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RESEARCH ARTICLE

# Utilization of Satellite Imagery for Mapping the Distribution of Seagrass on Buhung Pitue Island

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**Abstract** Buhung Pitue Island has seagrass beds those which are spread almost evenly along its coast. Research using remote sensing technology in an effort to support seagrass conservation in Indonesia needs to be carried out. Spatial data is relatively easy to obtain because there are many types of images with various spatial resolutions. The image can be obtained on google earth. Analysis of the distribution of seagrass areas was obtained by digitizing on screen in ArcGIS software, namely in seagrass areas where the boundaries are known. Digitizing is conducted by enlarging the seagrass area in the downloaded image, performing radiometric and geometric corrections, and digitizing to create a shapefile (shp) storing the location, shape, and attributes of geographic features. The seagrass distribution area of Buhung Pitue Island was of 36.5 Ha in 2014 and was of 39.6 in 2021. The rate of change in area from 2014 to 2021 was of 0.085% (an increase of 3.1 ha). The distribution area of seagrass has increased due to natural factors and restrictions on human activities during the COVID-19 pandemic. In addition, another factor supporting the increase in seagrass distribution is the abundance of Enhalus acoroides seagrass species growing and spreading over long distances. The sea surface temperature was high, which was 30.37 °C, while the current speed was categorized as slow because it was around 0.01 m/s. Although the results are obtained from high-resolution imagery, an accuracy test still needs to be conducted.

**Keywords:** Seagrass distribution area; ArcGIS; Google earth; Buhung Pitue Island

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## 1. Introduction

Sinjai Regency is one of 24 regencies within the province of South Sulawesi which is located on the south east coast. Sinjai Regency which has an area of 819.96 km² consists of 9 sub-districts, with a total of 67 villages and 13 sub-districts (Indriyani et al. 2019). Pulau Sembilan is one of the sub-districts in Sinjai Regency, which is the result of division from North Sinjai District. Pulau Sembilan consists of 9 small islands which have very potential coastal and marine resources, including seagrass beds those which are spread almost evenly along the coast of Buhung Pitue Island and small islands.

Seagrasses are high-level plants (Anthophyta) that live and grow immersed in the marine environment having rhizomes on the roots (Namakule et al. 2017; Melsasail et al. 2018). Seagrass reproduces generatively, namely by mating or sexually in single-seeded plants (monocots) and reproduces vegetatively or asexually (Rasyid et al. 2022; Rosalina et al. 2022a; Rosalina et al. 2022b). Seagrasses are also widely distributed throughout tropical, subtropical and temperate coastal waters (Hossain et al. 2015).

Seagrass plays an important role in coastal communities because this plant is one of the supporting factors of various kinds of flora and fauna, depending on the number of leaves, length, width, and biomass. Seagrasses can affect the productivity of coastal waters, play a sediment stabilizer role controlling water clarity and quality, produce oxygen and organic matter from photosynthesis, and affect other ecosystems around them (Maxwell et al. 2017; Joseph et al. 2018; Rosalina et al. 2018; O'Brien et al. 2018). Another important aspect is the physical structure for recruitment and attachment of a variety of small organisms increasing with seagrass presence, leading to a higher abundance and diversity of marine organisms in seagrass bed compared with bare areas (Barnes 2013).

Mapping using remote sensing technology has been widely used and developed to facilitate seagrass habitats in water areas (Carpenter et al. 2022). Satellite remote sensing provides a comprehensive alternative for spatially shallow water ecosystems, such as coral reefs and oceans (Hedley et al. 2016). Remote sensing sensors can penetrate clear shallow waters and identify the characteristics of the bottom substrate of these waters. Advances in remote sensing technology are marked by developments in satellite technology (Kutser et al. 2022). The development of several satellites with different levels of spatial resolution will provide different capabilities in terms of the complexity of an object (Zhao et al. 2016). Shallow water ecosystem mapping using satellite imagery data can provide great benefits in coastal ecosystem management plans (Naidu et al. 2018; Gissi et al. 2021; Stelzenmüller et al. 2022). Research on mapping and monitoring of shallow water ecosystems (corals, seagrasses and mangroves) has been carried out using satellite imagery data (Pham et al. 2019; Sari and Rosalina 2016). Spatial data is relatively easy to obtain because there are many types of images with various spatial resolutions. Satellite imagery has been widely published by companies engaged in the spatial field for making virtual earth programs. The image can be obtained on google earth. (Voinov et al 2016; Martoyo 2017; Azzari and Lobell 2017).

