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Identification of the Suitability of Sea Cucumber Cultivation Locations on Saugi Island Using GIS Based on Physical and Chemical Parameters

Identifikasi Kesesuaian Lokasi Budidaya Teripang di Pulau Saugi Menggunakan SIG Berdasarkan Parameter Fisika dan Kimia

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Mat Rasul[a]*, Faridun Ramadhan[(a)], Nurhaya[a], Syuura Annisa Faizin[(a)], Fathul Rahman[(a)], Muslimah[(a)], Rabi'ah Al-Adawiyah[(a)], Adam[a], Ikbal Sunandar[(a)], Siti Fadillah Ibrahim[(a)], Ahmad Zaky Rahman[(a)], Muhammad Ihsan Baci[a]

[a]*Department of Geography, Faculty of Mathematics and Natural Sciences, Makassar State University, Jl. Daeng Tata, Parangtambung, Tamalate, Makassar City, South Sulawesi*

Abstract

Indonesia holds significant potential for sea cucumber aquaculture due to its abundant natural resources. This study aims to map suitable sites for sea cucumber farming around Saugi Island by analyzing physical and chemical water parameters using Geographic Information Systems (GIS). Data were collected from 10 sampling stations through field surveys and analyzed using the weighted overlay method in ArcGIS 10.8. Parameters evaluated included temperature, salinity, pH, dissolved oxygen, water clarity, and depth. Results indicate that the northern, southwestern, and eastern parts of Saugi Island are highly suitable for sea cucumber farming, while the northwestern, northeastern, and parts of the southeastern areas are less suitable. These findings provide a valuable reference for sustainable sea cucumber farming and can support local economic development.

Keywords*: Geographic Information System, Physical*

Abstrak

Indonesia memiliki potensi besar dalam budidaya teripang karena kekayaan sumber daya alamnya. Penelitian ini bertujuan memetakan kesesuaian lokasi budidaya teripang di Pulau Saugi berdasarkan parameter fisik dan kimia perairan menggunakan Sistem Informasi Geografis (SIG). Data dikumpulkan dari 10 stasiun pengamatan melalui survei lapangan dan dianalisis dengan metode *weighted overlay* pada ArcGIS 10.8. Parameter yang dianalisis meliputi suhu, salinitas, pH, oksigen terlarut, kecerahan, dan kedalaman. Hasil menunjukkan bahwa wilayah utara, barat daya, dan timur Pulau Saugi merupakan lokasi yang sangat sesuai untuk budidaya teripang, sementara bagian barat laut, timur laut, dan sebagian tenggara kurang sesuai. Temuan ini dapat menjadi acuan bagi pengelolaan budidaya teripang yang berkelanjutan dan peningkatan ekonomi lokal.

Kata Kunci: *Budidaya Teripang, Parameter Fisika dan Kimia, Pulau Saugi, Sistem Informasi Geografis*

1. Introduction

Indonesia has great potential for sea cucumber farming thanks to its long coastline and diverse natural habitats, such as coral reefs, seagrass beds, and sandy seabeds. Nutrient-rich and stable water conditions, including temperature, salinity, and dissolved oxygen (DO) levels, support optimal sea cucumber growth (Muskananfola *et al*., 2021) . With these advantages, Indonesia has the opportunity to become a global sea cucumber production and export center while improving the economy of coastal communities.

Sea cucumbers are invertebrate animals that belong to the *phylum Echinodermata* and class *Holothuroidea*. This species plays an important role in the marine ecosystem as part of the food chain. Sea cucumbers function as *deposit feeders*, which consume organic matter on the seafloor, as well as suspension feeders, which filter suspended particles in the water. Their contribution to the ecosystem includes recycling organic matter and improving the quality of sediments in their habitat. In addition, sea cucumbers also play a role in the process of bioturbation, which is the stirring up of sediments that helps increase the fertility of the seabed, making them an important component in maintaining the balance and health of aquatic ecosystems (Marsoedi *et al* ., 2020)

On the other hand, sea cucumbers have long been a high-value fishery commodity in the international market. Demand for sea cucumbers continues to increase, especially in Asian

* *Correspondence: Department of Geography, Faculty of Mathematics and Natural Sciences, Makassar State University, Jl. Daeng Tata, Parangtambung, Tamalate, Makassar City, South Sulawesi*
e-mail: matrasul16april2005@gmail.com

countries such as China, Japan, and Korea, which regard them as a luxury food ingredient as well as efficacious for traditional medicine (Muskananfola *et al*., 2021) . Its economic value even surpasses other members of the *Echinodermata* group, such as starfish and sea urchins.

