PLATFORM REEF LAGOON DETECTION FROM SENTINEL-2 IN PANGGANG ISLAND AND SEMAKDAUN ISLAND, SERIBU ARCHIPELAGO, JAKARTA

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Abstract. Processing of satellite image data for the detection of platform reef lagoons is intended as one of the geo-physical parameters of the reef landform. Panggang Island and Semakdaun Island, Seribu Archipelago, Jakarta were chosen to make the detection model because they are ideal for lagoon reef landforms and tapulang court reefs. This model is only valid in the continental shelf area and the back arc and small island tectonic type. Determination of this location is done to improve the accuracy of spectral-based data processing. Platform reefs are one of four classes of reef landforms. Sentinel-2A data with a spatial resolution of 10m, blue, green, red, and near infrared bands were selected to investigate their ability to detect lagoons. Processing of data by calculating the Optimum Index Factor (OIF) to produce a composite image and drawing transect lines to produce pixel values and spectral graphics of the lagoon. The results of data processing in the form of graphs, composite images and pixel values were built to realize a digital lagoon detection model. These results are used for lagoon growth stage analysis for the classification of three platform reef landforms, visually and digitally interpretation. This digital and visual detection system design is useful for monitoring coral reef ecosystems.

Keywords: *Lagoon, platform reef, remote sensing, spectral, coral reef*

1 INTRODUCTION

Coral reefs are being degraded worldwide (Bellwood et al., 2004). 19% of coral reefs are lost and 75% are threatened in 2011 (Burke et al., 2012) due to threats from natural conditions (CO2 levels increased through global warming and ocean acidification) and anthropogenic (coastal development, overexploitation, overfishing and damaging, and waste) on a regional and global scale (Wilkinson, *et al.,* 2008). This makes reef lagoon detection modeling for landform classification important in order to assess the impact of disturbances and efforts to restore/reduce degradation

Reefs are a landform that built from coral and calcareous algae. Reef landforms are grouped into 3, namely fringing reefs, barrier reefs and atolls (Selby, 1985). While Maxwell, (1968) referred to Zuidam, (1985), the three groups are called oceanic reefs and there are other groups of shelf reefs.

The Faculty of Geography UGM and Bakosurtanal in 2000 adopted the Maxwell classification, which includes the classification of landforms of organic origin. This classification is based on the origin of the formation (genesis) of landforms using relief/topography parameters, geological/rock structures, geomorphological processes, and the level of geomorphological processes acting on the landform(Table 2-1). The balance of the direction of organic landform development is controlled by hydrological, bathymetric, and biological factors. The balance of these three factors will produce a lagoonal platform reef, but if it is influenced by bathymetry, it forms an elongated platform reef (Asriningrum, 2009). The platform reef is one of the four classes of landforms and is the focus of this study. Lagoon are marine waters that form inside reefs.

Areas within the lagoon have high productivity in the fisheries sector (Anthony et al., 2009). The lagoon is a source of community livelihood and as a provider of ecosystem resources and services, so that the lagoon can be used as a complex socio-ecological system for life in nature (Newton et al., 2014). The high utilization of this ecosystem has the potential to cause resource degradation (Louhenapessy, 2019), so that the sustainable planning and management efforts are necessary in order to maintain the coral reef ecosystems. The lagoon detection model can be used for monitoring reef changes quickly and effectively.

Spatial information related to the composition, condition, and dynamics of coral reefs at appropriate spatial scales and relevant forms, is a fundamental requirement for understanding and managing coral reefs. Meanwhile, the classification of coral reefs is based on geomorphology which produces maps of 15 geomorphic zones and benthic communities for each reef using the OBIA method from Quickbird-2 image data and benthic surveys. This approach is to produce coral reef maps with more relevant classes by integrating the structures, biological and geomorphic processes that make up coral reefs (Phinn et al., 2012). One of the challenges in detecting coral reef cover is the complex and heterogeneous nature of the coral reef environment (Joyce & Phinn, 2013). Therefore, this conditioning lagoon detection study is intended to support productivity that suppresses heterogeneity.

Provision of accurate coral reef maps where the scale and labels are mapped according to the mapping unit to identify biological and geomorphic structures and processes is a major challenge for remote sensing (Mumby et al., 2004); (Andréfouët, 2008), this is due to the complex nature of the coral reef environment and the limitations of the visual interpretation mapping approach and per pixel classification.

Research on the use of remote sensing technology for coral reef detection was initiated by Lizenga (1981), who mapped the bottom cover material of the North Cat Cay Bahamas from Landsat MAA images. Asriningrum et al., (2008), conducting research related to reef landforms by digitally processing data and visual detection. Research on similar groups has been carried out by (Asriningrum, 2009), related to the geomorphological analysis of reefs in Sikka Regency, where platform reef landforms are found on Pomana Island. (Louhenapessy, 2019) conduct research related to the analysis of zoning maps and the status of the lagoon ecosystem area using the GIS (Geographical Information System) and FGD (focus group discussion) approach methods that produce the location of the lagoon and its area. Digital data processing and detection need to be developed for the management of coral reefs and their ecosystems.

The state of the art of this research is that lagoon detection can guide reef landform classification. The breakthrough of this research is in lagoon detection as a geo-bio-physical parameter for reef landform classification using remote sensing data.

This research is designed to support the management of coral reefs based on remote sensing imagery, by building a lagoon detection model for the classification of platform reef landforms (Table 2-1). This model was built to be applied to the waters of continental shelf and back arc which is symbolized in yellow on the map (Figure 2-2), which is one of the grouping of small islands based on tectonogenesis (Pusat survei geologi, 2007).

2 MATERIALS AND METHODOLOGY

2.1 Location and Data

The research sites are located on Panggang Island and Semakdaun Island, Seribu Archipelago, Jakarta (Figure 2-1). These two islands are small tectonic islands (Asriningrum, 2009), with a platform reef landform. This location was chosen with consideration to be able to represent the landform platform reef in Indonesia.

The main data used in this study is Sentinel 2A Level 2 satellite image which has a medium resolution recording dated August 12, 2021. This data was obtained from the Sentinels Scientific Data Hub (Serco Italia SPA, 2019) and already atmospherically, radiometrically, and geometrically corrected.

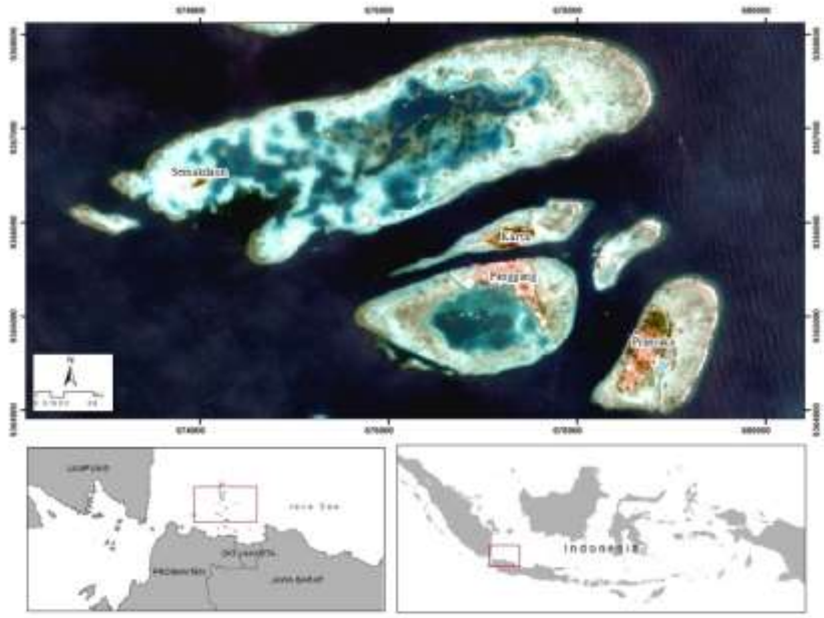


Figure. 2-1: Research locations on Semakdaun Island and Panggang Island, Seribu Archipelago

The supporting data used is the result of processing the Landsat-8 image recorded on April 22, 2022. The processing data for Landsat-8 is in the form of an RGB 613 composite image and a line transect graph as a comparison of the spectral value of the lagoon at 2 different types of resolution.

