teupah Subdistrict. This research was carried out in situ to measure the suitability of seaweed land based on oceanographic parameters such as current, depth, substrate, salinity, temperature, pH, and dissolved oxygen. The value of the suitability of the seaweed land will be overlayed using the Arc GIS application and visualized in a map that contains information on the extent of the seaweed distribution in the waters of Simeulue Island.

Data analysis

Supervised classification

Supervised classification is a process of managing land cover image data by taking training samples. Supervised classification is a method needed to transform multispectral image data into classes of spatial elements in the form of thematic information (Marini et al., 2014). The supervised classification method begins with the technical parameters of the proposed remote sensing processing standards and the creation of sample areas to determine the class characteristics. It is an activity to identify prototypes of a number of pixels representing each desired class or category by determining the position of the samples in the field with the help of land cover maps as a reference for each class.

Seaweed land suitability

The suitability of seaweed land can be analyzed by overlaying all stations and setting the highest and lowest thresholds to get a score (Table 1).

The seaweed habitat suitability score was obtained by overlaying all parameters with the reference seaweed suitability score. The maximum land class interval was obtained on the basis of the equal interval method. Based on the equation above, the interval of each class was obtained, and the value was determined (Table 2).

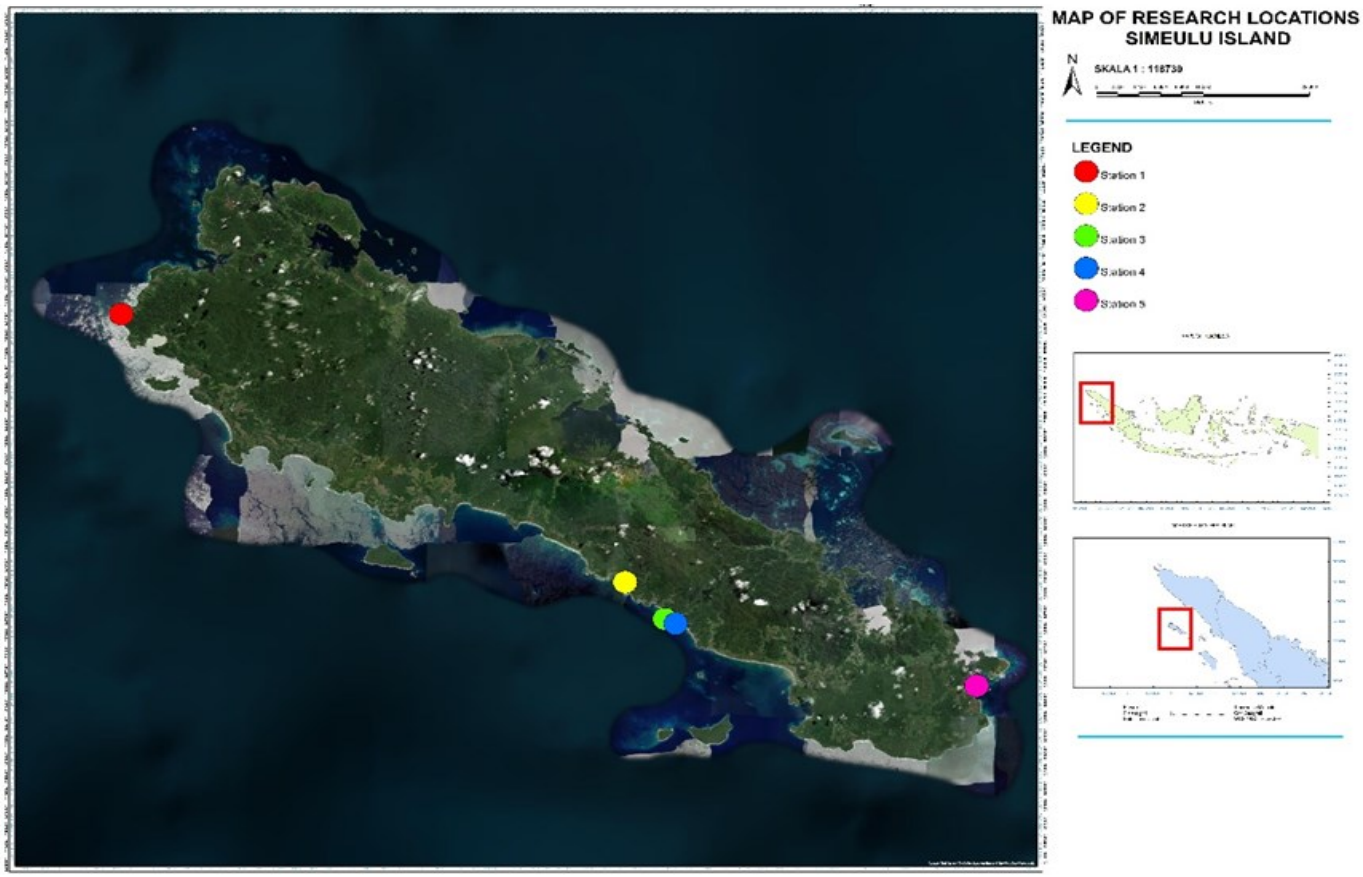

Figure 1. Research location map on Simeulue Island

Table 1. Land suitability score parameters as overlay threshold values (Nashrullah et al., 2021).

Parameters score (A x B)	Range	Score	Weight
Current (m/s)	<0.10 & >0.40	1	3
	>0.10 ≤ 0.25 & > 0.40 – 0.60	3	
	0.25 – 0.40	5	
Depth (m)	<2 & > 10	1	3
	2 ≤ 3 or >5 ≥10	3	
	3 – 5	5	
Water bottom (substrate)	Mud & coral	1	3
	Fine sand, fragments	3	
	Coral & macro algae	5	