The waters of Buhung Pitue Island are an area having a diversity of marine life. One of the most potential marine biota is sea grass. At this location, there are many ship transportation activities indirectly affecting the existence of seagrass. A lot of research have been conducted on the presence of seagrass on Buhung Pitue Island, related to biophysical aspects, species composition and marine biota living in the seagrass bed area. However, the spatial aspects and distribution of seagrass beds on Buhung Pitue Island are still very limited. Therefore, research using remote sensing technology in an effort to support seagrass conservation in Indonesia needs to be carried out by knowing the seagrass distribution area, sea surface temperature distribution value, and current movement pattern in Buhung Pitue Island.

## 2. Methods

This research was conducted for 2 months starting from September 26th – November 25th 2022 at the Computer Laboratory of the Faculty of Marine Sciences and Fisheries (FIKP), Universitas Hasanuddin. The location for data collection was Buhung Pitue Island, Sinjai Regency, which can be seen in Figure 1. Buhung Pitue Island, Pulau Sembilan District, Sinjai Regency has coordinate limits of 5°7'17.000' South Latitude and 120°23'34.000' East Longitude.

Seagrass area is the two-dimensional scale or size of seagrass beds which are part of the earth's surface with clear boundaries. The software used in this research was Google Earth Pro with a recording date of January 09th 2014 and April 21st 2021 and ArcGIS (for making spatial data bases and maps). The area of seagrass was obtained through on-screen digitization using ArcGIS software in seagrass areas whose boundaries were known. Digitizing with ArcGIS was conducted by enlarging the seagrass area in the image that was previously downloaded on the Google Earth Pro application. Google Earth Pro is capable of provide imagery with very high spatial resolution very high spatial resolution, relatively up-to-date, and can be accessed for free. After performing radiometric and geometric corrections, digitization was performed to create a shapefile (shp) storing the location, shape, and attributes of the geographic features. After the entire seagrass area was digitized perfectly and the area was obtained, the data was then stored in one folder to make processing easier. Furthermore, maps and seagrass area data then would be obtained.

Calculation of the change rate of seagrass distribution area can be processed using the Siregar and Purwanto formula namely:

$$\Delta L = \frac{(Lt2 - Lt1)}{Lt1} x100\%$$

ΔL = area change rate (%)
Lt1 = total area in the first observation year (ha)
Lt2 = total area in the second observation year (ha)