Bathymetric data were used for lagoon and non-lagoon validation. Data obtained from Allen Coral Atlas (Allencoralatlas, 2022). This data is the average depth value (cm) which is processed using Sentinel 2 image mosaic data in 2020.

2.2. Field Check

Field checks were carried out to validate spectral-based lagoons and non-lagoons in several conditions (deep and shallow lagoons).

Field check activities were carried out by measuring depth using a depth sounder meter, taking the coordinates of the location using a GPS device, and taking photos of the condition of the lagoon.

2.3 Platform reef Detection System Design

The system design is built to combine remote sensing technology satellite image data processing with the needs of coral reef management.

Of the three main objects of satellite imagery, this lagoon detection focuses on water, or there are no vegetation and vacant land objects. A lagoon is water in the middle of a reef. The characteristics of lagoon water and sea water are examined differently by displaying graphics, composite images and pixel values. This is the model for classification of reef landforms.

This research is the first year of the planned three years. This is a challenge for deep research, because the design of the system is aimed at creating a model that can be used by users of satellite imagery managing coral reefs.

The data used are medium spatial resolution satellite images such as Sentinel, on multispectral channels. Coral reef management is built from its framework in the form of reef landforms (Table 2-1).

Table 2-1: Classification of Reef Landforms

No	Platform reef	
	Scale 1:250.000	**Scale 1:50.000**
1	Platform Reef	Lagoonal platform reef Elongate platform reef Resorbed reef
2	Wall Reef	Cuspate reef prong reef
3	Plug Reef	Plug Reef
4	Oceanic Reefs	Fringing reef barrier reef atoll

Reference: Modified from Geography–UGM and Bakosurtanal, 2000.

The platform reef landform is in the continental shelf and back arc area (Peta Pengelompokan pulau kecil berdasarkan tektonogenesis, 2006) and in detail on tectonic type islands (Asriningrum, 2009) (Figure 2-2)

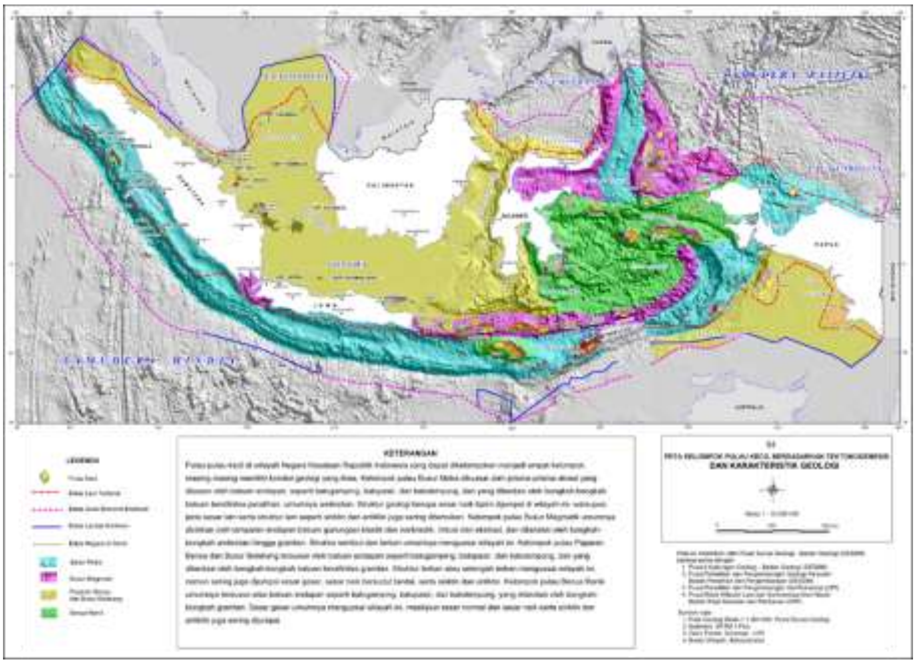


Figure 2-2: Small Islands Grouping Map Based on Tectonogenesis
Reference : (Pusat survei geologi, 2007)

2.4 Data Processing Method

This research produces lagoon and non-lagoon detection models in the platform reef landform class (Platform Reef). This reef class consists of 3 stages of lagoon conditions, including lagoon reefs (Lagoonal platform reefs) and tapulang (Resorbed reefs).(Table 2-1).

Analysis of lagoon and non-lagoon detection results using visual and digital interpretation methods on Sentinel 2A Satellite Imagery data. Lagoon and non-lagoon objects can be detected from the results of the transect line drawn at several locations and the value of the spectral graph results at Panggang Island and Semakdaun.

Cropping AOI

In general, the methods used in data processing consist of data pre-processing and image extraction. Data pre-processing starts from the AOI cropping process. Of the 13 channels in Sentinel 2A imagery, 4 channels were selected in this study, namely band 2 (blue), band 3 (green), band 4 (red), and band 8 (Near Infrared). The cropping results produce 1 process image scene that focuses on the study area, namely Panggang Island and Semakdaun Island, Seribu Archipelago.

Optimum Index Factor (OIF)

Optimum Index Factor (OIF) calculation is done to obtain the right combination of channels to visualize the significant differences between lagoons and non-lagoons. The process of calculating OIF by evaluating the correlation of each channel with the standard deviation that can produce the highest ranking, so that the selected band combination is produced. The OIF calculation process is carried out using the matrix correlation method at ILWIS with the following 2-1 equation:

$$OIF = \frac{\sum_{k=1}^{3} S_k}{\sum_{j=1}^{3} Abs\,(r_j)} \quad \text{..(2-1)}$$

Description :

S_k : Standard deviation of spectral values in the Abs band

(r_j) : The absolute value of the correlation coefficient between any two of the three bands

(Chavez et al., 1982)

The results of the OIF calculation obtained the best 5 channel combinations. Based on the results of calculations with matrix correlation, the highest ranking is obtained and one selected channel composite is obtained which will be used to extract the observed object

Sunglint Corection

The sunglint correction is carried out to minimize the reflection of the water column due to solar radiation on the object below which will have an influence on the pixel value, by utilizing the NIR channel which has the maximum absorption of water bodies (Mumby et al., 2004). The sunglint correction uses the application of the algorithm of (Hedley et al., 2005) in the following 2-2 equation:

$$R'_i = R_i - b_i(R_{NIR} - Min_{NIR}) \text{ ....(2-2)}$$

Description :
R'i : Glittered pixels on band i
Ri : The reflection of the band looks i
bi : Regression slope
RNIR : NIR band value
MinNIR : Minimum NIR value of the sample

Land and Sea Masking

The land sea masking process aims to highlight open water objects by eliminating land pixel values. The process is carried out by applying the results of the Normalized Difference Vegetation Index (NDVI) algorithm. NDVI based on NDVI is based on the observation that different surfaces reflect different types of light waves. The NDVI algorithm is presented in the following equation 2-3:

$$NDVI = \frac{(NIR-RED)}{(NIR+RED)} \text{......................................(2-3)}$$

(Maselli et al., 2020)

Composite Image

The next process is the composite band and selected composite selection results from the OIF calculation. 6 composites were made from the results of the highest ranking OIF, so that 1 selected composite was produced which was used for lagoon detection and spectral transect line drawing.

Transect line

The main process in this research is image extraction which aims to obtain spectral values that represent lagoon and non-lagoon objects on the platform reef landform, in this case using 2 locations, namely Panggang Island and Semakdaun. The processing starts from the selection of transect lines at several locations which aims to perform spectral sampling over the lagoon object.

The draw of the transect line begins by making one point in the open water near the coast and then drawn straight until the lagoon is closed and ends at the second point in the open water. The transect line was taken 1 time horizontally and 2 times vertically on each island. The total line transects produced are 6 lines. The transect line data was then processed to produce 6 graphs of spectral values for Panggang Island and Semakdaun.

