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WATER SUITABILITY FOR SEAWEED *Kappaphycus alvarezii* CULTURE USING SENTINEL-2A IN AENG BATU-BATU VILLAGE, TAKALAR REGENCY

Kesesuaian Perairan Budidaya Rumput Laut *Kappaphycus alvarezii* Menggunakan Citra Sentinel-2A di Desa Aeng Batu-Batu Kabupaten Takalar

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ABSTRACT

Certain individuals residing in Aeng Batu-Batu Village are engaged in the cultivation of seaweed (*Kappaphycus alvaezii*). However, the community encounters a challenge in identifying suitable areas for seaweed farming. The objective of this study is to assess the appropriateness of the waters for cultivating seaweed. The present study was carried out in June 2023. The exploration method utilized in this study seeks to ascertain the degree of suitability exhibited by the waters for seaweed cultivation. An Aeng Batu-Batu Village sampling procedure was implemented, consisting of three repetitions. A unique set of water quality parameters was acquired at each sampling point. In descending order, the values of each parameter are presented. Current velocity (23.62-11.47 cm/s), depth (5-2 meters), water clarity (3.35-2.3 meters), pH (7.91-7.73), salinity (27-23 ppt), temperature (30-28°C), phosphate (0.0362-0.0122 mg/L), and nitrate (0.069-0.014 mg/L). The water suitability matrix indicates that 185.06 ha of the valley's water is suitable for seaweed cultivation in Aeng Batu-Batu Village, while 0.3 hectare of the valley's water is unsuitable for seaweed cultivation.

Keywords: Aquaculture, GIS, Kappaphycus alvarezii, Sentinel 2A, Water Suitability

ABSTRAK

Sebagian warga Desa Aeng Batu-Batu berprofesi sebagai pembudidaya rumput laut jenis *Kappaphycus alvarezii*. Namun, mereka menghadapi kendala utama berupa kurangnya pemahaman tentang lokasi yang ideal untuk budidaya rumput laut tersebut. Penelitian ini bertujuan untuk mengidentifikasi tingkat kesesuaian perairan bagi budidaya *Kappaphycus alvarezii*. Penelitian dilaksanakan pada Juni 2023 dengan menggunakan metode IDW (*Inverse Distance Weighting*) dan *overlay* untuk mengevaluasi kesesuaian perairan. Pengambilan sampel dilakukan di perairan Desa Aeng Batu-Batu dengan tiga kali pengulangan di setiap lokasi pengambilan. Parameter kualitas air yang diukur di setiap titik sampling menunjukkan

variasi. Nilai parameter yang diperoleh meliputi kedalaman (5-2 meter), kecerahan air (3,35-2,3 meter), kecepatan arus (23,62-11,47 cm/s), pH (7,91-7,73), salinitas (27-23 ppt), suhu (30-28 ℃), fosfat (0,0362-0,0122 mg/L), dan nitrat (0,069-0,014 mg/L). Berdasarkan analisis matriks kesesuaian perairan, ditemukan bahwa luas perairan yang cocok untuk budidaya *Kappaphycus alvarezii* mencapai 185,06 hektar, sementara area yang tidak sesuai hanya seluas 0,3 hektar.

Kata Kunci: Akuakultur, SIG, *Kappaphycus alvarezii*, Sentinel 2A, Kesesuaian Perairan

INTRODUCTION

Takalar Regency is one of the government areas located in the southern part of South Sulawesi. Geologically, the Takalar area is located about 40 km south of Makassar City. Takalar Regency is one of the centers of seaweed production in South Sulawesi where the advancement of seaweed growth is spread throughout the sub-area. One of the sub-locales that is the center of seaweed development in Takalar is the North Galesong Area.