Saugi Island, a small inhabited island in the Spermonde Archipelago, is located in the waters of the Makassar Strait and is administratively included in Mattiro Baji Village, North Liukang Tupabbiring Sub-district, Pangkajene and Islands Regency, South Sulawesi. With an area of approximately 38,173 m², the island is rich in biodiversity. This research has high relevance, given the great economic value of sea cucumbers in the international market and the increasing global demand. However, unsustainable sea cucumber management can damage the ecosystem and the local economy. Therefore, it is crucial to identify appropriate locations for sea cucumber cultivation by considering environmental conditions that support their growth.

This research utilizes Geographic Information System (GIS) which aims to map the optimal location of sea cucumber cultivation based on physical and chemical parameters of waters (Marsoedi *et al*., 2020) . Through the use of Geographic Information System (GIS) applications, this research aims to produce a map of the suitability of sea cucumber cultivation locations. The results of this study can provide in-depth information about the conditions of physical and chemical aspects that can support the growth and survival of sea cucumbers.

By understanding the bioecology of sea cucumbers in the waters of Saugi Island, this research is expected to provide a strong basis for the management and development of sea cucumber aquaculture in the area. In addition, the results of this study are also expected to serve as a reference for the community and stakeholders in planning conservation strategies and sustainable utilization of marine resources, so that the existence of sea cucumbers can be maintained and optimally utilized for the welfare of local communities.

2. Research Methods

The location of this research is Saugi Island, Liukang Tuppabiring Utara Subdistrict, Pangkajene and Islands Regency. Measurements in this study were carried out on October 12, 2024 including the collection of the necessary data and sampling was carried out at 10 station points scattered around Saugi Island.

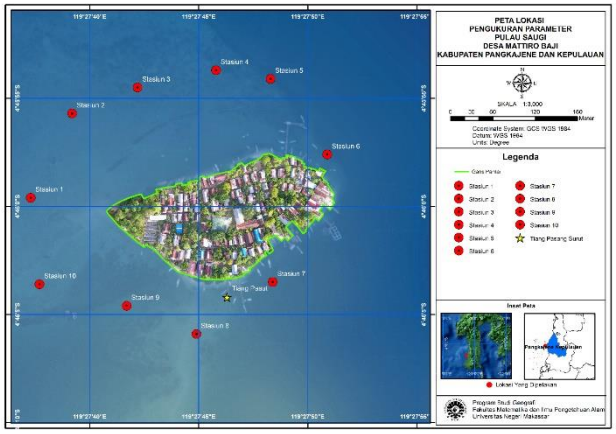


Figure 1: Research location map

The method used in this research is survey, which is collecting field data on parameters that affect sea cucumber growth. The parameters used in this study are temperature, salinity, depth, pH, dissolved oxygen (DO) levels and brightness. The data obtained is then given a score and weight according to its influence on the suitability of sea cucumber growth which is then analyzed using one of the tools contained in ArcGIS 10.8, namely *Weighted Overlay*

2.1. Tools and Materials

The tools used in measuring parameters on Saugi Island include the following:

Table 1.
Tools and materials used during field data collection

No.	Tools and Materials	Function
1.	Thermometer	To measure sea water and air temperature
2.	*Fish Finder*	To measure the depth of sea water
3.	*Secchi Disk*	To measure the brightness of seawater
4.	Universal Indicator Stick	To measure the pH of seawater
5.	Titration Apparatus	To measure the marine oxygen content (DO)
6.	*Hand Refractometer*	To measure seawater salinity
7.	GPS (*Global Positioning System*)	To retrieve the coordinates of each point
8.	*Stopwatch*	To calculate the time used in parameter measurement
9.	Rope	To be connected to a thermometer that serves as a handle
10.	Wipes	To dry tools and containers
11.	Label	To give a name to each sample measurement
12.	Sample Container	To store samples
13.	Ship	Transportation to Saugi Island as well as to the data collection location

2.2. Research Stages

The stages of this research are presented in the flow chart in Figure 2. These stages include problem identification, problem formulation, primary data collection, determination of parameter scores and weights, *weighted overlay*, analysis and conclusions.

2.4. Spatial Analysis

In this study, spatial analysis was used to identify suitable locations for sea cucumber cultivation. Geographic information system is a tool designed to input, store, analyze, and manipulate all geographic data (Rahmanto & Hotijah, 2020) . Utilization of this geographic information system can be used to facilitate the distribution of ideal locations for sea cucumber cultivation. In the Geographic Information System tool, the *overlay* method is used, this method is used to analyze and integrate several spatial data or overlap 2 or more different spatial data (Hasrin & Rasul, 2024) . This method is done by scoring each parameter needed in determining the location of sea cucumber cultivation, which is given a value and weighting according to the classification of each parameter (Nuryadin *et al*, 2024) . Because each parameter has its own share that is different from other parameters in supporting the life of sea cucumber commodities.

Nurchayati *et al* (2021) stated that the parameters used for land suitability are ranked based on their influence on the growth of biota to be studied. The determination of the score in this study is worth three, two and one. The value of three is for locations that are very suitable or ideal for sea cucumber cultivation, value two is for locations that are suitable for sea cucumber cultivation. While the value of one is the value given for locations that are not suitable for sea cucumber cultivation (Hamka *et al*., 2021)

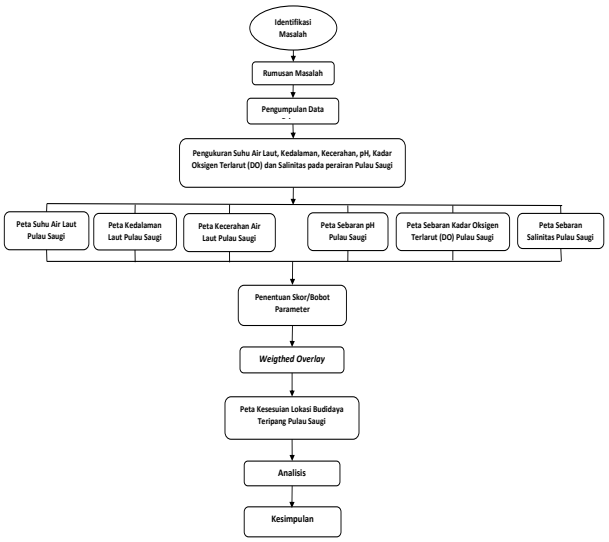


Figure 2. Research Flow Chart

Table 2
Criteria, Weight and Scoring

No.	Parameters	Description Location Suitability	Criteria	Score (N)	Weight (B)
1.	Depth	S1	1 - 1,5 m	3	30
		S2	0,5 - 1 m	2	
		S3	<0,5 m, >1,5	1	
2.	Salinity	S1	32 - 35‰	3	15
		S2	24 - 32‰	2	
		S3	< 24 ‰, > 35‰	1	
3.	Degree of Acidity	S1	7,5 - 8,5	3	15
		S2	6,5 - 7,5	2	
		S3	5,5 - 6,5	1	
4.	Brightness	S1	100 - 150 cm	3	15
		S2	50 - 100 cm	2	
		S3	< 50 cm	1	
5.	Dissolved Oxygen	S1	6 - 8 ppm	3	10
		S2	3 - 6 ppm	2	
		S3	< 3 ppm, > 8 ppm	1	
6.	Seawater Temperature	S1	26 - 31 °C	3	15
		S2	20 - 25 °C	2	
		S3	< 19°C, > 31°C	1	