Salinity (ppt)	< 25 & > 37	1	3
	>25 ≤ 28 or >34 ≥ 37	3	
	28 – 34	5	
Temperature (℃)	< 20 & > 30	1	3
	20 – 24	3	
	24 – 30	5	
pH	<4 or >9,5	1	2
	4 – 6,4 or 8,5 – 9	3	
	6,5 – 8,5	5	
Dissolved oxygen (mg/L)	<3	1	3
	3 –7	3	
	>7	5	

Table 2. Seaweed land suitability score.

Value (score)	Class
20 - 33,3	Not suitable
33,4 - 66,66	Appropriate
66,7 – 100	Very suitable

Result

Based on the results of the sentinel-2 image data processing, the seaweed on Simeulue Island spread along the coastline and attached to coral reefs and rocks with a depth of 2-5 meters. Based on the length of the beach on the island of Simeulue, it shows the growth of seaweed along 57,51 km of 206,12 km long beach or 27% of the coastline of Simeulue island, with a total area of seaweed growth reaching ± 351,83 hectares (Figure 2).

The seaweed habitat in the Simeulue Island area has a pH of 7,7-7,9, salinity 31-35,3, temperature 20-30 °C, DO 3-4,3 mg/L, depth 2-5 meters, current speed 0,10 to 0,60 m/s, sandy coral substrate, depth 2-5 meters, with a seaweed growth area of approximately 351,83 hectares of coastline 206,12 km (Figure 3). The suitability of seaweed land in the waters of Simeulue Island shows good conditions. This is evidenced by the score value of land suitability ranging from 64-88; it is included in the very suitable category. The highest score value was obtained at station 3, which was 88, followed by stations 1 and 2, which had a score of 82, station 4 had a score of 76, and station 5 had the lowest score value of 64 (Figure 4). One of the factors that causes station 5 to have a low score is that the substrate is muddy and has a shallow depth.

Discussion

Seaweed requires a metabolic process or exchange of substances to produce energy for growth. An essential factor for seaweed growth is water quality, which is its habitat. Based on the results of this study, the measured water quality parameters include dissolved oxygen, pH, salinity, temperature, depth, and ocean currents. Each parameter has an ideal quality standard value for seaweed land suitability based on KEPMEN LH No.51 of 2004 (KLH, 2004) regarding seawater quality standards.