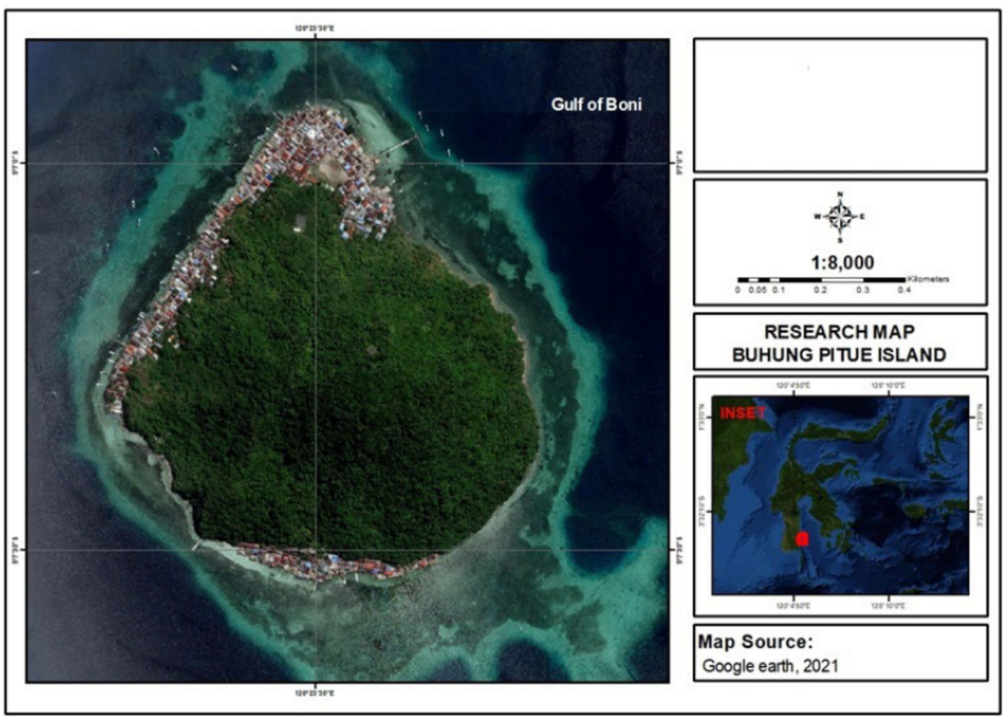



Figure 1. Research location image

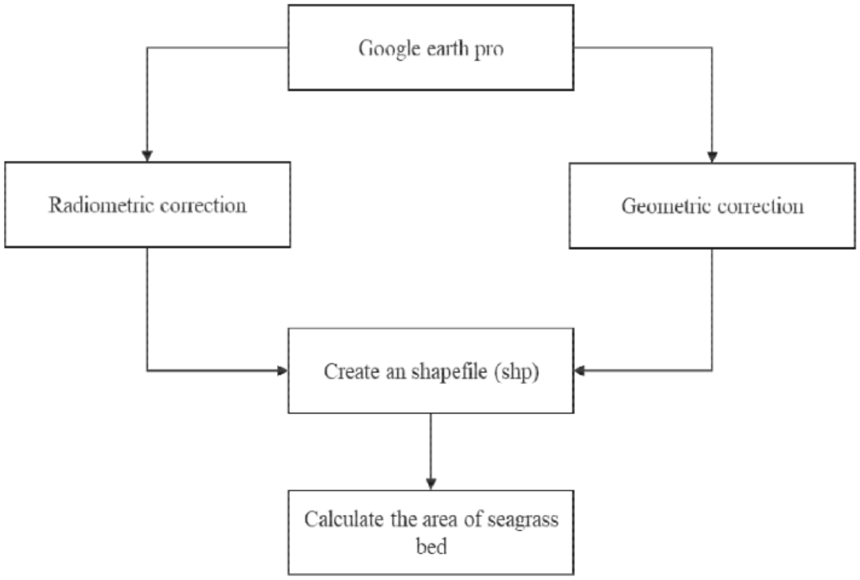
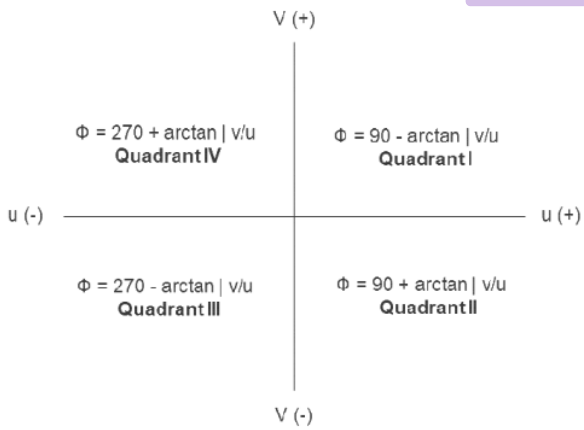



Figure 2. Flowchart for calculating seagrass area




In calculating the velocity and direction of surface currents, the equation :

$$c = (u^2 + v^2)^{1/2}$$

c = current speed (m/s)
u = speed of seawater towards the east (m/s)
v = seawater velocity towards the north (m/s)

To see the pattern of wind direction and can find out the mechanism of surface current formation in the waters can use the formula:

Φ = current position / current direction
u = speed of seawater towards the east (m/s)
v = seawater velocity towards the north (m/s)

## 3. Results and Discussion

### Radiometric Correction

Radiometric correction is used to improve the quality of the appearance of objects on satellite imagery, namely by correcting pixel values that do not match the value of the spectral reflection or emission of actual objects on the earth's surface, namely by adjusting band 123. The corrected image as a whole looks brighter and clearer in shallow water and land.

### Seagrass Distribution Area

The distribution area of seagrass beds in the waters of Buhung Pitue Island, Sinjai Regency was obtained through on-screen digitization in the arcgis software from Google Earth Pro imagery and saved in shp (shapefile) format without the need for field sampling. Google Earth Pro is capable of provide imagery with very high spatial resolution very high spatial resolution, relatively up-to-date, and can be accessed for free (Hu et al., 2013). The level of accuracy of seagrass distribution using this method depends on the image downloaded. If the