Source: Modified Hamka (2021) and Marsoedi (2020)
Description:
S1: Very Suitable
S2: Appropriate
S3: Not Appropriate

Determination of the total score value is obtained using the following formula (Harmilia & Ma, 2022) :

$$\text{Skor} \sum_{i;1} N \times B$$

Description:
N = Score
B = Overall Weight Value

The total of the highest score with the overall summation result to get the class value is very suitable or S1, the result is 300 (Nmax) while the multiplication between the lowest score value and the total weight is 100 (Nmin). The value is then entered into the class interval formula (Equation 2) as follows (Hidayah & Marson., 2019) :

$$\text{Selang Interval Kelas} = \frac{Nmaks - Nmin}{3}$$

Description:
Nmax = Maximum Value
Nmin = Minimum Value
3 = Number of Katerogi

From the calculation using the formula above, the interval result is 66.6 rounded to 65, in addition to the value obtained with Nmin of 100 and Nmax of 300. So that the category of land suitability is determined as follows:

1. Very suitable (S1) : >232
2. Suitable (S2) : >165 and <231
3. Not suitable (S3) : <165

Table 3
Sea Culture Site Suitability Category

No.	Category	Description
1.	S1	*Heighly Suitable*, a location that has no severe barriers or limitations so that it has the potential to be used as a sustainable sea cucumber farming location.
2.	S2	*Suitable*, a location that has few constraints for sea cucumber farming that will reduce productivity and profit but can still be used for farming.
3.	S3	*Not Suitable*, a location that has serious constraints or limitations so that it cannot be used for sea cucumber farming.

Source : (Hamka *et al*., 2021)

3. Results and Discussion

3.1. Seawater Temperature

In the measurements taken on October 12, 2024 on Saugi Island, the results showed that the waters on Saugi Island were dominated by temperatures >31°C, symbolized in the red map (Figure 3). Meanwhile, several stations were also found to have seawater temperatures ranging from 26 - 31°C. The distribution of seawater temperatures> 31 ° C which is symbolized in red is scattered at several station points such as stations 7, 5, 4, 3 and 2. While for temperatures 26 - 31 ° C is scattered at stations 6, 8 and station 1.

For the life of marine biota such as sea cucumbers have a suitability for temperatures with a range of 26 - 31 ° C (Muskananfola *et al*., 2021) . This indicates that sea cucumbers can be cultivated in waters with a range of seawater temperatures that are symbolized in dark green. As for waters with temperatures> 31 ° C is not suitable for cultivating sea cucumbers because this range can make it difficult for sea cucumbers to develop, the appropriate range for sea cucumber growth is 20 - 31 ° C (Baransano *et al* .., 2019)

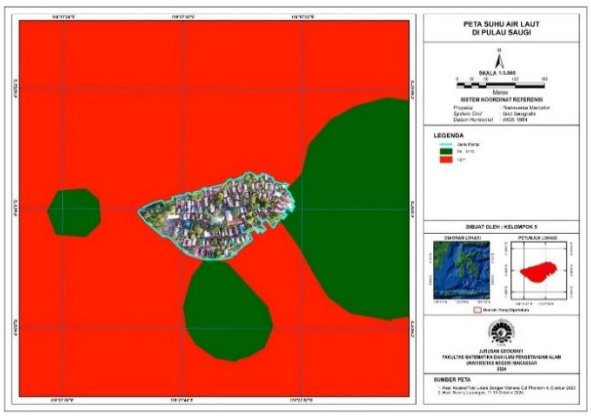
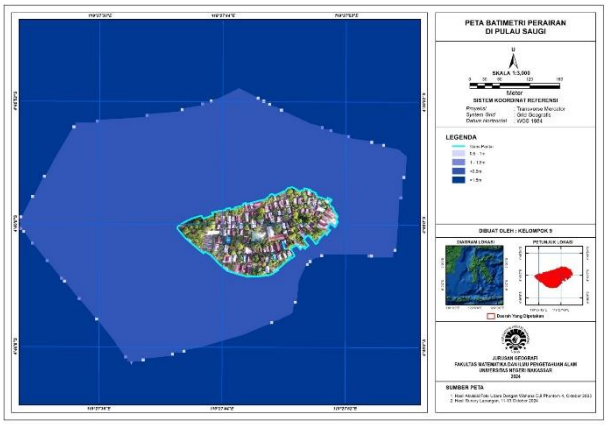


