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CARBON STOCK ESTIMATION OF SEAGRASS SPECIES THALASSIA HEMPRICII USING PLANET IMAGERY WITH BAND RATIO TRANSFORMATION IN NIRWANA BEACH , PADANG CITY

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Abstract. Coastal ecosystems such as seagrass beds can store large amounts of carbon over a relatively long period of time, so a special study is needed for the seagrass ecosystem. Nirwana Beach located in Padang City presents an overview of extensive seagrass ecosystem. The carbon stock is estimated by utilizing Planet imagery with spatial resolution 3m with band ratio transformation method. Band ratio used are band ratio Green / Blue, Green / Red, and Blue / Red. Data processing is done based on correlation analysis and regression analysis between band ratio pixel value on image with value of carbon stock in field. The results show that band ratio of Green / Red has the highest r2 indicating a strong correlation relationship. The carbon stock in Nirwana Beach with total carbon 3,776,42 gC / m2 or or 3,78 kgC / m2. Accuracy test is done with standard estimate error where the highest accuracy value is obtained through the Green / Red band ratio with accuracy percent 59.98%. This research shows that the carbon stock estimation in Nirwana Beach is underestimate.

Keyword : band ratio ,carbon stock, climate change, coastal ecosystem, marine ecosystem, Nirwana beach, Planet imagery, regression analysis, remote sensing, Thalassia hempricii.

1. Introduction

Carbon stock in a vegetation, especially trees is very necessary for environmental harmony of excessive emissions because trees and other photo-muscle organisms undergo photosynthesis during the day, the process requires an important component of CO₂ from the atmosphere. Oceans have an important role in the global carbon cycle. According to [18] about 93% of CO₂ on the earth is circulated and stored through the oceans which are capable of storing large amounts of carbon in a relatively long period of time. Oceanic ecosystems that have a major role in storing carbon stocks are seagrass. Carbon produced and stored by seagrass is blue carbon absorbed by oceans on earth which represents 55% of green carbon, which is absorbed by living organisms in the oceans [11]. So that the global warming problems that occur everywhere certainly can be stabilized by optimizing information on carbon storage abundance through mapping in the oceans, especially in Nirwana Beach waters that have vast seagrass beds with the dominance of seagrass *Thalassia hempricii* species. Carbon stock mapping with remote sensing data makes it easy to extract information in a wide area. Multispectral image as a remote sensing data product is considered effective and efficient. Through the concept of image processing based on spectral values, certain allometrics are used in satellite imagery



Seagrass ecosystem is one type of ecosystem that is found in coastal areas, seagrass ecosystem consist of one species or more seagrass plants which have interaction with biotic factors with abiotics in the surrounding environment [14]. Seagrasses are unique flowering plants adapted to live in seawater, seagrasses are equivalent to coral reefs and mangroves as the most productive and most important plants in the ecology of marine ecosystems [4]. There are about 60 species of seagrass worldwide. Seagrasses can be found in tropical waters and subtropics, generally seagrasses are scattered in Atlantic and Indo-Pacific ocean waters [16]. Seagrass diversity in the Indo-pacific region, it is known that there are up to 14 species of seagrass in one ecosystem, seagrasses in tropical waters are dominated by *Thalassia* sp species. In Indonesia, there are currently 13 seagrass species known, including 13 species belonging to seven genera namely *Enhalus*, *Thalassia*, *Halophila*, *Halodule*, *Cymodocea*, *Syringodium* and *Thalassodendron* [16]. Seagrasses provide shelter for many animal species, one of which is fish, another seagrass function is provides a direct food source for manate animals, dugongs, turtles, water ungas, some herbivorous fish [1]. The roots and rhizomes of seagrass plants function to stabilize sediment and prevent temporary erosion, the leaves filter sediment and nutrients. Seagrasses can prevent erosion on the coast, especially after strong winds, rain and flooding, besides seagrass are also very important subsurface carbon stocks, because of the slow decomposition rate [1].