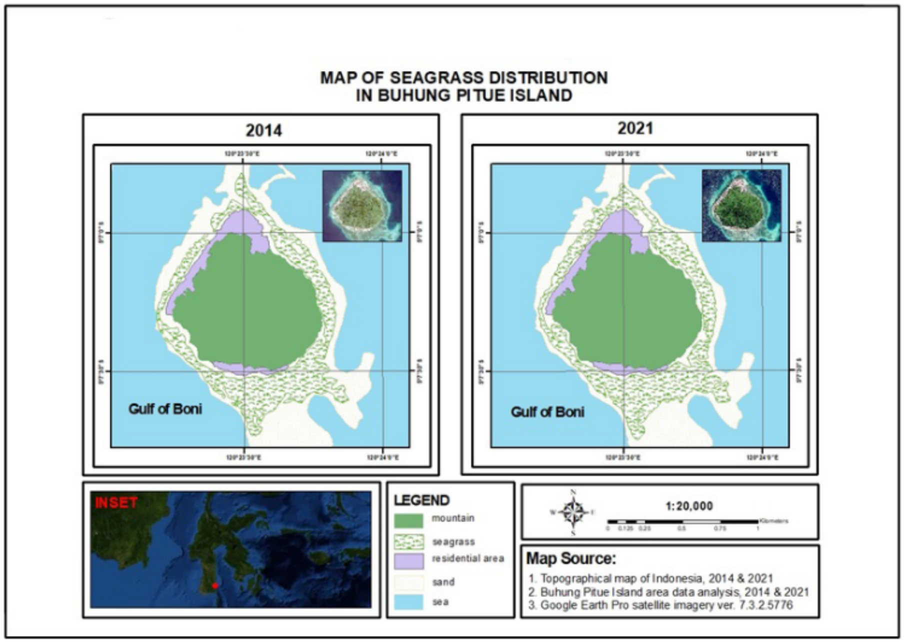



Figure 3. Map of seagrass distribution Buhung Pitue Island 2014 & 2021

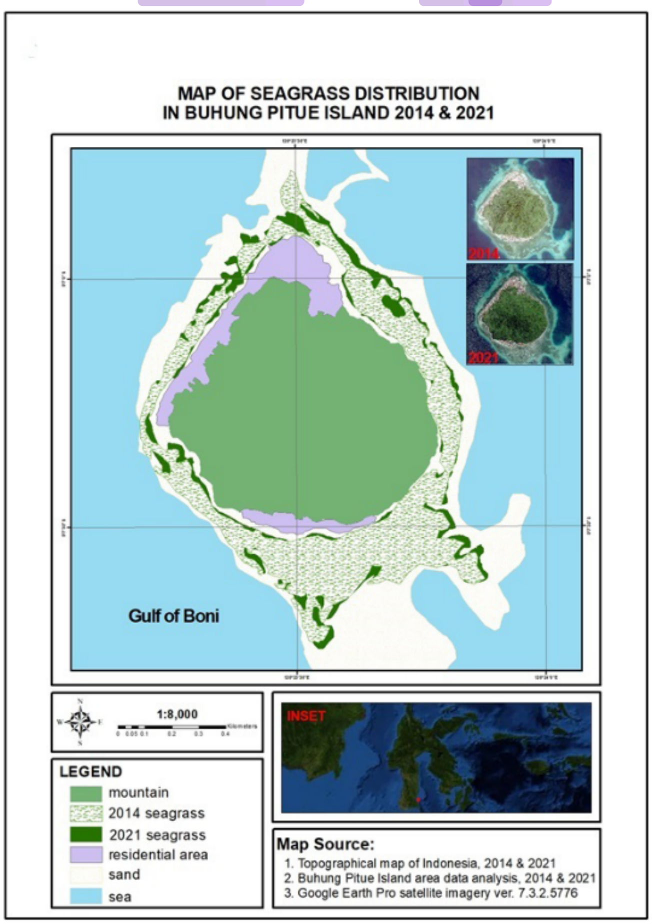



Figure 4. Map of seagrass distribution in 7 years

Table 1. Distribution area of seagrass bed in Buhung Pitue Island

| Type | Area (Ha) | | | Rate of change (%) |
|---|---|---|---|---|
| | 2014 | 2021 | Area change | |
| Seagrass | 36.5 | 39.6 | 3.1 | 0.09 |

image of seagrass scattering has high resolution and looks clear, then the output level of imaging accuracy will also be high. Buhung Pitue Island images in 2014 and 2021 were available in 8192 x 4925 (8K UHD) resolution, in which this resolution is the maximum resolution in Google Earth Pro imagery. According to Maras (2015), the result of the RMS error for geometric correction of Google Earth satellite imagery was 0.142588 (acceptable). This result meets the requirement of Root Mean Square Error (RMSE), which is ≤ 1 pixel, so that the geometric correction process for Google Earth satellite image was in accordance with the earth's coordinate system. The results of the map of the distribution area of seagrass can be calculated from the digitization on the screen. Buhung Pitue Island, Sinjai Regency had a seagrass distribution area of 36.5 Ha in 2014 and of 39.6 in 2021 (Figure 3).

The distribution of seagrass distribution over a period of 7 years (from 2014 to 2021) can be seen in Figure 4. The dark green color shows the distribution direction and cover area of seagrass on Buhung Pitue Island, Sinjai Regency.