Based on the spectral graphs and the resulting lagoon spectral values, lagoon and non-lagoon locations can be detected at locations where the transect line passes. The results of this detection are then validated using bathymetric data, the best composite image, and field data. The final result is obtained lagoon and non-lagoon information in the form of spectral values.

The final process is to do a visual interpretation for the analysis of the classification of the platform reef (Platform Reef) and the phase of the lagoon condition (Table 2-1).

The results of this study are graphs, composite images, and the pixel values of lagoons and non-lagoons in Panggang Island and Semakdaun. These three outputs are used to analyze the classification of platform reef landforms including lagoonal platform reefs, elongate platform reefs, and resorbed reefs (Table 2-1) to support lagoon detection models in continental shelf and back arc regions (Figure 2-2). The research flow chart can be seen in Figure 2-3.

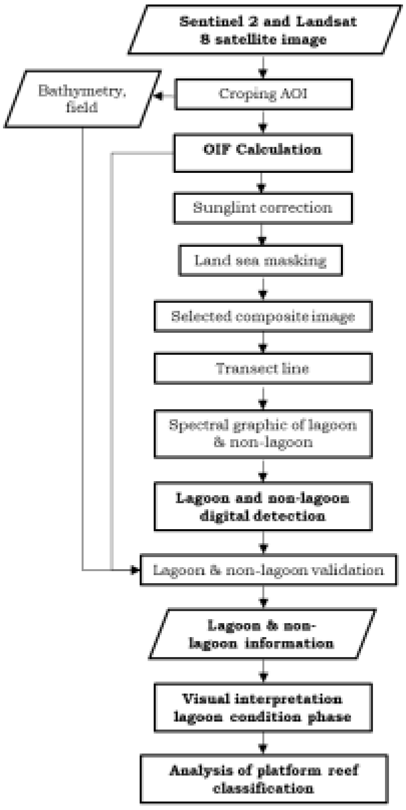


Figure. 2-3: Research flow chart

3 RESULTS AND DISCUSSION

3.1 Lagoon Detection

Detection of geomorphological objects is carried out in several stages of processing. The first stage is to group Indonesian shallow waters on the same physical characteristics. The study area is in the continental platform water group and the back arc area indicated by the yellow symbol on the small island classification map based on tectonogenesis sourced from the Bandung Geological Survey Center (Pusat survei geologi, 2007), in Figure 2-2.

The small islands in the study area and their surroundings are tectonic island types. The study area in this study belongs to the group of continental platforms and tectonic island types, so that this area is highly correlated with coral reefs, especially the landforms of platform reef corals (Table 2-1).

Spectral phenomena from image data are only carried out in certain areas with the aim of finding the best model. According to Maxwell's (1968) classification of reef landforms, lagoons are formed at an advanced stage of the platform reef type and wall shelf reef (Asriningrum et al., 2008) Lagoons are more commonly found in waters facing the open sea and this location is a good place for coral reefs to develop.

The lagoon can be an indication of a stage of development of the reef landform and is a description of the hydrological conditions on the reef landform (Asriningrum, 2009).


Figure. 3-1: Lagoon Panggang Island
(Source : Field data, 2022)

The detection of lagoons on Panggang Island and Semakdaun Island is used to see the characteristics of lagoon and non-lagoon objects with spectral line patterns. The study area consists of two small islands. Based on the lagoon condition stage, Panggang Island is grouped into Lagoonal platform reef class and Semakdaun Island is grouped into Resorbed reef landform class (Table 2-1). which covers 4570 small islands and is administratively located in 103 districts and 29 provinces.

3.2. Composite Image Sentinel 2A

This study uses a multispectral imagery band with a spatial resolution of 10m for Panggang Island and Semakdaun Island. The OIF calculation uses four visible Bands on the Sentinel 2A image. The Bands used in the calculation of OIF include Bands 2 (blue), 3 (green), 4 (red), and 8 (NIR). This Band was chosen based on the same resolution of 10 m.

The results of processing and calculating OIF obtained the following values (Tables 3-1 and 3-2).

Table 3-1: Correlation Matrix Sentinel Image 2A

Band	B2	B3	B4	B8
B2	1	0.98	0.91	0.17
B3	0.98	1	0.94	0.22
B4	0.91	0.94	1	0.42

B8	0.17	0.22	0.42	1
Mean	757.29	659.78	353.52	185.83
Sd	327.05	483.36	312.76	256.9

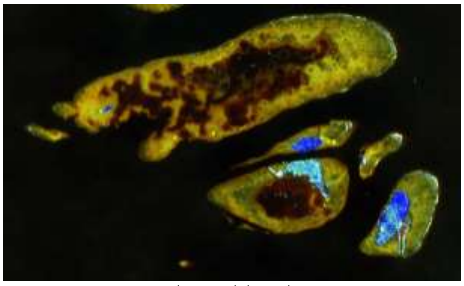
Table 3-2: OIF Value and Sentinel Band Combination Rank 2A

No	Combination	Total Sd	OIF	Rating
1	238	1067.31	772.83	1
2	348	1053.02	664.87	2
3	248	896.71	593.95	3
4	234	1123.17	395.6	4

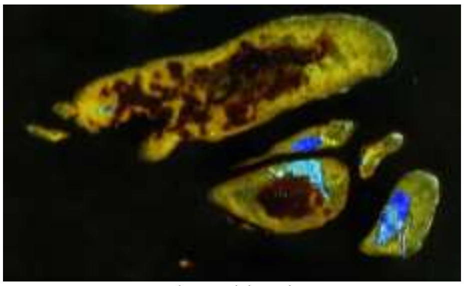
Based on the results of the OIF calculation, the selected band combination is composite 238 (blue, green, NIR) with an OIF value of 772.83 and a total standard deviation of 1067.31. A high OIF value is a composite form that has the most diversity of spectral information (Asriningrum, 2009).

The lowest OIF value for Sentinel 2A is 395.6 with a composite image of 234 (blue, green, red) with a standard deviation of 1123.17. This standard deviation is the highest among other combinations, but the lowest OIF value, this is because a high correlation coefficient value will result in a low OIF value. (Purwanto et al., 2019).

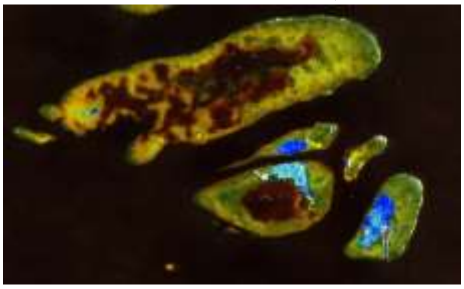
The composite image of the combined Band OIF ranking can be seen in Figure 3-2.



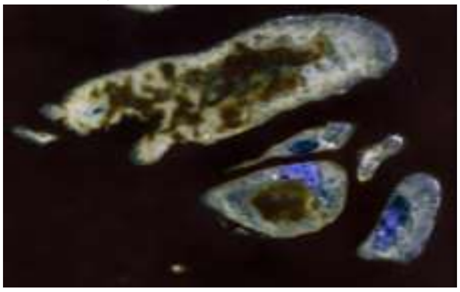
1. Band combination 238



2. Band combination 348



3. Band combination 248

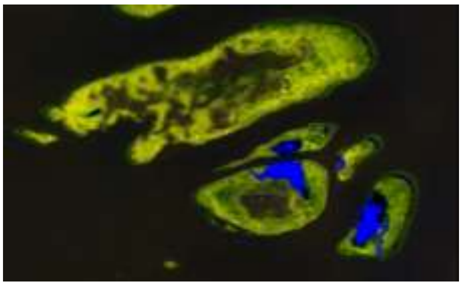


4. Band combination 234

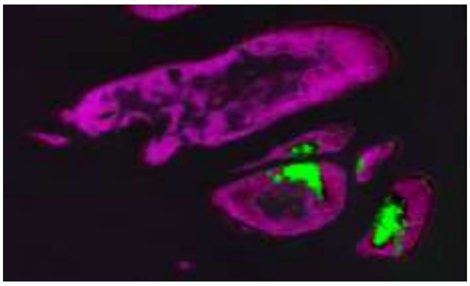
Figure. 3-2: OIF Calculation Result Band Combination

Based on the results of the OIF calculation, the selected band combination is 238. This band combination can provide the best visualization in detecting and distinguishing lagoon and non-lagoon objects.