Figure 3. Saugi Island Seawater Temperature Map

3.2. Seawater Depth

Depth is an important factor in sea cucumber farming because it allows sunlight to reach the bottom substrate which

supports the growth of seagrasses and microalgae (Sugama *et al*., 2019) . It allows sea cucumbers to move freely and can shelter from predators because seagrass is the native habitat of sea cucumbers (Bachmid *et al*., 2020) . In addition, microalgae are natural food for sea cucumbers (Isnanda *et al*., 2024) . So that seas that tend to be shallow and have seagrasses are very good for sea cucumber cultivation (Sugama *et al* ., 2019)



Saugi Island Depth Map

Sea cucumbers live at different depths because it is influenced by the magnitude of the biota, at a young age sea cucumbers tend to live and spread in tidal areas, along with increasing age in sea cucumbers, the biota moves to a depth of 0.40 - 1.50 m at the lowest tide (Hamka *et al*., 2021) . According to Gultom (2021) in Hamka *et al* (2021) said that the good depth for sea cucumber development is in the range of 0.5 - 1.5 m.

On Saugi Island, the sea depth can be seen in the map below (Figure 4). The depth is obtained from measurement data using a *fish finder.* On the map above, it can be seen that around the island of Saugi has a depth ranging from 1 - 1.5 m. This can be utilized for sea cucumber cultivation because if the sea depth is >1.5 m and <0.5 m it is not suitable for sea cucumber cultivation (Mandowen & Mambrasar, 2021) . This is because to avoid sea cucumbers experiencing drought and rising water temperatures that can interfere with sea cucumber cultivation (D. Manuputty *et al* .., 2022)

3.3. Seawater Brightness

Brightness measurements in this study used a *secchi disk* measured at several points around Saugi Island. The results obtained that the North and Southeast of Saugi Island have a better tendency to penetrate seawater compared to the West of Saugi Island (Figure 5). The ability of light to penetrate the water to the bottom is strongly influenced by water turbidity. Water turbidity is influenced by several factors such as fine suspended objects such as microorganisms, water color and mud (Anjani *et al* . ., 2019)

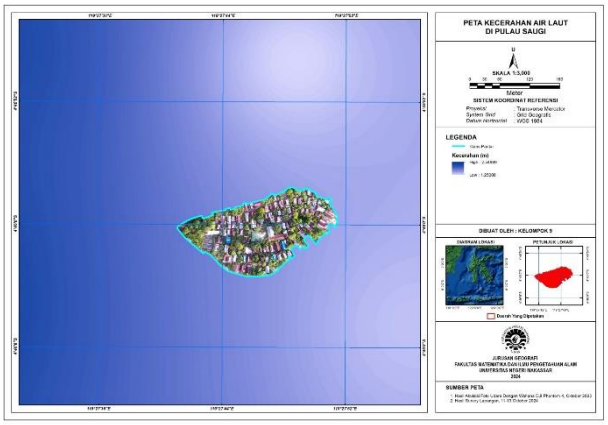


Figure 5. Saugi Island Seawater Brightness Map

Marine life such as sea cucumbers generally prefer clear waters, but it is also possible that sea cucumbers like slightly turbid waters but have a large amount of food supply (Faroby *et al*., 2021) . In research conducted by Putri *et al* (2023) said that sea cucumbers have the suitability to be cultivated if they have a brightness of> 50 cm. This is in line with research conducted by *Roni et al* (2020) which states that the ideal habitat for sea cucumbers is the brightness of seawater in the range of 50 - 150 cm.