Based on the results in Table 1, the distribution area of seagrass in the waters of Buhung Pitue Island in 2021 was 395,561 m² (39.6 ha). This shows an increase in seagrass distribution area compared to 2014, which was 365,177 m² (36.5 ha). The natural conditions on Buhung Pitue Island were quite good, so seagrass could grow well and its distribution was expanding every past year. The rate of change in area from 2014 to 2021 was of 0.085% (an increase of 3.1 ha) over a period of 6 years. This is quite high on a small island (2.15 km²) in a relatively short span of time (only 7 years).

The distribution rate of seagrass beds on Buhung Pitue Island for 7 years can be explained by the factors influencing this distribution. According to Ondiviela et al. (2014), the internal factor for the distribution of seagrasses is the ability of seagrasses to reproduce. For example, seagrasses spreading their seeds a few centimeters below the surface of the sediment are *Halophila* and *Cymodocea*, while seagrass seeds and fruits that are in the water column are *Thalassia hemprichii* and *Enhalus acoroides* (which can spread within 3 meters to 15 meters). Environmental conditions such as the uneven quality of nutrients and substrates lead to an even distribution of seagrasses in all places (Mananglakangi et al. 2022; Fitrian et al. 2017; Nugraha et al. 2021; Houngnandan et al. 2020).

According to Asmus et al. 2018; Whitfield 2017, seagrass species *Enhalus acoroides* and *Cymodocea rotundata* dominate (high distribution), with a total percentage of 32% on Buhung Pitue Island. This is thought to be related to the adaptability of this type of seagrass to the environmental conditions of the waters of Buhung Pitue Island. Therefore, the distribution of seagrass on Buhung Pitue Island can be said to increase from 2014 to 2021 due to the many types of *Enhalus acoroides* seagrass that grow and spread over long distances. *Enhalus acoroides* grows well on mud, sand and coral rubble substrates. However on muddy substrates, *Enhalus acoroides* has a higher growth rate compared to the growth rate on sandy substrates and coral rubble (Tuahatu et al. 2016; Clarito et al. 2020). the research which stated that the type of substrate on Buhung Pitue Island in the north and southwest is sandy, while muddy substrates are found in the eastern part of the island.

Another factor affecting seagrass growth is the density of human activities and ship activities (Xu et al. 2020; Madin et al. 2015; Sondak and Kaligis 2022). This resulted in the growth of seagrass distribution on Buhung Pitue Island which was quite low in 2014. In that year, there was a pier in the northern part of the island which became the center of ship activity on this island. However, at the end of 2019 when the covid-19 pandemic was imposed and a lockdown was imposed, not much activity was taking place on the island. This condition has a very positive effect on environmental conditions, such as reducing gas emissions, reducing pollutants, improving air and water quality in cities, and reducing ship activity (Menhat et al. 2021; Alqasemi et al. 2021), so that the area of seagrass in the wharf area spreads drastically compared to other areas on Buhung Pitue Island. As a result of the lockdown, seagrass conditions have also been maintained and have increased in area. According to Ceccherelli et al. 2014; Grech et al. 2012; McCloskey and Unsworth et al. 2015; Duarte et al. 2013; Brodie et al. 2020, areas that have been disturbed by human activity have the smallest percentage of seagrass cover. Seagrass cover will be higher in natural areas. This is supported by the opinion of Harah et al. (2013) which states that the decrease in the area of seagrass beds in the world is the impact of environmental pressures, both natural and the result of human activities (Murphy et al. 2022; Unsworth 2018; Ng et al. 2020).

## Physical Properties of Seawater

The condition of the aquatic environment affects all forms of life in it, both directly and indirectly (Thushari and Senevirathna 2020; Islam and Tanaka 2004). The parameters used for water quality on Buhung Pitue Island, Sinjai Regency included temperature and current speed. Temperature analysis was carried out using data from NASA Ocean Color, while current velocity used data from Marine Copernicus.

### Sea Surface Temperature (SST)

The highest temperature occurred in November with a temperature of 31.7°C and the lowest temperature occurred in August with a temperature of 29.1°C (Figure 5), where this temperature range exceeds the optimal range of seawater quality standards (Kepmen LH No. 51 Year 2004), namely ranges from 28 °C - 30 °C. According to Savva et al. 2018; Nguyen et al. 2021, the optimal temperature range for the development of seagrass species is 28 °C  30 °C and the tolerance range is between 26 °C - 36 °C. In addition, for the process of photosynthesis and respiration, seagrass requires an optimum temperature between 25°C to 35°C (Collier et al. 2017; Collier et al. 2018). Thus, the measured temperature is still feasible for seagrass growth because the temperature is still within the seagrass tolerance range (Koch et al. 2013; Artika et al. 2020; Pazzaglia et al. 2022). The value of sea surface temperature on Buhung Pitue Island per month can be seen in Figure 5. The highest temperature started from October to April. This period was the period of the dry season and the rainy season, which started from April to October. However, the difference in dry season and rainy season temperatures in this area was not too significant because the temperature during the rainy season was also quite high, which was only around 29°C.