In 2017, Takalar Regency produced a number of *Kappaphycus alvarezii* seaweed as much as 760,726.0 but in 2018, 2019 and 2020 *K. alvarezii* seaweed experienced a decrease in production, namely in 2018 as much as 325,068.8 tons, in 2019 as much as 247,138.40 tons and in 2020 as much as 222,052.80 tons. This shows a consistent decrease in *K. alvarezii* seaweed production. However, in 2021, the development of *K. alvarezii* seaweed increased by 309,753.68 tons and in 2022 it became 340,624.72 tons. The increase in the growth of *K. alvarezii* seaweed that occurred in 2022 was not comparable to the total production of *K. alvarezii* marine growth in 2017 with a difference of 420,101.28 tons (Fatonny et al., 2023).

Information from the data received stated that the production of *K. alvarezii* seaweed in the North Gelesong Area in 2014 was 18,712 tons, in 2015 seaweed growth increased by 1% to 19,086 tons, in 2016 it became 28,090 tons and in 2017 the production of *K. alvarezii* seaweed decreased to 26,907 tons. The decline in the development of *K. alvarezii* seaweed can occur due to climate change, ecological elements and disease (Rustam et al., 2020).

Aeng Batu-Batu Village is one of the villages located in Galesong Utara District, Takalar Regency, South Sulawesi which has great potential in seaweed development. In 2017, the production of *Kappaphycus alvarezii* seaweed in this village reached 20,180 tons. Geographically, Aeng Batu-Batu Village stretches from north to south, bordering Makassar City to the north, Gowa Regency to the east, Takalar City to the south, and the Makassar Strait to the west (Kasmiati et al., 2021).

The development of seaweed cannot be separated from the influence of the substance and actual variables of water quality in the water area. Water quality is an important marker that greatly influences the course of seaweed development activities. A large water quality limit value will affect the increase in the level of seaweed growth efficiency. Some water boundaries that greatly affect the level of seaweed harvest efficiency are phosphate and nitrate limits and actual limits including current speed, depth, water clarity, temperature, pH, and salinity. Water boundaries play a fundamental role in the biological system elements of seaweed development (Wafi et al., 2021).

Seaweed water quality measurement must be carried out to avoid seaweed production failure and to determine the area of waters that are still possible for seaweed cultivation activities. Geographic Information Systems (GIS) can be used to overlay and share values to spatial information. GIS is a PC-based framework for capturing, storing, checking, coordinating, controlling and displaying information with computerized maps. GIS offers a framework that coordinates spatial information with printed information which is a comprehensive picture of an item and its relationship to different items. With this framework,

information can be monitored and controlled for complete examination purposes and at the same time show the results in a map structure (Ansar et al., 2020).

Based on the study of references and existing study results, researchers are interested in knowing the suitability of waters in terms of physics and chemistry in supporting the development of *Kappaphycus alvarezii* seaweed in the waters of Aeng Batu-Batu Village, Takalar Regency.

METHODS

This research was conducted in the waters of Aeng Batu-Batu Village, Takalar Regency. Data collection of physical and chemical oceanography parameters was carried out in May 2023 at 3 locations with 3 repetitions. The basis for choosing the location is the existing condition of seaweed cultivation activities in the waters of Aeng Batu-Batu Village (Figure 1).