The combination of 238 selected bands produces 6 new composite images to find the best composite in distinguishing lagoon and non-lagoon objects on platform reef landforms. The following are 6 composite images of blue, green, and NIR bands in Figure 3-3.



238



382

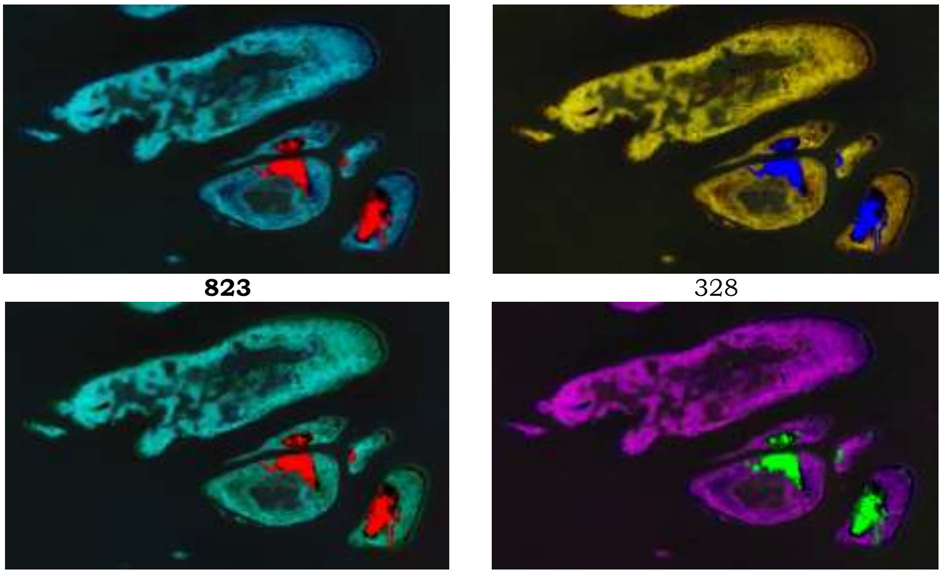


Figure. 3-3: Composite Band Combination 823

Based on the results of the analysis, composite 823 is produced, which is the best composite in terms of lagoon and non-lagoon detection. Composite 8 (nir), 2 (Blue), 3 (Green) Can clearly distinguish land objects in red, reef objects in bright blue, and lagoon objects in dark blue.

3.3 Spectral Transect Line

Graphs and spectral values were obtained from the results of transect line drawing at several locations in Panggang Island and Semakdaun Island. The transect line was drawn 3 times on each island, where 2 vertically and 1 horizontally.

The results of values and graphs are assumed to represent the spectral values of the lagoon on each island as a whole. The transect line draw produces the spectral values which are presented in the Table and the spectral graphs are presented in the form of Figures.

The spectral graph of each transect line can be seen in Figures 3-4 – 3-9. Land objects are well detected from the results of pre-processing during the land sea mask process. The classes detected were lagoons, reefs (all shallow marine habitats), and deep seas.

Spectral graphs 1, 2, and 3 represent Panggang Island transect lines, while graphs 4, 5, 6 represent Semakdaun Island. Based on the spectral graph, the pattern of transects 1, 2, 3 (Panggang Island) is dominated by high spectral values, this is because the Panggang Island transect line passes through many reef objects, while in Semakdaun Island, the transect line passes through many areas that are submerged in water.

Based on the line transects, it is stated that the lagoon objects can be detected well through the spectral graphs in some parts of the island.

3.4 Lagoon and Non-lagoon Spectral

Based on the results of the transect line, the max and min pixel values and lagoon value intervals in each band are obtained. The following Table 3-1 shows the spectral values of objects in Sentinel 2A images.

A spectral value of 0 is generated from land objects that have been carried out by land sea masks. The lagoon spectral value interval in the blue band (B2) is 0.032 – 0.150. The green band (B3) produces a lagoon spectral interval of 0.026 – 0.161. The red band (B4) is 0.008 – 0.063, while the NIR band (B8) produces an interval of 0.008 – 0.034.

The penetration ability of electromagnetic waves in the water column is strongly influenced by the characteristics of the water (Dimara et al., 2020). Optical remote sensing can be used for mapping shallow waters that are relatively clear and will decrease in capacity as the waters become turbid

(Green et al., 2000). The more turbid the sea water, the less penetrating power of the two spectrums (green and blue) will be (Guntur et al., 2012). Especially for clear shallow waters, the optical remote sensing method is able to sense or detect water depths of 15-30 m.

Table 3-3: Object Spectral Value in Sentinel Image 2A

No	Transect	Band 2			Band 3			Band 4			Band 8		
		Min	Max	Lagoon Spectral	Min	Max	Lagoon Spectral	Min	Max	Lagoon Spectral	Min	Max	Lagoon Spectral
1	Line 1	0	0.1680	0.032 - 0.099	0	0.2007	0.026 - 0.101	0	0.0995	0.008- 0.034	0	0.0670	0.011 - 0.034
2	Line 2	0	0.1661	0.040 - 0.136	0	0.2040	0.032 - 0.139	0	0.1216	0.012 - 0.046	0	0.0966	0.009 - 0.027
3	Line 3	0.0360	0.1738	0.060 - 0.139	0.0344	0.2095	0.046 - 0.156	0.0149	0.1532	0.014 - 0.063	0.0087	0.0386	0.008 - 0.015
4	Line 4	0.0193	0.1844	0.052 -0.135	0.0293	0.2165	0.041 - 0.14	0.0135	0.1343	0.013 - 0.053	0.0106	0.0664	0.010 - 0.016
5	Line 5	0.0500	0.1890	0.051 - 0.098	0.0300	0.2220	0.04 - 0.090	0.0150	0.1160	0.016 - 0.035	0.0100	0.0270	0.01 - 0.016
6	Line 6	0	0.2043	0.053 - 0.150	0	0.2393	0.036 - 0.161	0	0.1516	0.012 - 0.062	0	0.0802	0.010 - 0.018

Visually, lagoons can be grouped into shallow and deep lagoons. This group is based on the color difference in the image and the pattern of spectral values. (Kennedy et al., 2020), dividing reef cover classes into lagoons and shallow lagoons. The lagoon is a large protected water, semi-covered by reefs, the bottom of the water is flat and deep, but shallower than the surrounding sea and dominated by soft sediments. While shallow lagoons are all protected waters with a depth of <5 m, the bottom of the waters is flat and predominantly sedimentary.

Based on the spectral graph, visual interpretation, and the results of field checks, this study divides the lagoons into 3 groups in general, namely deep, medium, and shallow lagoons.

a. Panggang Island

The results of the spectral transect graph can detect several objects in the image, including the lagoon which is a water object covered by the surrounding reefs, the characteristics of the water tend to be calm and quite clear, a habitat for the surrounding flora and fauna. (Louhenapessy, 2019).