Figure 1. *Thalassia Hemprichii* Seagrass Species (Source: Field Research, 2018)

Thalassia hemprichii is a species of seagrass that grows in tropical seas. According to [8] Said this species is very common and is found in flat reef areas, both those that grow individually (monospecific) and those that grow together with seagrasses of other species or other plants (mixed vegetation). This species has a rhizome (rhizoma) which is brown or black with a thickness of 1-4 mm and a length of 3-6 cm. Each node is overgrown by one root where the roots are surrounded by dense small hair. Each stand has 2-5 leaves with rounded apex, 6 - 30 cm long and 5-10 mm wide. Blue carbon is carbon captured / absorbed by oceans on earth which represents 55% of green carbon, carbon captured by living organisms in the oceans is stored in the form of sediments in mangrove forests, salt marshes and seagrass ecosystem, blue carbon is stored in thousands of years, not stored for decades or centuries (such as rainforests) [13]. The complexity of structures in coastal ecosystems (root systems, dense vegetation, leafy canopies) becomes very efficient in trapping bonded sediments and organics [10]. Ecological value of seagrass reaches 19,900 USD per year per hectare [20]. This ecological value is much higher in the distribution of other marine ecosystems such as coral reefs, mangrove forests and macro algae. The main factor in seagrass mapping using remote sensing data is understanding the relationship between variations in the characteristics of seagrass meadows and spectral reflections recorded by sensors, the relationship is useful for mapping the biophysical conditions of seagrass with remote sensing data [20].

The calculation of carbon stock refers to SNI 7724-2011 concerning the measurement and calculation of carbon stocks - field measurements for estimating forest carbon stocks (ground based forest carbon accounting) [2]. In this research, allometric concepts are used. Allometry is a function or mathematical equation that shows the relationship between certain parts of living things with other parts or specific functions of living things. The equation is used to estimate certain parameters by using other parameters that are easier to measure. Biomass calculation can be done in various ways, namely (i) the selection of samples with harvesting (destructive sampling) in situ; (ii) selection of non-destructive sampling with in-situ forest data collection; (iii) Estimation through remote sensing; and (iv) modeling. The method described can be done by allometric equations to explain the appearance of extrapolation with a wider scope. The use of allometric equations is distinguished based on stems, twigs, leaves and roots. This is because there are reproductive differences in each species of seagrass that is influenced by environmental factors. The use of standard allometric equations is often done in several studies on carbon stock, but because the coefficient of allometric equations varies for each location and species, the use of these standard equations can cause significant errors in estimating the biomass of a vegetation. According to the Regulation of the Head of the Forestry Research and Development Agency Number: P.01 / VII-P3KR / 2012 explained the selection of allometric models to be used. The allometric models include (i) available tree biomass allometric models that are suitable for the type / ecosystem of the forest where the object is located and at the location of the object; (ii) available tree biomass allometric models that are in accordance with the type / forest ecosystem where the object is located but not at the location of the object; (iii) available tree volume allometric models that correspond to the type / forest ecosystem where the object is located and at the location of the object; (iv) available tree volume allometric models that match the type / ecosystem of the forest where the object is located but not at the location of the object; (v) there are no tree biomass allometric models or tree volume allometric models.

Planet imagery is an output image of Planet Labs, Inc., an American private image company based in San Francisco, CA. Planet imagery is produced from Doves satellites that continuously scan the Earth and produce a complete image of the Earth once per day at 3-5m optical resolution. Planet imagery can be accessed online and some of them are available under the open data access policy. Planet imagery provides up-to-date information relevant to climate monitoring, predictions of crop yields, urban planning, and disaster response. Planets collect and deliver information faster than anyone, so you can see what's happening on the ground in near real time.

Planet operates more than 175 Doves satellites, 13 SkySats satellites, and 5 RapidEye satellites which provide versatile data sets for geospatial analysis of its relationship to the environment and global change [13]. Planet image is a multispectral image color-corrected 3 band (displayed in the original color composite) and has been calibrated by sensors, and has been orthorectified, and has been in the form of surface reflectance and radiance. Planet imagery has a position accuracy of <10 m based on RMSE. Planet imagery emphasizes more on temporal aspects. As is known, the planet's image is the result of daily Dove (Planetscope) satellite recording. Because he places more emphasis on its highly qualified (very real-time) temporal resolution, the spatial resolution even though it is quite high (3 meters), compared to other high spatial resolution images, is less spatial resolution, far from expectations.

With regard to the problem of global warming it can be stabilized by optimizing information on carbon storage abundance through mapping in the oceans, especially in the waters of Nirwana Beach which are tourism areas and quite close to urban and industrial areas. This will require good carbon stocks in order to maintain the quality of the waters in this region. Remote sensing technology is considered capable of helping the process of processing carbon stock abundance data in this region effectively and efficiently. So it is necessary to analyze seagrass carbon stocks with band ratio transformation using Planet imagery in Nirwana Beach to find out how accurate the band ratio of Planet images is used for seagrass carbon stock mapping.