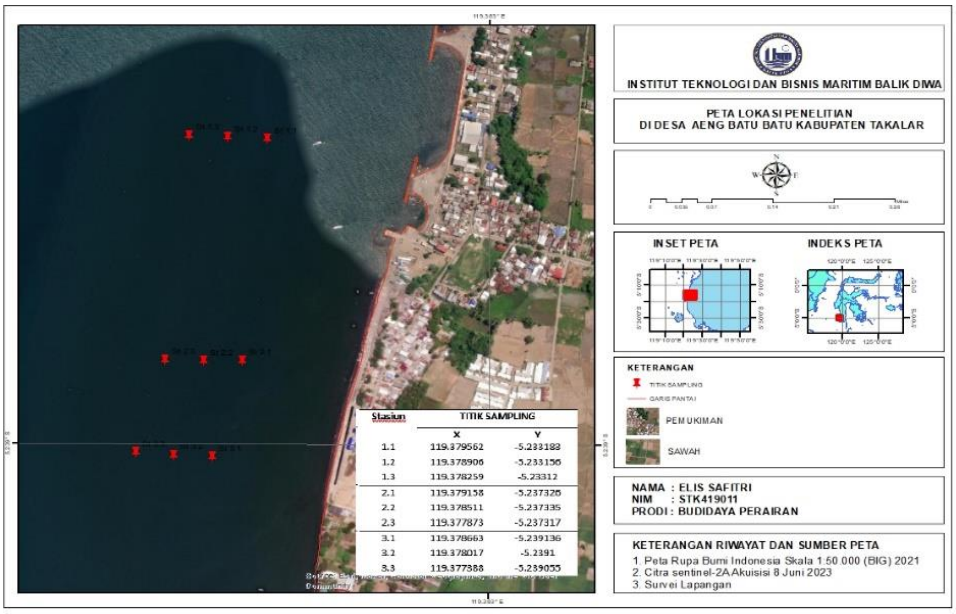

Figure 1. Research Location Map

In this study, the tools used include a refractometer to measure salinity, a pH meter to measure pH, a thermometer to monitor temperature, a secchi disk to measure water clarity, a curret meter to measure current speed, and an echosounder to determine water depth. Nitrate and phosphate analysis was carried out in the laboratory using a spectrophotometer. The materials used include the Indonesian Topographic Map obtained from the Geospatial Information Agency (BIG) and Sentinel-2A Imagery downloaded from the official ESA Copernicus website (https://scihub.copernicus.eu/dus/#/home).

This study utilizes primary and secondary data. Primary data were collected through direct measurements in the waters, while secondary data came from supporting literature and information from agencies relevant to this study.

The results of measurements of physical and chemical oceanographic parameters were processed using a weighting method, where each range of parameter values was given a certain score. The level of suitability of water areas varies depending on the suitability value of the oceanographic parameters that affect the assessment of water suitability. The suitability classification is based on two categories, namely 1.) Appropriate and 2.) Not Appropriate.

Weight based on the most dominant level of influence 1: Important; 2: Very Important, can be seen in Table 1 as follows:

Table 1. Water Suitability Matrix for Seaweed Cultivation

Parameter	Range	Rating Score (A)	Weight (B)	Score (AxB)
Brightness of Waters (m)	<2	1	3	3
	>2	2		6
Depth (m)	<1 & >10	1	1	1
	1-10	2		2
Temperature (◦C)	<24 & >32	1	2	2
	24-32	2		1
pH	<7 & >8.5	1	2	4
	7-8.5	2		2
Salinity (ppt)	<28 & >33	1	2	4
	28-33	2		2
Nitrate (mg/l)	<0.04	1	3	3
	>0.04	2		6
Current Speed (cm/sec)	<20 & >40	1	3	3
	20-40	2		6
Phosphate (mg/l)	<0.1	1	3	3
	>0.1	2		6

Source: Modification (Agustang et al., 2021; Atmanisa et al., 2020)

Based on the assessment results of each oceanographic parameter, an analysis was conducted to determine the feasibility of a location as a cultivation area for *Kappaphycus alvarezii* seaweed. Determination of the water suitability class interval was carried out using the Equal Interval method, where each class was determined by calculating the difference between the maximum and minimum scores, then dividing it by the desired number of classes.

$$Ci = \frac{maximum\ weight - minimum\ weight}{n}$$

Description:
Ci = Distance between classes
N = Number of planned classes

Table 2. Water Suitability Weighting Values

No.	**Kisaran Nilai Skor (%)**	**Kelas**
1	8-27	Tidak Sesuai (S2)
2	28-48	Sesuai (S1)

Source: Modification (Irawan & Handayani, 2020)