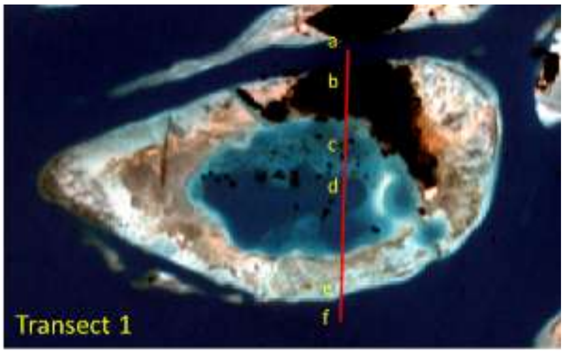


Figure. 3-4: Transect 1

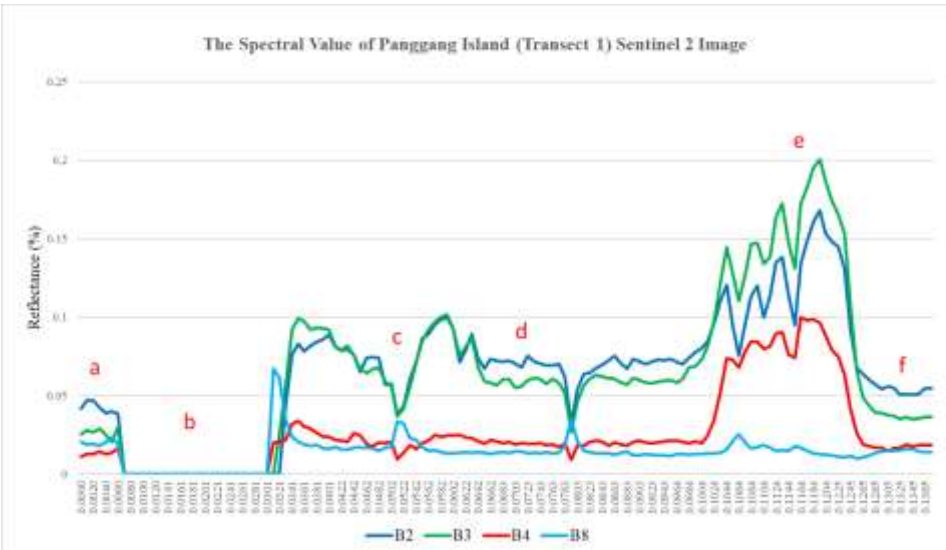


Figure. 3-5: Transect Spectral Graph 1

The next object is reefs consisting of shallow marine habitats (seagrass, coral reefs, macroalgae, and open substrate/ sand). Next is the land object that has been done the previous land sea masking process. The last object is the deep sea, which is a water object that is outside the island.

Medium lagoons with bottom waters in the form of coral fragments and dead coral have spectral graphic characteristics, namely the green and blue bands have decreased and the NIR band has increased. The spectral values of the green and blue bands increased when passing through a medium lagoon with sand as a substrate.

The deep lagoon is identified from the spectral graph, where the spectral value of the blue band is the highest. The highest green band spectral value on reef objects (open substrate/sand).

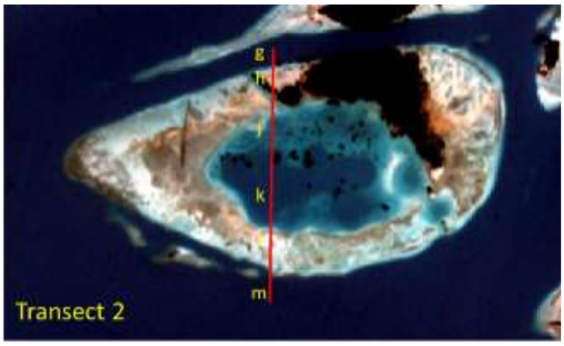


Figure. 3-6: Transect 2

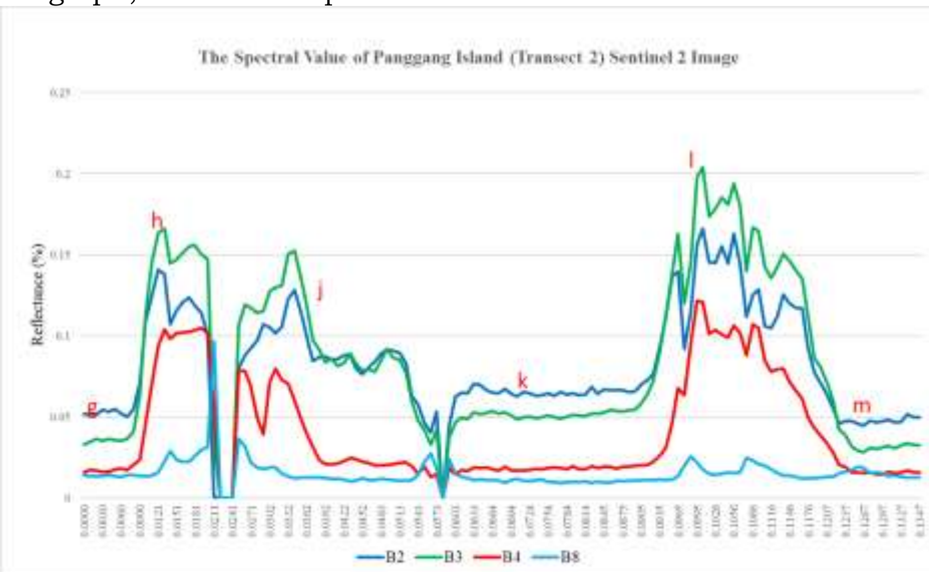


Figure. 3-7: Transect Spectral Graph 2

Passing through a medium lagoon with exposed substrate material, the spectral values of the green and blue bands coincide. Meanwhile, the pattern of the red band values follows.

As it passes through the deep lagoon, the blue spectral values are highest. The blue, green and red bands decrease as they pass through the coral object. While the NIR Band has increased.

The deepest lagoon has the highest spectral value of the blue band, followed by the green band and the red band. Reef objects (sand) in shallow lagoons are indicated by high spectral values in the green band, followed by the blue and red bands. Past the brightly colored dead coral, the increase in spectral values is also followed by the NIR band.

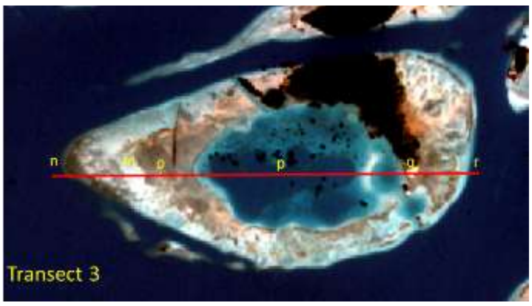


Figure. 3-8: Transect 3

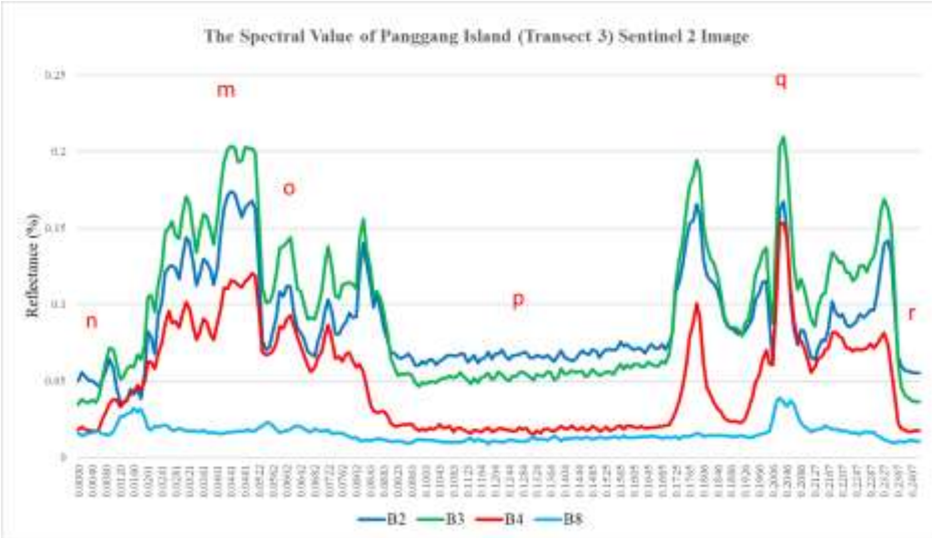


Figure. 3-9: Transect Spectral Graph 3

b. Semakdaun Island

In general, based on the spectral graph, the blue and green bands have the highest spectral values, while the red bands have almost the same pattern as the green bands. While the NIR band is quite high on reef/land objects.