The purpose of this study is to examine the transformation and test results of the best Planet image band ratio accuracy for carbon stock mapping at Nirwana Beach, as well as to map carbon stocks by transforming the best Planet ratio imagery on Nirwana Beach. This research is useful so that it can be used elsewhere not only at Nirwana Beach. The results are able to represent regions that have an abundance of carbon stock storage.

2. Methods

Nirwana Beach is located on the West Coast of Sumatra about 14 km from Padang City which is the capital of West Sumatra Province. This longitudinal beach has a location not far from Teluk Bayur Harbor which is quite famous for its beauty. Nirwana Beach has clear water so that the shallow marine ecosystem can be seen quite clearly. Some ecosystems that live in addition to seagrass are macro algae and coral. Some seagrass meadows were seen living and growing side by side with corals almost along Nirwana Beach. Other characteristics around the coast appear to have white sand with tropical plants and face to face with the hills.

Seagrass field data was obtained through the photo quadrant method by conducting a sample plot of 1 x 1 m above the seagrass cover to obtain the percent cover and number of leaves. The sampling method used is stratified random sampling to distribute the location of the selected transect. Sampling mapping of the unit was carried out by looking at the spectral class of seagrass beds and seagrass density. Samples taken in the form of samples to build models and samples for accuracy testing. The samples are separated by species and density to be cleaned and the number of leaves is calculated, the quadrants are then calculated and converted into carbon stock values based on the formulation developed from [18]. Seagrass sampling was carried out by taking seagrasses to the depth of root penetration by cutting the rhizoma that spread to the side (outer border of the square) using a harvest knife. Seagrass samples are then cleaned and packaged in a bottle sampling (called a wet herbarium). Samples were taken in each density class by observing seagrass species and dominating sizes in one square. Calculation of seagrass carbon content of samples (leaves) was analyzed using the Loss on Ignition (LOI) method conducted at the Geological Laboratory of the Faculty of Fisheries and Marine Sciences, Diponegoro University.

Carbon Stock Processing from the Results of the Carbon Stock Processing Laboratory is carried out in the Solid Waste Management Laboratory of Andalas University, West Sumatra. There were 30 samples analyzed to get the value of carbon stock. The calculation of the carbon stock provided by seagrass was obtained through several variables, namely the percentage of carbon (% C), the number of leaves and the mean value of the dry weight of the seagrass of *Thalassia hemprichii* (gr). According to research conducted by [18] that the species has an average dry weight of 1,275 gr. The percent carbon seagrass value was calculated through laboratory tests on several seagrass samples which had different numbers of leaves. Each leaf blade in the process of taking a quadrant sample has a different percent carbon value. These different values are then calculated to be the average percent carbon value per unit of leaves. Through several available variables, the value of AGC (Above Ground Carbon) seagrass can be found through multiplication between the average value of percent carbon per unit leaf (% C / leaf) with the average value of dry weight of seagrass *Thalassia hemprichii* (gr). The resulting AGC value has a unit (grC / leaf) which is then multiplied by the number of leaves in each quadrant sample. The results of seagrass carbon stock analysis produce a unit of value (grC / m²).

The empirical model used is correlation analysis and regression analysis. Correlation analysis uses image data in the form of pixel values and field data in the form of seagrass carbon stock values. Field data taken is used to determine the value of the relationship in the image used. The correlation that is done is knowing the relationship between field data and image pixel values. Image pixels here are the reflection values of seagrass objects through transformation in the form of a band ratio. Band ratio used involves 3 channels shown in Planet image, namely the band ratio between blue / green, green / red, and blue / red bands. Basically this correlation analysis is used to

determine the level of relationship between image pixel values and seagrass carbon stock values in the field. Regression analysis is then carried out based on the correlation analysis of each channel that has the highest determination coefficient.

Standard error estimate (SE) is used to calculate model errors as prediction and error tests with percent cover and carbon stock data. Standard error estimate is based on error accuracy analysis on image pixel value variables, field carbon stock values and carbon stock values that have been obtained on processing results. The number of samples was considered in the accuracy analysis. The smaller the SE value, the higher the accuracy produced. While the greater the SE value, the lower the accuracy produced.