In this study, we classified the suitability of waters into two categories, namely suitable and unsuitable. The selection was based on the nature of waters that tend to be easily changed and the limitations in intervening or modifying the environment when there is a slight unsuitability. The parameters used in this study are listed in Table 3 below:

Table 3. Measured Oceanographic Parameters

No	Range	Unit	Method
1	Brightness of Waters	m	In situ
2	Depth	m	In situ
3	Temperature	°C	In situ
4	pH	-	In situ

5	Salinity	ppt	In situ
6	Nitrate	mg/l	Laboratory
7	Current Speed (cm/s)	mg/l	In situ
8	Phosphate	mg/l	Laboratory

Data Analysis

Determination of the suitability of waters for seaweed cultivation refers to the water suitability matrix (Table 1) which has been weighted and scored for each oceanographic parameter studied. Furthermore, the parameter data obtained at the research location was then interpolated using Arcgis 10.8 software and a picture of the parameter distribution was obtained in the form of a map. The data analysis of each parameter data was carried out using the Inverse Distance Weighting (IDW) interpolation method. The interpolation results for each parameter produce a picture of the suitability of the *Kappaphycus alvarezii* seaweed cultivation waters along with its area. The area of land suitability for seaweed cultivation was obtained using the overlay method so that the area produced was suitable or unsuitable based on the criteria in the matrix contained in Table 1.

RESULT

The results of oceanographic parameter measurements and their weighting values according to the scoring in Table 1 can be seen in Table 4.

Table 4. Scoring Values of Suitability of Seaweed Cultivation Waters

Oceanographic Parameters	**Sampling Point**								
	1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3
Depth (m)	2	2	2	2	2	2	2	2	2
Current Speed (cm/s)	6	3	3	3	3	3	3	3	6
Brightness of Waters (m)	6	6	6	6	6	6	6	6	6
Salinity (ppt)	2	2		2	2	2	2	2	2
Temperature (°C)	4	4	4	4	4	4	4	4	4
Nitrate (mg/l)	3	6	6	6	3	6	6	6	6
Phosphate (mg/l)	3	3	3	3	3	3	3	3	3
pH	4	4	4	4	4	4	4	4	4
Total Score	30	30	30	30	27	30	30	30	33
Compliance Category	In accordance	In accordance	In accordance	In accordance	It is not in accordance	In accordance	In accordance	In accordance	In accordance

At the research location, the water depth at the sample points ranged from 3.20 to 5.80 meters. The greatest depth was found at point 1.3, while the smallest depth was at point 3.1. The cultivation method used in Aeng Batu-Batu Village is the long line method.

The current speed at the sampling point for seaweed cultivation in the waters of Aeng Batu-Batu Village was measured using a current kite. The average current speed was in the range of 11.47–23.62 cm/second. The highest current speed was found at point 1.1, while the lowest was at point 1.2.

The clarity of the waters at the sample points was measured using a secchi disk. The average clarity of the waters ranged from 2.3 to 3.35 meters. The highest clarity was found at point 2.3, while the lowest was at point 3.2.

The salinity of the waters was measured directly in the field using a refractometer. The salinity value of the waters in Aeng Batu-Batu Village is in the range of 23–27 ppt, with an average of 25.11 ppt. The highest salinity was found at points 2.3 and 3.1, while the lowest was at point 1.1.

Water temperature measurements were carried out directly in the field using a thermometer. Water temperatures ranged from 28–30°C, with an average of 29.11°C. The highest temperatures were found at points 2.1 and 3.3, while the lowest temperature was at point 3.1.

The nitrate levels in the waters of Aeng Batu-Batu Village were taken directly in the field and tested in the laboratory. The average nitrate levels were in the range of <0.014 to <0.071 mg/l. The highest nitrate levels were found at point 3.3, while the lowest were at point 2.2.