3.4. Degree of Acidity of Seawater

Based on measurements taken on Saugi Island on October 12, 2024, the results for the seawater acidity parameter (pH) ranged from 5.5 to 7.5 which is marked with a symbol on the map legend. Most stations have a pH of 5.5-6.5 except for one station that has a pH ranging from 6.5 to 7.5, namely station 9. This shows that most of the Saugi Island waters are dominated by the class of highly unsuitable for sea cucumber development (Figure 6). This condition indicates that the waters of Saugi Island tend to have a slightly acidic nature.

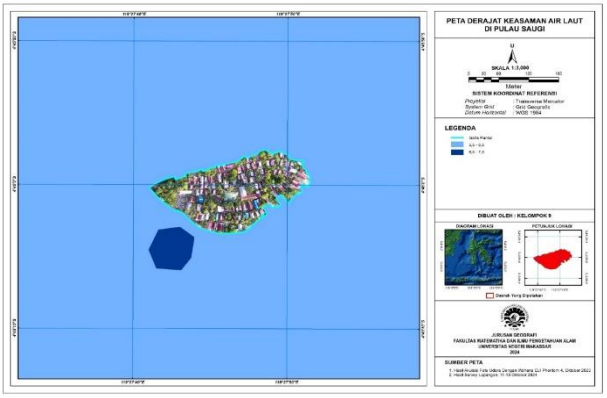
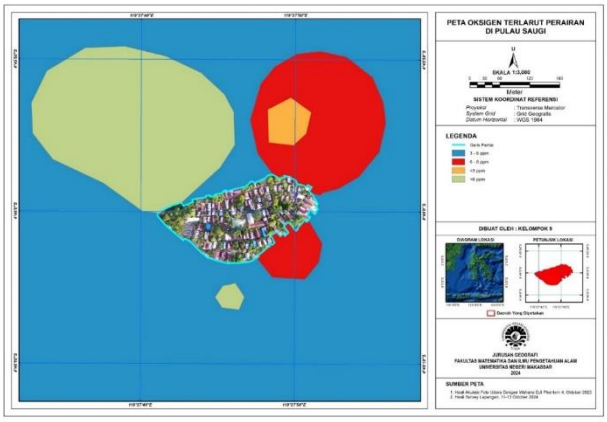


Figure 6: Saugi Island seawater acidity map

The degree of acidity is one of the chemical parameters that affect sea cucumber growth (Luluhima *et al*., 2020) . pH suitable for sea cucumber growth is 7.50-8.50 (Sahetapy *et al*., 2022) . The pH value is influenced by various factors, such as biological activity (e.g. respiration and decomposition), organic waste input, and dissolved carbon dioxide levels.

3.5. Dissolved Oxygen (DO)

Based on measurements taken on Saugi Island on October 12, 2024, the results for the dissolved oxygen parameter have the most dominant range of 3 - 6 ppm which is symbolized in blue. The greenish symbology map also shows a fairly dominant distribution which is spread in the northwest and a small part in the south of Saugi Island, this symbology has a dissolved oxygen range of more than 8 ppm which indicates that it is not ideal for sea cucumber development (Marsoedi *et al*., 2020) . In addition, there is also a range of DO obtained in the measurement results that are not ideal for sea cucumber development, namely <3 ppm (Marsoedi *et al*., 2020) . The ideal dissolved oxygen content in the development of sea cucumber marine biota is in the range of 3-8 ppm which is characterized by red and blue symbology (Marsoedi *et al* .., 2020)



Dissolved Oxygen Map of Saugi Island

This means that dissolved oxygen in Saugi Island waters is available in sufficient quantities for sea cucumber breathing and metabolism. According to (Hamuna *et al*., 2018) *Dissolved Oxygen* (*DO*) is the total amount of oxygen present (dissolved) in water. This is very important for the growth of sea cucumbers because DO is needed by all living things for breathing, metabolic processes or substance exchange which then produces energy for growth and development of culture.