The dissolved oxygen values at five stations ranged from 3-4.8 mg/L and were classified as moderate conditions because the value of dissolved oxygen that is good for seaweed is >5 mg/L. Seaweed generally has a degree of acidity or pH that makes it challenging to grow well. Based on the research results, the pH value of each research station ranged from 7.6 to 7.9. The value was included in the category according to the water quality standards of 7-8.5. The high and low pH parameters will affect the life of organisms. pH also affects seaweed growth (Ruslaini, 2016). If the waters have a low pH, it can interfere with the process of metabolism and respiration, and vice versa; if it has a high pH, it will affect the survival rate of organisms (Octavina et al., 2014).

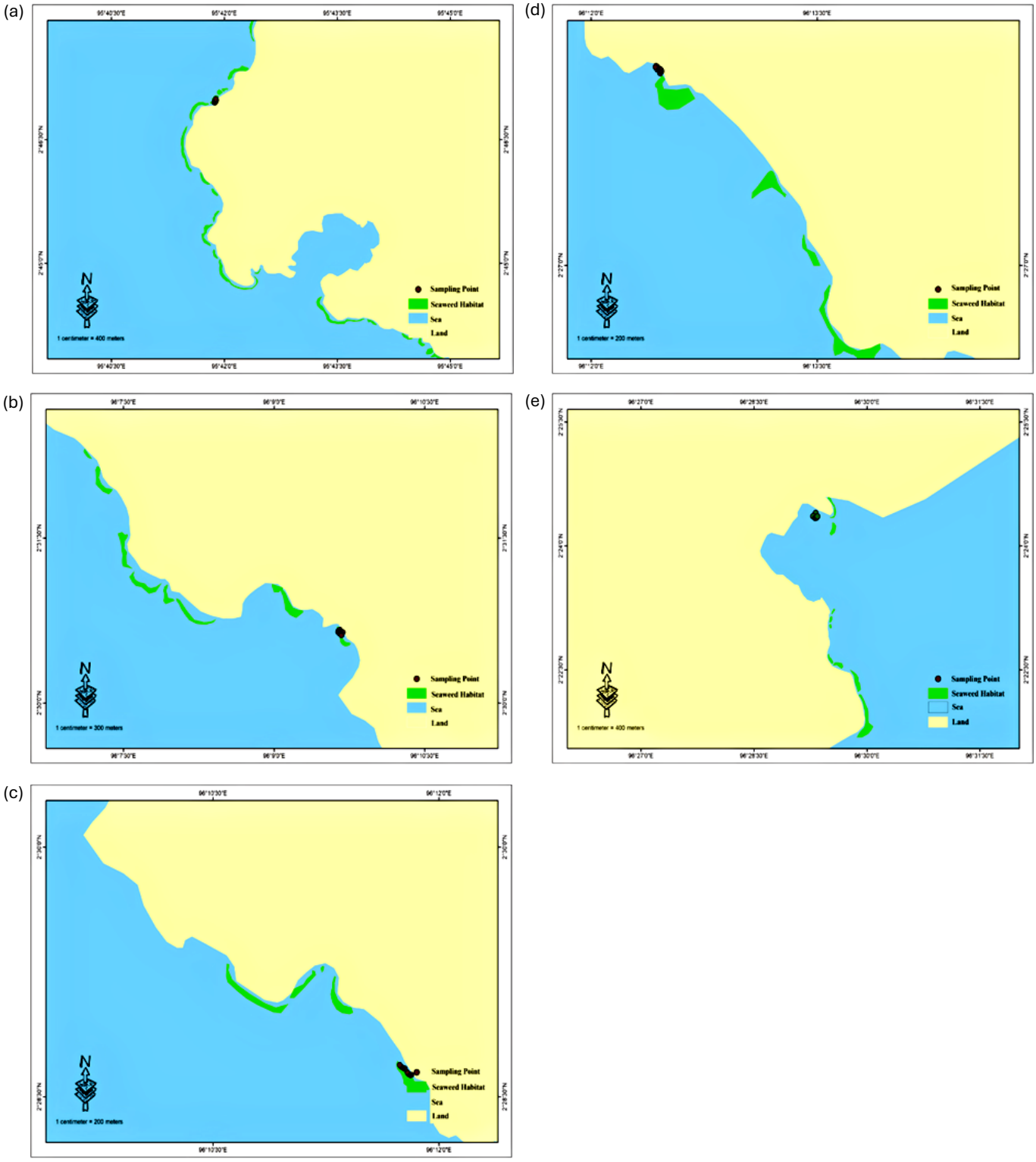

Figure 2. Seaweed distribution; (a) station I, (b) station II, (c) station III, (d) station IV, (e) station V.

Salinity values observed in this study ranged from 31 to 35.3 ppt. These levels are insufficient to induce ion stress, osmotic stress, or secondary stress in seaweed. Ion stress occurs when elevated salinity levels result in ionic toxicity. The optimal salinity range for seaweed growth is recommended to be between 28 and 35 ppt (Yuliyana et al., 2015). The appropriate temperature of the water certainly plays an essential role in seaweed growth. The water temperature at each research station does not differ significantly. The suitable water temperature for seaweed is 20 to 30 °C. Awaluddin (2016) states that seaweed can grow and develop well in waters with a temperature range of 26 to 30 °C. The depth of seawater significantly influences the quality of seaweed habitats due to the limitation of sunlight penetration. Seaweed relies on sunlight for photosynthesis and can only thrive in waters of sufficient depth where sunlight can reach the substrate (Alamsyah, 2016). Seaweed growth on Simeulue Island spreads along the coastline with depths of 2-5 meters. This

