Seagrass distribution using remote sensing along the Ujunggenteng Coastal, Sukabumi

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Abstract. Seagrass beds play an important role in marine ecosystems, primarily as a habitat that supports marine life. This study was undertaken to address the lack of available research regarding changes in seagrass density from year to year along the Ujunggenteng coastal, which is necessary to preserve seagrass beds in this area. More specifically, the purpose of this study was to determine the distribution of seagrass beds along the Ujunggenteng coastal and analyze their physical characteristics over a sixteen year period, from 2000–2016. The method used remote sensing technology that is used to look at the distribution of seagrass beds by performing calculations based on Lyzenga algorithms. Based on the results of data processing, seagrass in the study area was found to be distributed on three coral reefs. From year to year, the area of seagrass along the Ujunggenteng coastal appeared to increase. The physical characteristics affecting the distribution of seagrass along the Ujunggenteng coastal were found to be sea surface temperature, salinity, and depth of sea water, and the physical characteristics that did not affect the distribution of seagrass were currents and sea water transparency.

Keywords: Lyzenga, physical characteristics, remote sensing, seagrass

1. Introduction

Seagrasses are marine flowering plants that are widely distributed along the world’s temperate and tropical coastlines. To facilitate a global assessment of their distribution, seagrass species have been grouped into six bioregions [1]. They play a vital role in maintaining marine and coastal ecosystems. They perform numerous functions, including maintaining biodiversity, improving resilience of coastal environments, stabilizing the sea floor, producing organic carbon by sequestration, providing habitat for fish and vulnerable species, and supporting local economies in coastal regions [2]. These habitats are threatened by anthropogenic and natural impacts necessitating active monitoring and management [3].

One important seagrass region is in Indonesia along the Ujunggenteng coast located in Ujunggenteng Village, Ciracap District, Sukabumi Regency, West Java. The Ujunggenteng coast has a shallow beach and large waves. Seagrass beds can breed well near these beaches. The seagrass beds in Ujunggenteng are dominated by Thalassia sp, although there is limited data regarding how much of the seagrass cover is found on the south coast of West Java, which includeds the Ujunggenteng coast. The type of seagrass found along the Ujunggenteng coast generally grows above the reef flats. The percentage of seagrass cover along Ujunggenteng coast ranges from 10–15 %, and the average seagrass height in these beds is 20 cm. The growth of seagrass along the Ujunggenteng Coast is not optimum due to a variety of external factors that influence the growth of seagrass.
Seawater is different locations has different characteristics, both physically and chemically. Physical and chemical characteristics that affect the growth of seagrass include sea surface temperature, salinity, ocean currents, depth, and sea transparency. These five characteristics can change over time. The existence of such changes affects the spread of seagrass along Ujunggenteng coast.

This research was undertaken because there is a limited amount of published information regarding the spread of seagrass beds from year to year in this region. Seagrass dispersal information is needed to preserve seagrass beds along the Ujunggenteng Coast due to the important role of seagrass beds in marine ecosystems. If rapid mapping of seagrass habitats over a large area extent is desirable, then remote sensing technology using aerial and satellite sensors has proven to be more cost-effective than field survey [4]. During the past few decades, many methods have been developed to map and monitor seagrass habitats in shallow coastal waters, including the utilization of optical remote sensing. In conjunction with field survey monitoring, traditional remote sensing methods primarily relied on the use of aerial photography and moderate-resolution multispectral satellite image data, which includes Landsat Multispectral Scanner (MSS), Thematic Mapper (TM)/Enhanced Thematic Mapper Plus (ETM+), and Satellite Pour l’Observation de la Terre (SPOT) image data [5].

2. Methodology

This study utilized a regional approach in systematic geography with remote sensing. More specifically, this methodology included the interpretation of processed satellite imagery landsat-5 TM, landsat-7 ETM+, and landsat-8 OLI downloaded from http://earthexplorer.usgs.gov. The downloaded image was an image taken during the dry season (9th May 2000, 31st July 2004, 26th July 2008, 9th August 2013, and 2nd September 2016). The quantitative method of combining data variables that affect distribution of seagrass and scientifically comparing the stages of research was employed as part of this study. Variable used in this study included ocean current data sourced from website http://earth.nullschool.net, depth of seawater sourced from the Badan Informasi Geospasial (BIG), sea surface temperature, salinity, sea water transparency and seagrass distribution. Sea surface temperature and salinity data was obtained by field survey at 30 different sample locations, which was then validated with data obtained from other sources. After determine the list of variables, the steps of collecting and processing data in this study were as follows:

1. In the processing of satellite imagery for seagrass mapping, there are several methods that can be used, one of which is the Lyzenga algorithm. Lyzenga's analysis was used to analyze shallow waters [6]. However, before the Lyzenga algorithm could be applied, the data was converted to top of atmosphere (TOA) reflectance and corrected for atmospheric effects [7]. Procedures of the Lyzenga method are as follows:
   a. Determine the value of \( \frac{K_i}{K_j} \) by creating a training site. The training site was created using an image processing application. After the training site was created, the value appeared from band 1 and 2. The value was then processed using excel to find the value of variant and covariant of each band. Next the value of \( a \) was determined with the (1):

   \[
   a = \frac{(\text{varTM}1 - \text{varTM}2)}{2 \text{ cov arTM}1 \text{TM}2}
   \]  

   where the formula for finding \( \frac{K_i}{K_j} \) is:

   \[
   \frac{K_i}{K_j} = a + \sqrt{(a^2 + 1)}
   \]  

   b. Determine the value of land and sea boundaries. The values of land and sea boundaries were obtained from viewing pixel values in band 4.
   c. The Lyzenga algorithm was then used:

   \[
   y = [\log(b1)] + [\text{nilai} \frac{K_i}{K_j} \log(b2)]
   \]
After using the Lyzenga algorithm, the treated image that was generated had colors corresponding to different characteristics. Yellow corresponds to sand, cyan or green firmly corresponds to the living coral reef, red is dead coral, cyan or blue depicts areas with high turbidity, and the brown areas are the seagrass. After using these colors for identification, the territory of seagrass beds was digitized. Digitization was done to delineate the extent of seagrass and non-seagrass areas.

2. The temperature value was determined by using the formula:

\[ T = \frac{K^2}{\ln(K1/\mu + 1)} \]  \hspace{1cm} (4)

3. The algorithm of Cimandiri by [8] was used in this research to determine the salinity value in accordance with the equation below:

\[ \text{Salinity} = 29.983 + 165.047 \times (B2) - 260.227 \times (B3) + 2.609 \times (B4) \]  \hspace{1cm} (5)

4. To validate the salinity data, direct measurements were made in the field. The validation process in the field was important to validate the results obtained from the model [9]. The salinity data that was obtained from the field survey results was then processed into tabular data. Tabular data in the form of the salinity value was taken from the sample point specified along the Ujunggenteng coast. The salinity value was then calculated using a refractometer. The data was processed using map processing software to produce a salinity value map of the research area. The salinity maps were classified into areas suitable for growing seagrass.

5. Marine current data was obtained through the website http://earth.nullschool.net. On the website, the speed of currents in the research area were obtained. This data was then processed into tabular form, then converted into a map of ocean currents.

6. Seawater depth data was obtained from Geospatial Information Agency, then processed into a depth map of sea water or bathymetry. Seawater transparency (or clarity) was obtained from Total Suspended Solid (TSS) processing of the image. The low TSS value signifies the clear sea water condition. To find the value of TSS, the Budhiman algorithm [10] was used (6):

\[ \text{TSS (mg/L)} = 8.1744 \times \exp (23.738 \times \text{Red Band}) \]  \hspace{1cm} (6)

3. Results and discussion

From 2000 to 2016, the extent of seagrass beds covering the shallow seafloor along the Ujunggenteng coast was constantly changing. In the year 2000, seagrass beds was more scattered in the northern coral reefs, and this was also true in 2004 and 2013. In 2008 seagrass beds were mostly scattered in the southern coral reefs, whereas in 2016 seagrass beds were spread evenly across the three coral reef areas (figure 1). Changes in the extent of seagrass cover can be affected by the physical characteristics of the Ujunggenteng coastal with variables sea surface temperature, salinity, ocean currents, and sea water depth. Based on image processing result, the extent of seagrass in Ujunggenteng coast appears to have increased over this period, then declined from 2013 to 2016 (table 1).