The phosphate levels in the waters were also measured directly in the field and tested in the laboratory. The results showed the same phosphate levels at all sample points, namely <0.0392 mg/l.

Water pH measurements were carried out using a pH meter with the results showing variations in pH at each point, with an average ranging from 7.73–7.79 with the highest value at point 3.1, while the lowest pH was at points 1.1 and 1.2.

The overlay results after scoring in Table 4 show the area of *K. alvarezii* cultivation that is categorized as suitable and unsuitable, which can be seen in Figure 2.

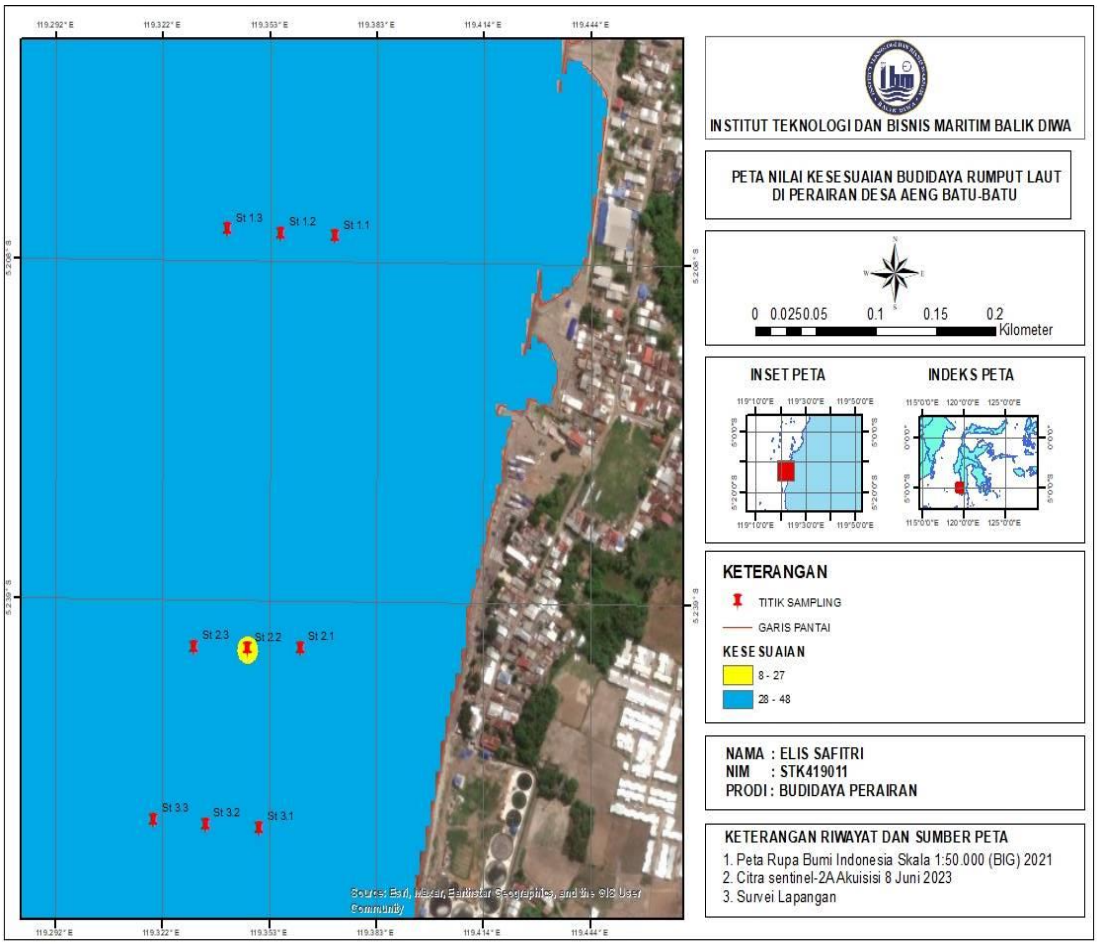

Figure 2. Map of Suitability of Seaweed Cultivation Waters

DISCUSSION

From the measurement results, the water depth value in Aeng Batu - Batu village was 2 meters. This value is suitable for seaweed cultivation which requires a depth ranging from 1 to 15 meters (Indriyani et al., 2019a; Logo et al., 2019; Noor, 2015). The current speed value obtained was 11.47 - 23.62 cm/sec. The current speed value obtained in this study is classified as a slow current so it is very good to support the growth of *Kappaphycus alvarezii* seaweed. Locations that are rich in nutrients can support good seaweed growth with lower current speeds. However, in locations with limited nutrient availability, a higher current speed is needed, although it remains below 40 cm/sec. Although a current speed of around 10 cm/sec is considered sufficient, in waters that have low nutrient content, it is more advisable to have a current speed of more than 20 cm/sec (Mansur et al., 2023).

The measured water clarity not only depends on the amount of sediment present, but is also influenced by the depth of the water itself (Indriyani et al., 2021). In the context of sampling in Aeng Batu-Batu Village, which has a shallow depth, the brightness condition with a distance of 1 meter is quite suitable for the cultivation of *Kappaphycus alvarezii* seaweed (Hardiana et al., 2023; Indriyani et al., 2019b).

The analysis of the suitability of the waters for the cultivation of *Kappaphycus alvarezii* seaweed in this study was in the unsuitable range. The salinity standard considered suitable for seaweed cultivation is around 28-33 ppt, as regulated in (National Standardization Agency, 2010; Rohman et al., 2018).