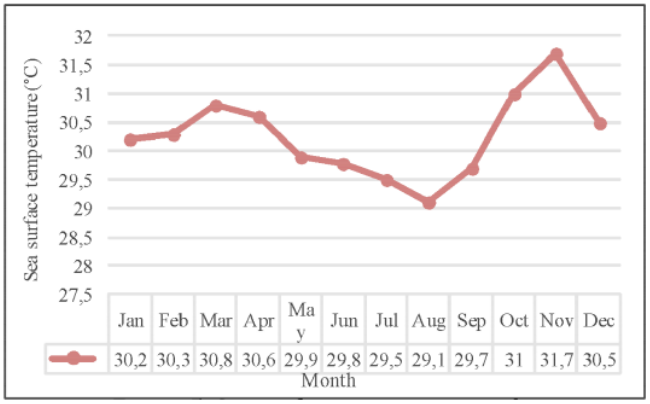



Figure 5. Sea surface temperature values

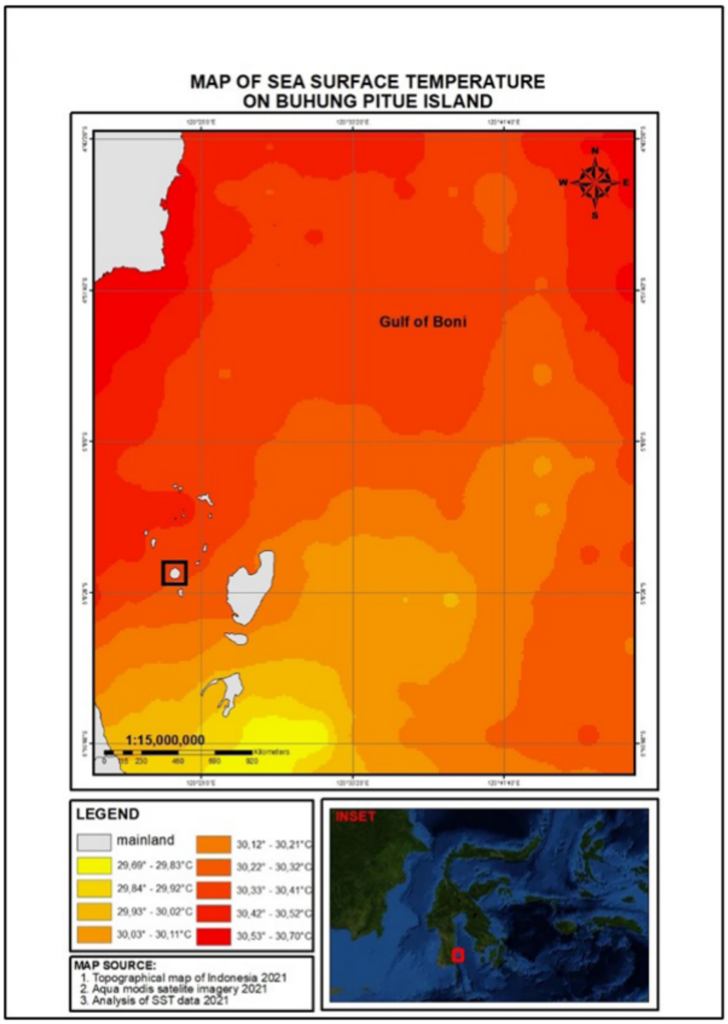



Figure 6. Map of SST on Buhung Pitue Island 2021

Temperature is one of the most influential environmental factors on the survival of seagrasses (Chefaoui et al. 2016; Zimmerman 2021). High temperatures are marked in orange and low temperatures are marked in yellow, with values ranging from 29.7 °C to 30.7 °C. Based on Figure 6, Buhung Pitue Island waters in 2021 had a relatively high sea surface temperature, because these waters were in the 7th class out of 9 class classifications, with a temperature value of 30.37 °C. Seagrass cannot tolerate temperatures that are too high as a study conducted by Collier and Waycott (2014). The study shows that temperatures that are too extreme can cause a decrease in leaf density and mortality in seagrasses (McKenzie et al. 2021). These events vary for each seagrass species, depending on the level of sensitivity of the seagrass species to extreme water temperatures (Thomson et al. 2015). Seagrass itself has the ability to adapt to high water temperatures, namely maintaining moisture by staying near areas of sediment and evaporation. Sea surface temperature is affected by physical factors such as solar heat, surface currents, cloud conditions, upwelling, divergence and convergence in estuaries and coastlines. Meteorological factors also influence sea surface temperatures such as rainfall, evaporation, air humidity, air temperature, wind speed and solar radiation intensity (Short et al. 2016; Bal and Minhas 2017).