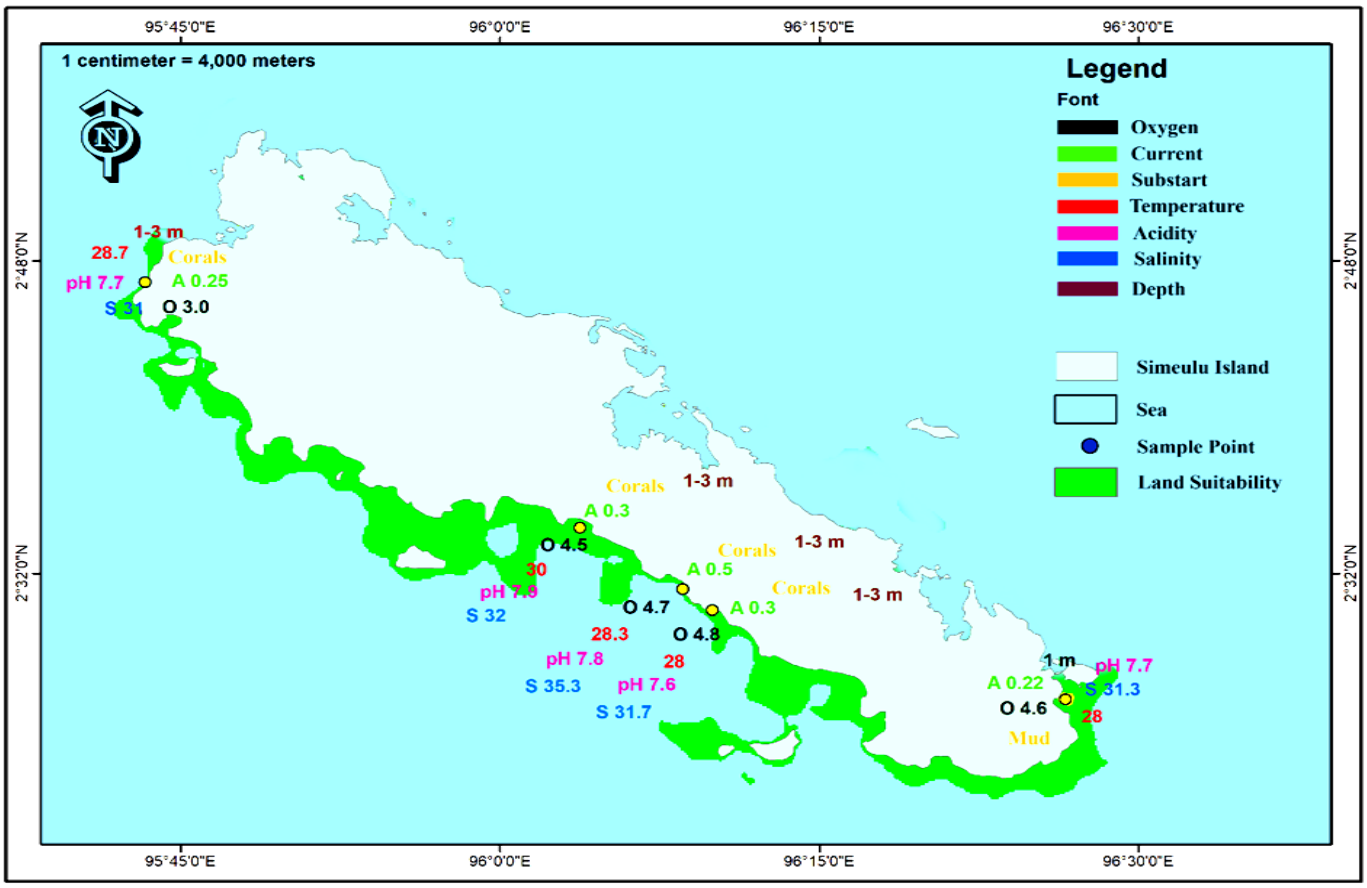

Figure 3. Water quality values in the seaweed habitat.