Based on the analysis of water suitability, the temperature in the Aeng Batu Batu Village area is included in the suitable category. The temperature standard considered suitable for seaweed cultivation is between 24°C and 32°C (Nashrullah et al., 2021). Temperature is the main environmental parameter that greatly influences the growth, metabolism, and production of *Kappaphycus alvarezii* seaweed. A 1° increase or decrease in temperature has greatly affected the metabolism of plants including seaweed (Atmanisa et al., 2020; Labenua & Muhammad, 2021).

The nitrate content considered suitable for seaweed cultivation is more than 0.04 mg/l. Waters suitable for cultivating *Kappaphycus alvarezii* seaweed require phosphate content that meets the standard, namely more than 0.1 mg/l (Lase et al., 2020). Nitrate is the main form of nitrogen in natural waters, which is produced through the oxidation process of ammonia into nitrite and nitrate with the help of microorganisms. The presence of nitrate in the sea is very beneficial for marine plants, including *K. alvarezii* seaweed (Wafi et al., 2021).

In this study, the pH value obtained ranged from 7.73 to 7.79. This value is suitable for seaweed cultivation ranging from 7 to 8.5 (Hidayah & Wiyanto, 2021). At the optimal pH range, metabolism and nutrient absorption in seaweed are efficient and support thallus growth (Nani et al., 2023; Pauwah et al., 2020).

From the overlay results, the area of waters in Aeng Batu-Batu Village that is suitable for *Kappaphycus alvarezii* seaweed cultivation is 185.06 hectares, while the area of waters that are not suitable for developing *Kappaphycus alvarezii* seaweed cultivation is around 0.3 hectares. The unsuitability of these waters is caused by low nitrate levels at the location, which is confirmed through laboratory test results. This data was obtained through field parameter measurements. Evaluation of water suitability is carried out by multiplying the weight by the score value, and then calculating the range between classes, which finally provides the level of suitability and the area that can be used for *Kappaphycus alvarezii* seaweed cultivation.

CONCLUSION

From the suitability index value of *Kappaphycus alvarezii* seaweed cultivation waters in Aeng Batu-Batu Village, Takalar, it is included in the suitable category (185.06 Ha) which has

a few limiting factors, namely current speed, which causes a small part of the area to be categorized as unsuitable (0.3 Ha).

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