## Current Speed and Direction of Seagrass Beds

The speed of currents in seagrass beds has a very significant effect on the supply of nutrients and dissolved gases in seagrass plants (Egea et al. 2018). Current can also dislodge metabolic by product and waste that can affect the primary productivity of seagrass plants. One of the current generating factors is the wind. Surface currents in the waters are generally influenced by monsoon wind patterns.

The data shows that the highest current speed occurred in November, namely 0.122 m/s, while the lowest current speed occurred in December, namely 0.04 m/s. This can be seen in Figure 7. Overall, the condition of the water currents was a rather slow current condition because it was only around 0.1 m/s for the annual temperature, where according to Kumar et al. 2019, the current speed is categorized as fast in the range of 0.5 m/s to 1 m/s and slow in the range of 0.01 to 0.25 m/s. Currents or water movements greatly determine the growth of aquatic plants, both those that float and those that stick to the bottom of the waters. Very high current speeds and strong turbulence can result in an increase in suspended solids which leads to a reduction in the penetration of light into the water or a decrease in the brightness of the water. This condition can cause a low rate of seagrass production (Hansen et al. 2013; Liu et al 2019; Ruiz-Montoya et al. 2015). However, Rappe (2022) stated that *Enhalus acoroides* seagrass is able to adapt well to different conditions because this type of seagrass has strong roots to withstand currents and supports better nutrient absorption compared to other types of seagrass. Therefore, the growth is relatively faster. Wicaksono and Hafizt (2013) added that *Enhalus acoroides* can dominate seagrass communities because this type of seagrass forms pure vegetation even though it grows close to other species.

Seagrasses also need currents to wash away the sediment that sticks to them. Therefore, the current speed on Buhung Pitue Island is quite vulnerable because it is too slow. The speed of water currents affects the productivity of seagrass beds. Current with a speed of 0.5 m/s can support seagrass growth properly (Carr 2016; Reidenbach and Thomas 2018). Current speed can affect the distribution of seagrass and the process of attaching seagrass roots to the sediment. Current speed in the waters can affect the productivity of seagrass beds. Current has a very important role for seagrass ecosystems to clear sediment or stuck muddy sand particles (Zhang et al. 2020; Silvi 2022; Pivato et al. 2020).

The pattern of current movement in the waters of Buhung Pitue Island can be seen in Figure 8. In the west season (December – February), the current moves north and in the east season (June – August), the current moves south. Between the two seasons, there is a transitional season where transitional season 1 occurs in March – May. In that period, the current moves to the south. Furthermore, transitional season 2 occurs in September – November, where the current moves to the north. Therefore, the distribution of seagrass on Buhung Pitue Island spreads to the north and south of the island because there are two factors that cause an increase