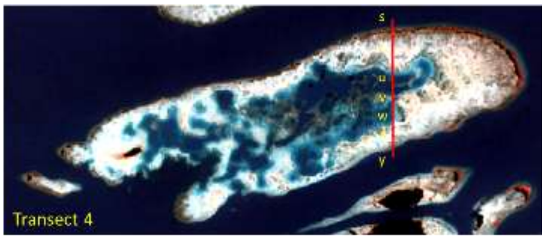


Figure. 3-10: Transect 4

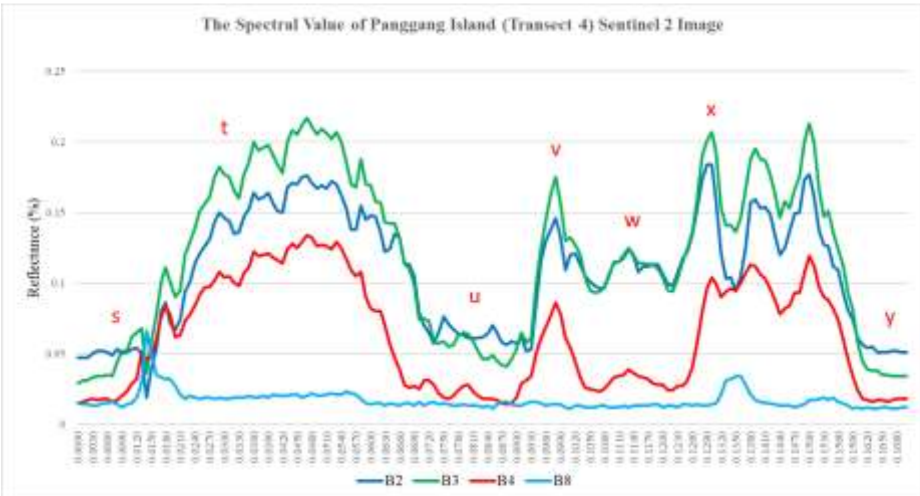


Figure. 3-11: Transect Spectral Graph 4

Upon entering the shallow lagoon, the spectrals in the blue band are high and balanced with the green band. Entering the deep lagoon, the blue band is highest and the green band is decreasing. Meanwhile, while on the reef in the deep lagoon, the green spectral band rose again.

The lowest green spectral band can identify the deepest lagoon. When passing through the reef/land, the green band spectral is very high. The lowest green spectral band as it enters the medium lagoon. The pattern of green and blue band spectral values is the same in the medium lagoon. This is because the sand substrate is still detected. The green band spectral is very high on open/sand substrate objects.

The spectral value of the green band gets higher when it passes through reef objects (coral to open substrate/sand). In reef class, the highest spectral value is in the green band, followed by blue, red, and NIR bands.

Entering the shallow lagoon object, the spectral values for the blue and green bands are the same. The spectral value of the blue band increases as the lagoon gets deeper. In deep lagoon objects, the blue spectral value is high and the green band and red band are low.

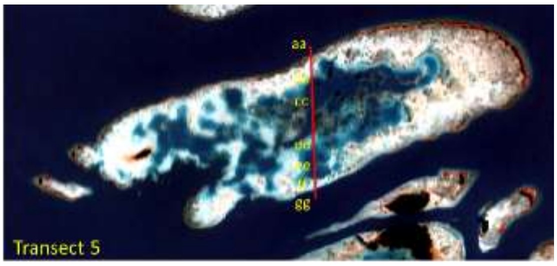


Figure. 3-12: Transect 5

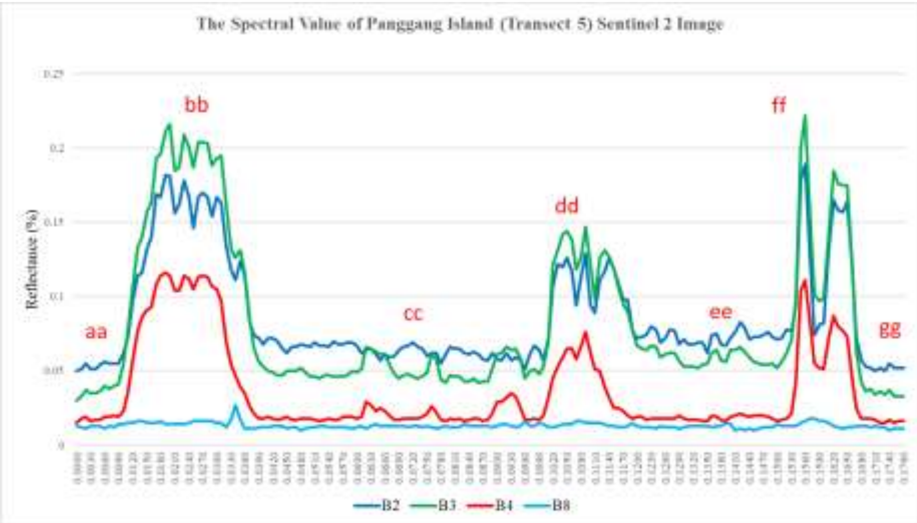


Figure. 3-13: Transect Spectral Graph 5

When passing through deep lagoon objects that contain coral reefs, the spectral values of the green and red bands increase. The spectral value of the green band is very high through the reef object (open substrate/sand). The whole band is depreciated as it passes through the seagrass object.

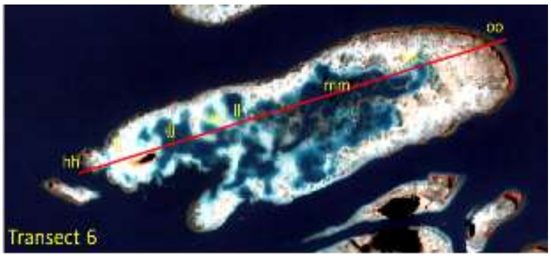


Figure. 3-4: Transect 6

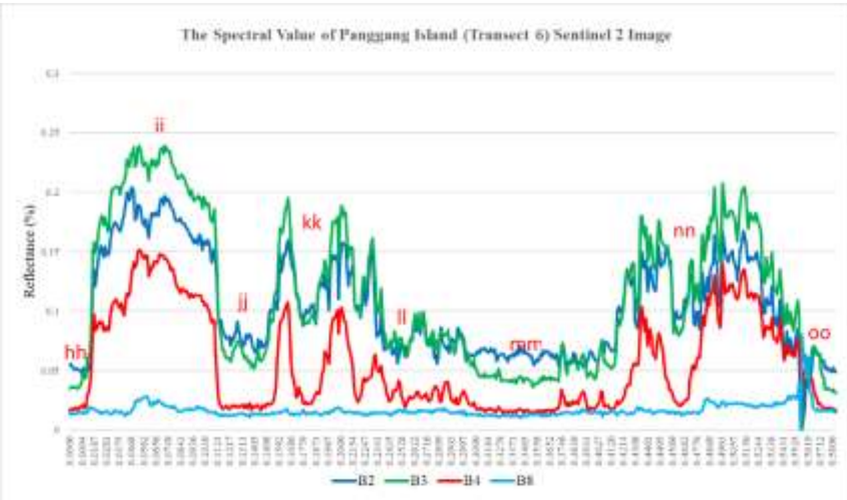


Figure. 3-15: Transect Spectral Graph 6

Passing through reef objects (substrate/sand), the spectral value of the green band is very high. Deep lagoon with coral habitat in it, green and blue bands coincide. Medium lagoons, the pattern of spectral values is higher than deep lagoons. Deep lagoon objects can be detected with the highest blue band spectral value pattern compared to other bands. As it passes through the reef in the deep lagoon, the green band will be higher. The blue band has decreased. The red band is also increasing following the green band pattern.