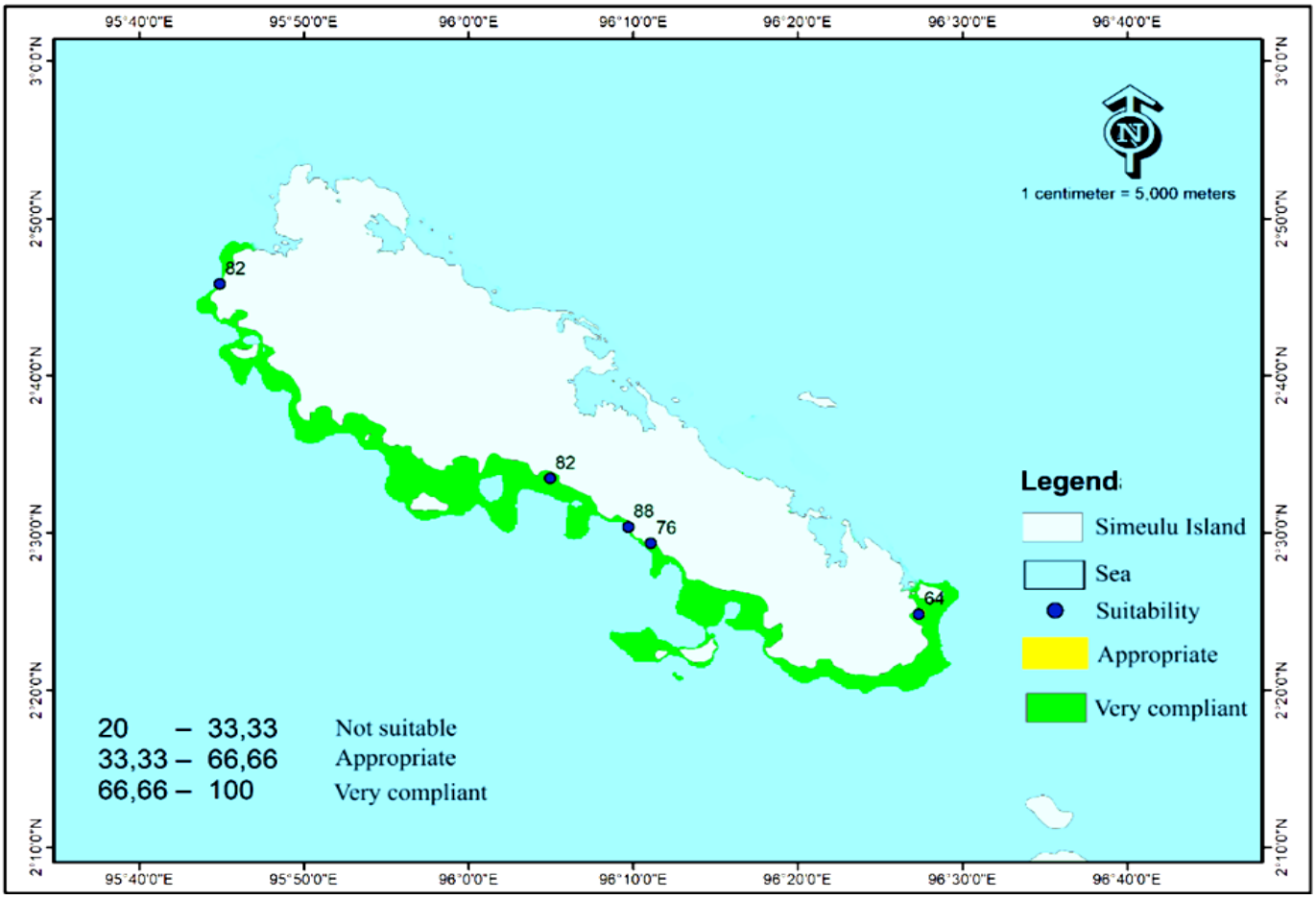

Figure 4. Seaweed land suitability.

value was still classified as suitable for the suitability of seaweed growth land. Then, water currents play a very necessary role in the seaweed growth process, especially for nutrient transport, making it easier to absorb nutrients (Nikhlani & Kusumaningrum, 2021). The current movement at each station does not have a significant difference and is still in an optimal state for seaweed; the current is not too high because the area has a sandy coral substrate, and the current is split. Seaweed grows by sticking or requires medium to grow. According to (Nashrullah et al., 2021), seaweed can grow on mud & coral substrates, medium muddy sand, fine sand, and coral fragments.

Based on the results of the study, the level of suitability of the land for seaweed growth is classified as a very suitable criterion. Seaweed growth can develop optimally if the water conditions are perfect and the needs of the organisms are maintained (Muliyadi, 2023). Safitri & Rachmadiarti (2023), added that optimal environmental conditions must always be maintained during maintenance so that plant metabolism can continue to increase. This is an opportunity for the surrounding community, especially on Simeulue Island, to optimally use seaweed resources (Radiarta & Erlania, 2015).

Conclusions