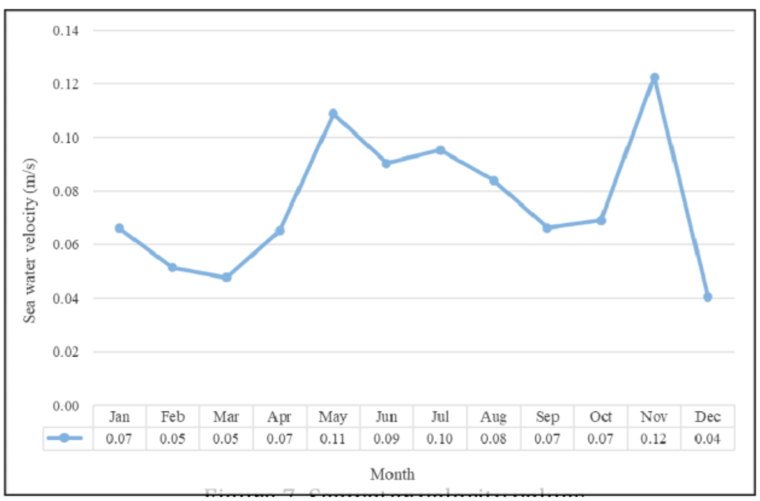



Figure 7. Seawater velocity values

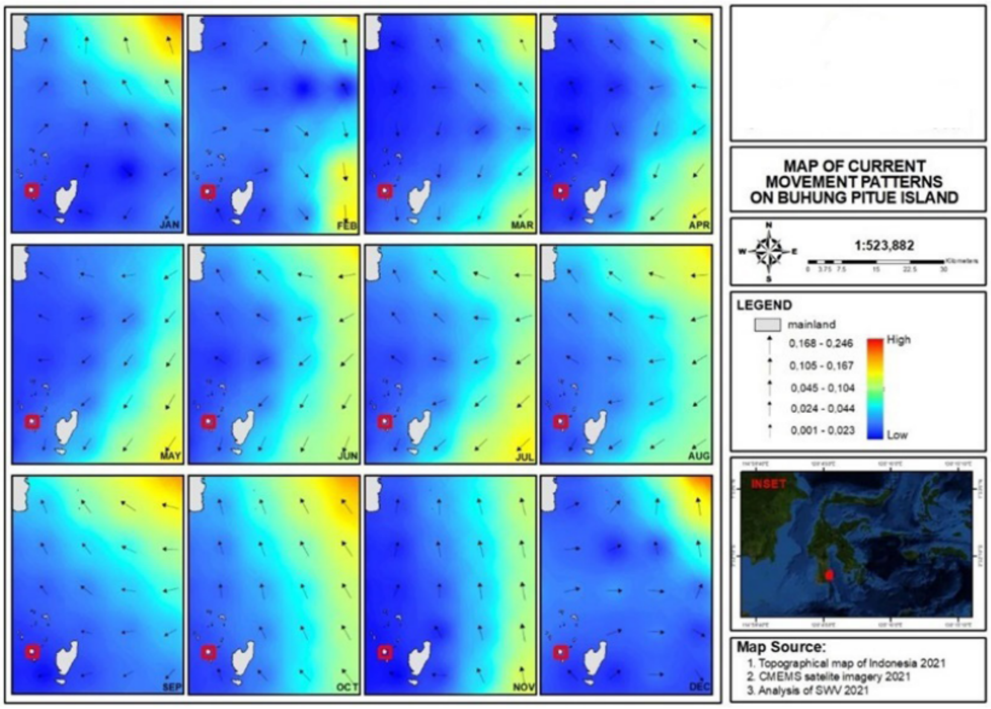



Figure 8. Map of current velocity and movement patterns on Buhung Pitue Island

or decrease in the distribution of seagrass beds in a location abiotically. According to Ruiz-Montoya et al. (2015), current and wind are the causes of carrying seagrass seeds from one place to a new place, so that the spread of seagrass can increase or decrease.

Based on the results of current observations carried out for 1 year on Buhung Pitue Island from CMEMS (Copernicus Marine Environment Service), the current direction on Buhung Pitue Island was heading south towards Java Island and the Bali Strait, with speeds reaching 0 to 0.014 m/s. The direction of this current resulted in an increase in the area of seagrass beds on Buhung Pitue Island, Sinjai Regency.

## 4. Conclusion

The seagrass distribution area of Buhung Pitue Island in 2021 was 395,561 $m^2$ (39.6 ha), where the seagrass distribution area had increased compared to 2014, which was 365,177 $m^2$ (36.5 ha). The highest sea surface temperature occurred in November with a temperature of 31.5 °C and the lowest temperature occurred in July with a temperature of 29.6 °C. The average annual temperature in 2021 was 30.37 °C. Current speed in the waters of Buhung Pitue Island was categorized as slow because it was only in the range of 0.01 m/s. The highest current speed was in November, namely of 0.122 m/s. The lowest current speed occurred in December (i.e. 0.04 m/s) with the current heading south towards Java Island and the Bali Strait. The rapid development of satellite sensor technology today, especially the high spatial resolution of Google earth Pro can improve the quality of seagrass distribution maps. However, in the future accuracy tests still need to be carried out to assess the accuracy of the position of the coordinate points resulting from orthorectification on the image against the position of these coordinate points on the ground.

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**Article Error** You may need to use an article before this word. Consider using the article **the**.

**Missing ","** Review the rules for using punctuation marks.

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**Wrong Article** You may have used the wrong article or pronoun. Proofread the sentence to make sure that the article or pronoun agrees with the word it describes.

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**Confused** You have used either an imprecise word or an incorrect word.

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Article Error You may need to remove this article.

Run-on This sentence may be a run-on sentence.

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**Proper Nouns** You may need to use a capital letter for this proper noun.

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**Prep.** You may be using the wrong preposition.

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