The ideal temperature range for the seagrass habitat is 28–30 °C. Field survey results indicated that the temperature at 30 sample points in the study area ranged from 28-33 °C. In addition to the field survey, sea surface temperature in the waters off the Ujunggenteng Coast are also estimated from image processing. In 2000 and 2004 sea surface temperature was dominated by a range of 28–30 °C. In 2008, 2013 and 2016, sea surface temperatures were dominated by temperatures that were less than 28 °C. In the coral reef area, from 2000 to 2016, the dominant sea-level temperature was 28–30 °C, which is an appropriate temperature range for seagrass growth (figure 2). Based on the overlay of the seagrass distribution map with the sea surface temperature map, it can be seen that sea surface temperature
influences the distribution of seagrass beds. From 2000–2016, over 89 % of the seagrass cover had a direct correlation to sea surface temperature.

Under the terms of growing seagrass, the suitable salinity to be seagrass habitat is 24–35 %. Based on the result of field survey of salinity value in Ujunggenteng Coast waters ranged from 20–30 %. In addition to the field survey, the salinity value of Ujunggenteng Coast waters is also seen from the results of satellite image processing. In 2000, 2004, 2008, 2013, and 2016 the predominant salinity value was 24–35 % (figure 3). When the seagrass dispersion map and the salinity map are overlain, it is clear that salinity affects the distribution of seagrass beds. From 2000–2016 over 50 % of the seagrass cover was associated with salinity values in the predominant range.

Sea currents suitable for seagrass growth generally have a velocity around 0.5 m/s. Based on data from earth.nullschool.net website, the speed of ocean currents in Ujunggenteng Coast waters in 2013 ranged from 0.09–0.40 m/s and in 2016 ranged from 0.05–0.37 m/s. In accordance with the data in August 2013, seagrass beds still grew well, although the current velocity was less than 0.5 m/s (est. 0.29 m/s). Similarly, the current velocity in September 2016 was 0.22 m/s, but the growth of seagrasses was not impaired. So when the current velocity in Ujunggenteng Coast waters averaged below 0.5 m/s, the growth and spread of seagrass was not affected.

![Distribution of seagrass along the Ujunggenteng Coast based on image processing and analysis.](image1)

**Figure 1.** Distribution of seagrass along the Ujunggenteng Coast based on image processing and analysis.

| Image date       | Extent          |
|------------------|-----------------|
| Seagrass (ha)    | Non-seagrass (ha) | Seagrass (%) | Non-seagrass (%) |
| 9th May 2000     | 76.58           | 105.30       | 57.90            |
| 31st July 2004   | 88.12           | 93.76        | 51.55            |
| 26th July 2008   | 87.56           | 94.32        | 51.86            |
| 9th August 2013  | 107.38          | 74.50        | 40.96            |
| 2nd September 2016 | 97.10          | 84.77        | 46.61            |

**Table 1.** Distribution of seagrass along the Ujunggenteng Coast based on image processing and analysis.
Figure 2. Sea surface temperature along the Ujunggenteng Coast based on image processing and analysis.

Figure 3. Salinity in Ujunggenteng Coast based on image processing and analysis.

In Ujunggenteng coastal waters have a depth ranging from 0–30 m, but the research area of sea water depth ranged from 0–5 m (figure 4). The depth is appropriate for the growth of seagrass. The field survey results, the transparency (or clarity) of sea water can be seen of evaluated using TSS processing on Landsat images. Based on the results of TSS processing of images from 2000, 2004, 2008, 2013 and 2016, the dominant TSS value was between 20–40 mL (figure 5). From the TSS data processing, it can be seen that although TSS value exceeds the requirement value of seagrass growth, seagrass beds still grow well. This suggests that TSS in this study did not affect the spread of seagrass beds.
4. Conclusion
Seagrass distribution along the Ujunggenteng Coast is influenced by physical characteristics, such as sea surface temperature, salinity, ocean currents, sea water depth, and sea water clarity. Based on the analysis of these five characteristics, sea surface temperature, salinity, and sea water depth affected the spread of seagrass, while ocean currents and sea water transparency did not. In 2000, seagrass beds were mostly scattered in northern coral reefs that had sea-level temperatures, salinity and seawater depths corresponding to the ideal conditions for seagrass habitat, which was also true in 2004 and 2013. In
2008 and 2016 seagrass beds were spread evenly across the three coral reef areas. Based on data collected in 2000, 2004, 2008, 2013 and 2016, the percentage of seagrass area in the coral reef area along the Ujunggenteng Coast generally displayed an increasing trend.

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