When passing medium lagoon objects with sand substrate material, the red band has the lowest spectral value close to the NIR band value. The drop pattern for the blue, green and red bands is the same in the medium lagoon object. The NIR band spectral value is very high when passing through reef objects (coral reefs)

The pattern of spectral values for the green, blue, and red bands on reef objects is quite the same, where the highest value is the green band, followed by the blue band, and the red band. Meanwhile, the spectral value of the NIR band increases as it passes through coral reef habitats.

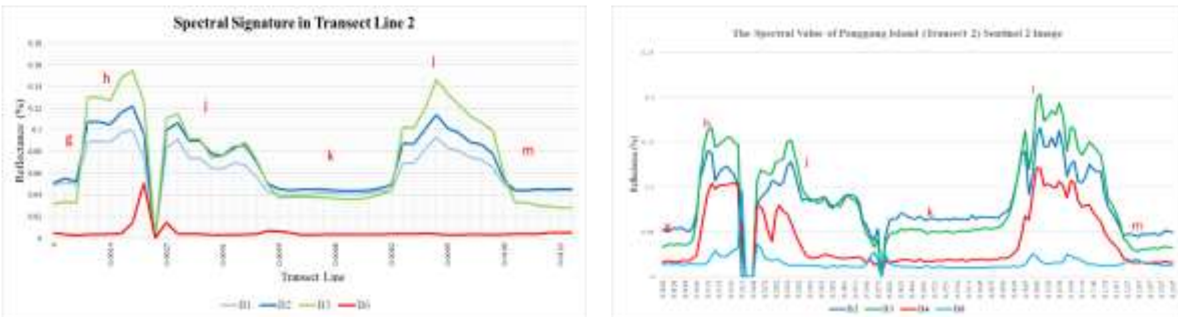
The lagoon can be detected directly through the spectral graph. The spectral values for lagoon objects tend to be low compared to other objects, this is because water objects absorb energy and little is reflected back.

When passing through deep lagoon objects, the blue band spectral value pattern is highest, while the green band will be very low. The very low red band follows the green band pattern. While the NIR band has no effect / flat graph.

When passing through a medium/shallow lagoon with substrate/sand or reef/land in it, the green band will be higher than the blue band. Low green band spectral values in lagoon objects can detect deep lagoons. The red band is very low when it is in a medium lagoon with the dominant sand substrate material.

3.5 Comparison of Sentinel 2A and Landsat 8 . Spectral Values

Similar research has been carried out by (Asriningrum et al., 2022) related to lagoon detection from Landsat-8 data recorded April 22, 2020. Figure 3-9 and Semakdaun Island spectral graph in Figure 3-10. Based on the resulting spectral graph, it is known that the spectral graph pattern on Semakdaun Island is more dynamic and heterogeneous than Panggang Island. Analysis of spectral values in Panggang Island using transect 2, while at Semakdaun Island using transect 5.

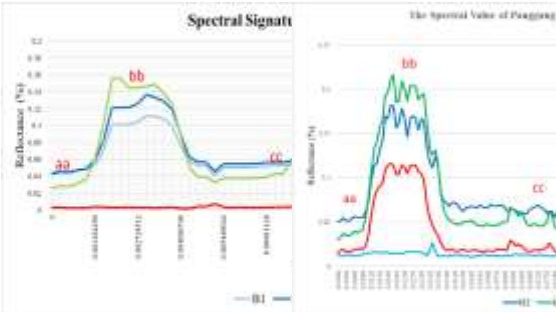


Landsat 8 **Sentinel 2A**

Figure. 3-16: Panggang Island Spectral Graphics

In accordance with the resulting graph from Landsat-8, it explains that the line changes are more dynamic in Sentinel 2 imagery. This can be influenced by the resolution factor, where the sentinel image has a resolution of 10m and on Landsat-8 30m.

In addition to the resolution factor, the composite band used in each image is different. Composite bands used in Sentinel 2 imagery are blue (B2), green (B3), red (B4), and NIR (B8), while in Landsat-8 imagery are coastal aerosol (B1), blue (B2), green (B3), SWIR (B6). The following is a graph comparison of 1 Panggang Island's transect on 2 images (Figure 3-10).



3.6 Lagoon Validation

It is known that the brightness of the lagoon waters in Panggang Island is lower due to the influence of the use of the waters for floating net cages (KJA). Aquaculture activities in Panggang Island are carried out quite intensively by the community (Figure 3-12). KJA is mostly done in deep lagoons.

Figure. 3-12: KJA in Panggang Island

This aquaculture activity has an impact on the socio-economic community (Widjayanthi & Yeni, 2020), but in excessive amounts it also has an impact on the environmental quality of the lagoon waters due to organic material waste (Bramana et al., 2014); (Anas et al., 2017). As a result, the ecosystem in the lagoon can be disturbed.

In general, the bottom waters in the Panggang Island lagoon are sand and mud sediments. The lagoon in Panggang does not provide unfavorable conditions for the growth of corals and various types of fish, so many dead corals and rocks are found. (Fig. 3-13).

Seen from the graph, the spectral value of each band on the Sentinel 2 image is higher than the Landsat-8 image, thus affecting the value of the lagoon interval.

Landsat 8 **Sentinel 2A**

Figure. 3-17: Semakdaun Island Spectral Graphics

Figure. 3-12: Lagoon Waterbed at Panggang Island

The bottom of the waters on Semakdaun Island is dominated by sandy sediments and many seagrasses are found and the waters tend to be clearer (Figure 3-13).

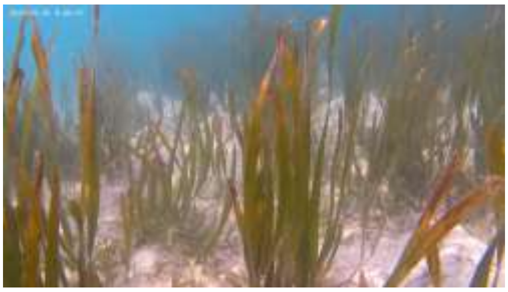


Figure. 3-13: Lagoon Waterbed at Semakdaun Island

Based on the results of field checks, the highest lagoon depth obtained is 14.5m and the lowest depth is 1.7m. Based on the division of 3 lagoon groups, the depth of shallow lagoons is in the range of 0.9m – 5.6m, medium lagoons 5.4m – 10.3m, and deep lagoons 9.9m - 15m. Based on the results of field checks, it is known that the lagoon has a fairly large error.

The lagoon is very attractive for several activities such as seaweed cultivation and KJA because the waters tend to be cleaner and calmer. The condition of coral reefs around Panggang Island and Pramuka Island can be seen in (Figure 3-14).

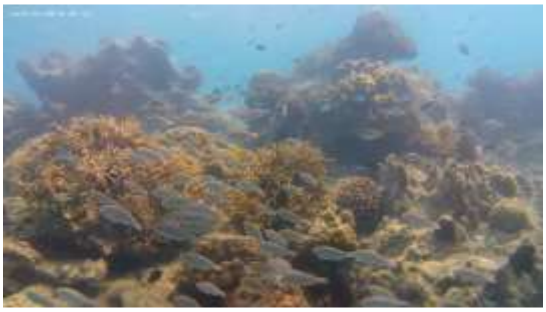


Figure. 3-14: Condition of Coral Reef Study Location

4 CONCLUSIONS

Based on the results obtained, it can be concluded that the detection of the lagoon with the spectral graph model on the Sentinel-2 image shows a more detailed view than the Landsat-8 image, such as the depth of the lagoon and reefs. This is in line with the difference in spatial resolution, the higher the spatial resolution the more detailed the graph. Detection of the lagoon with the Sentinel 2 composite image model, namely RGB 823 (NIR, Blue, Green) in accordance with Landsat-8, namely RGB 613 (SWIR, Coastal-aerosol, Green), where the selected bands are NIR and SWIR (highest wavelength), Blue and Coastal-aerosol (shortest wavelength), and Green. These two models are for the classification of three platform reef landforms with an analysis of the stages of their formation. Dynamic graphs and composite images of coarse texture are an indication of the landforms of the reefs of the tapulang yard, homogeneous graphics and fine textured composite images are the indications of the landforms of the lagoons of the reefs, the rest are the ovals of the reefs.