3.6. Salinity

Based on measurements taken at Saugi Island on October 12, 2024, the results for the water salinity parameter at the research site ranged from 24-32‰ according to the map legend. The majority of salinity in Saugi Island waters has a salinity of 32-35‰ or symbolized in light purple. In addition, salinity is also obtained which ranges from 24-32‰ which is symbolized in dark blue, and there is also salinity <24‰ which is located in the Southeast.

According to Gultom (2004) in Faroby (2021) sea cucumbers like waters with salinity around 32-35‰, changes in salinity can have an impact on the exfoliation of sea cucumber skin to cause death in sea cucumbers. An increase of just 3 ppt can have an impact on sea cucumber survival because it greatly affects the physical condition of sea cucumbers. This is supported by research conducted by Marsoedi (2020) which states that the value of salinity between 24-35‰ is still classified as a category that is very suitable for sea cucumber cultivation.

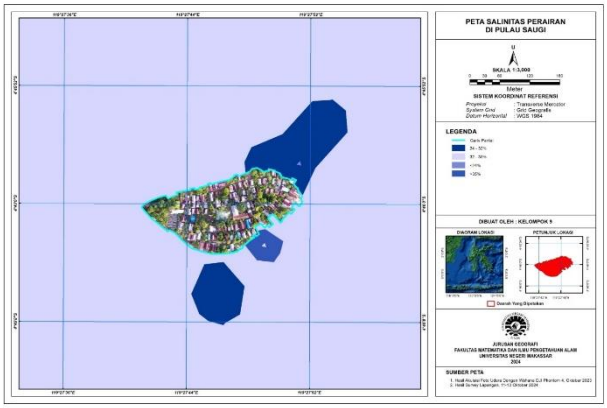


Figure 8. Salinity map of Saugi Island

3.6. Location Map of the Suitability of Sea Cucumber Cultivation in Saugi Island

Based on the results of *overlaying* several physical and chemical parameters for the suitability of sea cucumber cultivation locations including depth, salinity, acidity, brightness, dissolved oxygen (D0), and seawater temperature, the spatial data above shows that most of the waters on Saugi Island are suitable for sea cucumber cultivation. This is symbolized on the map as yellow. But there are also locations that are not suitable for sea cucumber cultivation.

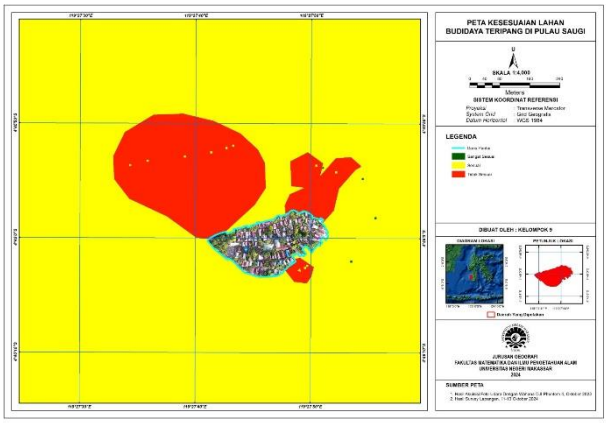


Figure 9. Location suitability map Saugi Island sea cucumber farming

The red symbology on the map indicates that the location is not suitable for sea cucumber cultivation. The distribution of locations suitable for sea cucumber cultivation is in the North, Southwest and East. While locations that are not ideal for sea cucumber cultivation are scattered in the Northwest, Northeast and a small portion in the Southeast. The distribution of suitable locations is strongly influenced by several parameters such as DO, temperature, and salinity that exist at that location which makes the location not ideal for sea cucumber cultivation.

4. Conclusion

Measurements in the waters around Saugi Island show that most of the area is suitable for sea cucumber cultivation, especially in the north, southwest, and east of the island. The unsuitability of locations in the northwest, northeast, and a small part of the southeast is influenced by environmental parameters such as DO, temperature, and salinity. Highly suitable areas are found in limited areas, indicating the need for zoning-based management for optimal cultivation.

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