3. Results and Discussion

The main factor in mapping seagrass meadows resources using remote sensing data is understanding the relationship between variations in the characteristics of seagrass meadows and spectral reflections recorded by sensors, these relationships are useful for mapping the biophysical conditions of seagrasses with remote sensing data [20]. This will help the mapping process to be more effective and efficient which will minimize field difficulties in a wide area of study. The remote sensing image used is Planet image. The use of these images to see how representative seagrass carbon stock mapping uses this high spatial resolution image. Its use uses a combination of 3 visible bands to see which band combination is the most representative of seagrass carbon stocks

The band ratio used in this study combines 3 visible bands on the planet cira namely blue, green, and red channels. The band ratio used is the green / blue, green / red, and blue / red band ratio. The results show that the band ratio between green / red has the highest coefficient of determination (r^2) with the highest accuracy, followed by the ratio of green / blue, and blue / red. The band ratio used can be related to the sensitivity of each channel to the value of carbon stock. The combination of red and green has the greatest influence in representing carbon stocks. This is because the range of green to red wavelengths is sensitive enough to describe the pixel value of a seagrass biophysical property [19]. Red and green channels have a longer and deeper penetration ability for seagrass beds that are found in the shallow depths of the sea without the influence of high water reflection [16].

Red and green channels are low absorption values compared to blue channels when interacting with vegetation objects in the water such as seagrass beds. The red channel will reflect the appearance of the vegetation higher than water but both of them still include low reflections. Whereas the green channel reflects vegetation higher than water and has a higher reflection from the reflection of water and vegetation in the red channel. That is what causes the green / red ratio to have a higher correlation than the green / blue ratio. Even though the blue band has good water body penetration ability, but when interacting with vegetation objects related to chlorophyll or biomass, the absorption will be stronger and have implications for the lower recorded reflection value [19]. It seems clearer when the blue / red band ratio has the lowest coefficient of determination (r^2) because both have high absorption when interacting with vegetation objects such as seagrasses. All three have a negative relationship influenced by the relationship between bands of the Planet image that does have a negative or non-linear relationship.

Have the highest carbon content value in the model sample of 1.047% and the highest AGC of 1.335 is the M14 sample. The total carbon stock in the quadrant in the highest model sample in the M17 sample with a value of 4.6829 gC / m², whereas in the highest validation sample on the VM11 sample with a value of 5.0308 gC / m². Furthermore, the values obtained from the results of laboratory tests for sample models are used to analyze carbon stocks in other pixels using linear regression.

The carbon stock test results in the laboratory in accordance with Annex 1. have the highest carbon content value in the model sample of 1.047% and the highest AGC of 1.335 is the M14

sample. The total carbon stock in the quadrant in the highest model sample in the M17 sample with a value of 4.6829 gC / m², whereas in the highest validation sample on the VM11 sample with a value of 5.0308 gC / m². Furthermore, the values obtained from the results of laboratory tests for sample models are used to analyze carbon stocks in other pixels using linear regression.