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REFERENCES

Allencoralatlas. (2022). Bathymetry Data of Panggang and Semakdaun Island. https://allencoralatlas.org/%0A

Anas, P., Jubaedah, I., & Sudinno, D. (2017). Kualitas Air dan Beban Limbah Karamba Jaring Apung di Waduk Jatiluhur Jawa Barat. Jurnal Penyuluhan Perikanan Dan Kelautan, 11(1), 35–47. https://doi.org/10.33378/jppik.v11i1.84 (in Bahasa)

Andréfouët, S. (2008). Coral reef habitat mapping using remote sensing: A user vs producer perspective. Implications for research, management and capacity building. Journal of Spatial Science, 53(1), 113–129. https://doi.org/10.1080/14498596.2008.9635140

Anthony, A., Atwood, J., August, P., Byron, C., Cobb, S., Foster, C., Fry, C., Gold, A., Hagos, K., Heffner, L., Kellogg, D. Q., Lellis-Dibble, K., Opaluch, J. J., Oviatt, C., Pfeiffer-Herbert, A., Rohr, N., Smith, L., Smythe, T., Swift, J., & Vinhateiro, N. (2009). Coastal lagoons and climate change: Ecological and social ramifications in U.S. Atlantic and Gulf coast ecosystems. Ecology and Society, 14(1). https://doi.org/10.5751/ES-02719-140108

Asriningrum, W. (2009). Pengelompokan Pulau Kecil Dan Ekosistemnya Berbasis Geomorfologi Di Indonesia. Thesis. (in Bahasa)

Asriningrum, W., Muchsin, A., Suwargana, N., Muchsin, A., & Tjahjono, B. (2008). Analisis geomorfologi terumbu di Kabupaten sikka. (in Bahasa)

Asriningrum, W., Ulfa, A., Setiawan, K. T., Ibrahim, A., & Aziz, K. (2022). Lagoon Detection , Platform Reef Analysis In Jakarta Indonesia Using Landsat-8. The 9Th International Seminar on Aerospace Science and Technology ISAST 2022, Figure 1.

Bellwood, D. R., Hughes, T. P., Folke, C., & Nyström, M. (2004). Confronting the coral reef crisis. Nature, 429(6994), 827–833. https://doi.org/10.1038/nature02691

Bramana, A., Damar, A., Kurnia, R., Manajemen, D., Perairan, S., Sumberdaya, P., Perikanan, F., & Bogor, I. P. (2014). Estimasi Daya Dukung Lingkungan Keramba Jaring Apung. Jurnal Teknologi Perikanan Dan Kelautan, 5(2), 161–170. (in Bahasa)

Burke, L., Reytar, K., Spalding, M., & Perry, A. (2012). Menengok Kembali Terumbu Karang yang Terancam di Segitiga Terumbu Karang. (in Bahasa)

Chavez, P. S., Berlin, G. L., & Sowers, L. B. (1982). Statistical Method for Selecting Landsat Mss Ratios. Journal of Applied Photographic Engineering, 8(1), 23–30.

Dimara, A., Hamuna, B., & Bay, H. (2020). Pemanfaatan Citra Satelit Sentinel-2A Untuk Pemetaan Habitat Dasar Perairan Dangkal (Studi Kasus : Teluk Humbolt , Kota Jayapura). Jurnal Ilmu Kelautan Dan Perikanan Papua, 3(1), 25–31. https://doi.org/10.31957/acr.v3i1.1213 (in Bahasa)

Green, E. P., Mumby, P. J., & Clark, A. J. E. C. D. (2000). Remote Sensing Handbook for Tropical Coastal Management. UNESCO PUBLISHING. https://doi.org/10.1109/6.367967

Guntur, Dita, P., & Wawan. (2012). Pemetaan Terumbu Karang Teori, metode, dan Praktik. Ghalia Indonesia. (in Bahasa)

Hedley, J. D., Harborne, A. R., & Mumby, P. J. (2005). Simple and robust removal of sun glint for mapping shallow-water benthos. International Journal of Remote Sensing, 26(10), 2107–2112. https://doi.org/10.1080/01431160500034086

Joyce, K. E., & Phinn, S. R. (2013). Spectral index development for mapping live coral cover. Journal of Applied Remote Sensing, 7(1), 073590. https://doi.org/10.1117/1.jrs.7.073590

Kennedy, E., Roelfsema, C., Kovacs, E., Lyons, M., Borrego-Acevedo, R., Roe, M., Yuwono, D., Wolff, J., Tudman, P., Murray, N., & Phinn, S. (2020). Reef Cover Classification Coral reef internal class descriptors for global habitat mapping.

Louhenapessy, D. (2019). Zonasi Dan Status Kawasan Ekosistem Laguna Di Negeri Ihamahu, Maluku Tengah. TRITON: Jurnal Manajemen Sumberdaya Perairan, 15(2), 69–75. https://doi.org/10.30598/tritonvol15issue2page69-75 (in Bahasa)

Maselli, F., Angeli, L., Battista, P., Fibbi, L., Gardin, L., Magno, R., Rapi, B., & Chiesi, M. (2020). Evaluation of Terra/Aqua MODIS and Sentinel-2 MSI NDVI data for predicting actual evapotranspiration in Mediterranean regions. International Journal of Remote Sensing, 41(14), 5186–5205. https://doi.org/10.1080/01431161.202 0.1731000

Mumby, P. J., Skirving, W., Strong, A. E., Hardy, J. T., LeDrew, E. F., Hochberg, E. J., Stumpf, R. P., & David, L. T. (2004). Remote sensing of coral reefs and their physical environment. Marine Pollution Bulletin, 48(3–4), 219–228. https://doi.org/10.1016/j.marpolbul.2003.10.031

Newton, A., Icely, J., Cristina, S., Brito, A., Cardoso, A. C., Colijn, F., Riva, S. D., Gertz, F., Hansen, J. W., Holmer, M., Ivanova, K., Leppäkoski, E., Canu, D. M., Mocenni, C., Mudge, S., Murray, N., Pejrup, M., Razinkovas, A., Reizopoulou, S., … Zaldívar, J. M. (2014). An overview of ecological status, vulnerability and future perspectives of European large shallow, semi-enclosed coastal systems, lagoons and transitional waters. Estuarine, Coastal and Shelf Science, 140(June), 95–122. https://doi.org/10.1016/j.ecss.2013.05.023

Phinn, S. R., Roelfsema, C. M., & Mumby, P. J. (2012). Multi-scale, object-based image analysis for mapping geomorphic and ecological zones on coral reefs. International Journal of Remote Sensing, 33(12), 3768–3797. https://doi.org/10.1080/01431161.2011.633122

Purwanto, A. D., Setiawan, K. T., & Ginting, D. N. B. (2019). Pemanfaatan Data Penginderaan Jauh untuk Ekstraksi Habitat Perairan Laut Dangkal di Pantai Pemuteran, Bali, Indonesia. Jurnal Kelautan Tropis, 22(2), 165. https://doi.org/10.14710/jkt.v22i2.5092 (in Bahasa)

Pusat survei geologi. (2007). Atlas Pengelompokan Pulau Kecil Berdasarkan Tektonogenesis untuk Perencanaan Tata Ruang Darat Laut dan Dirgantara Nasional. (in Bahasa)

Serco Italia SPA. (2019). Sen2Coral Toolbox for Coral Reef Monitoring, Great Barrier Reef (1st ed.). RUS Copernicus.

Widjayanthi, L., & Yeni, A. W. (2020). Jurnal Komunikasi dan Penyuluhan Pertanian Journal of Communication and Agricultural Extension Dampak Penggunaan Keramba Jaring Apung pada Pembudidaya Ikan Kerapu Berdasarkan Perspektif Sosial Ekonomi) Impact of Using Floating Net Cages on Grouper Farmers. Jurnal Kirana, 1(1), 12–18. https://jurnal.unej.ac.id/index.php/jkrn (in Bahasa)