The seaweed habitat around Simelue Island is characterized by a pH of 7.7-7.9, salinity of 31-35.3 ppt, temperature range of 20-30 ºC, dissolved oxygen levels of 3-4.3 mg/L, water depth of 2-5 meters, and current speeds of 0.10-0.60 m/s. The substrate is primarily sandy coral, and the seaweed growth area spans approximately 351.83 hectares along a 206.12 km coastline. The habitat is deemed highly suitable for seaweed growth, with water quality and substrate conditions yielding high suitability scores ranging from 64 to 88 across different stations.

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Authorship contribution

Imamshadiqin Imamshadiqin: conceptualization, methodology, investigation, sample processing and analysis, visualization, supervision, writing, review and editing. **Gara Hasonangan Ritonga:** methodology, investigation, sample processing and analysis, visualization, writing, original draft preparation, review and editing. **Erlangga Erlangga:** Methodology, writing - review and editing, supervision. **Erniati Erniati:** Conceptualization, methodology, review and editing, supervision. **Imanullah Imanullah:** writing - review and editing. **Syahrial Syahrial:** writing - review and editing. **Salmarika Salmarika:** writing - review and editing. All authors gave final approval for publication and agreed to be held accountable for the work performed therein.

Data availability

Datasets generated during and/or analysed throughout the present study are available from the corresponding author upon reasonable request.

Conflict of interest

On behalf of all authors, the corresponding author states that there are no conflicts of interest.

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