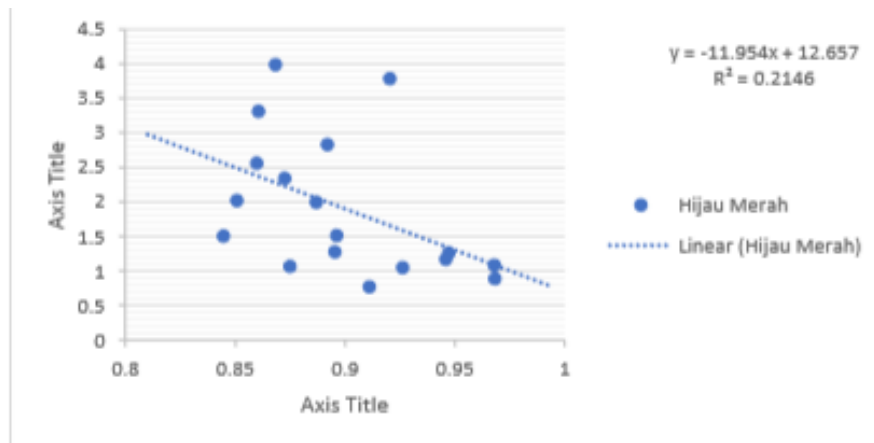


Figure 2. Carbon Stock Regression – Green-Red Band Ratio

The regression results obtained also show saturation. In shallow aquatic ecosystems most of the primary water productivity is carried out by phytoplankton / micro algae [3] and a small portion by aquatic plants / macro algae [7]. Seagrass is a type of aquatic plant that has primary productivity and functions as the rate of tethering or storing the energy of sunlight in shallow waters. Seagrass productivity is one type of producer that is able to overhaul some inorganic substances into organic matter and be used by seagrass itself [17]. Primary productivity is the rate of production of organic carbon (carbohydrate) per unit of time and volume through the photosynthesis process carried out by green plant organisms [9]. The level of primary productivity of an aquatic gives an idea that it is quite productive in producing plant biomass including the supply of oxygen produced from photosynthesis. Through the availability of fulfilled biomass and oxygen, seagrass plants can affect the development of the surrounding aquatic ecosystem.

Sunlight is the main energy needed by plants in photosynthesis.

Seagrasses are in shallow water areas so that they are close to a good surface layer of water in photosynthesis. Sunlight that enters shallow waters is also affected by the absorption of light in the atmosphere and the angle of arrival. Energy entering shallow waters depends on atmospheric conditions such as dust, clouds and other gases. The wavelength appears to have a penetrating power greater than the other wavelengths. Looking at the good wavelength for shallow water, Planet's image has several bands capable of representing these visible wavelengths. According to [17] and [7] explain that sunlight entering an optical medium such as water intensity will decrease or experience extinction attenuation along with increasing depth in the waters. Looking at the poor radiometric quality of Planet imagery, sunglint correction cannot be carried out effectively to affect the intensity of sunlight.

Materials that are in shallow water will also affect the dimming value of sunlight so that the radiometric values of Planet images will also be affected. The higher the level of turbidity, the higher the level of dimming. Seagrasses that undergo photosynthesis will be in line with the increase in light intensity to a certain optimum value (saturation light). This causes the seagrass pixel value on the Planet image to have the same pixel value pattern as other objects. The implications of this affect the further analysis in this case is regression and correlation analysis. The results of regression analysis and correlation between seagrass pixel values and carbon stock

values in the field have a relatively not too high influence relationship but are still quite good due to the saturation.

The results of the regression relationship between images and low carbon stock values which means many other factors that influence. One of them is the seagrass species in the study area which is the type of seagrass *Thalassia hemprichii*. According to [5], seagrass species that are morphologically large tend to have high biomass. *Thalassia hemprichii* (Th) species are small seagrasses with relatively small leaf size, so low accuracy can be caused by reflection of other objects in one quadrant. *Thalassia hemprichii* has a relatively small size and is in the shallow sea at Nirwana Beach. This will cause the possibility of a reflection of the mixture between the bottom of the water in the form of coral, the result is a reflection value that increases and does not match the reflection of the real seagrass.

Another most influential factor is the image used in the estimation of carbon stocks. Image Planet that is used has poor radiometric quality. Although radiometrically has a resolution of 12 bits, but the image of the Planet is a combination or constellation of several small images. This combination of multiple images can reduce the radiometric quality. Each image has a different quality, where there are several parts of the image that have good quality and some others have poor quality. To get an overall image scene, it requires calibration by averaging the radiometric quality. So that this has an effect on visual image quality in relation to radiometric quality. Besides that, the image of Planet emphasizes its geometric quality compared to its radiometric quality [12].

It can be seen from the regression results between carbon stock results with pixel values in 3 single bands of Planet image, blue green red which shows a negative relationship with a very low coefficient of determination (r^2). The very low value of the coefficient of determination means that the analysis of carbon stocks using a single band of Planet imagery will produce low accuracy and have a corresponding negative relationship in Figure 2. Estimates of mapping carbon stocks using Planet imagery are rarely done.

Poor radiometric quality also affects the spatial resolution of the Planet image, which is 3 m with the length and width of the quadrant, which is only 1 m x 1 m, which may affect the results of mapping and modeling. When measuring coordinates at the midpoint of the quadrant getting a coordinate, it could be that the coordinates are not the midpoint of a pixel of the Planet image. Other things like mixed pixels affected by algae cover, sand and coral at Nirwana Beach will also affect the results.

The estimation results of the carbon stock obtained were also strongly influenced by the measurement of the number of leaves per quadrant in the field. This will affect the total carbon stock value of one pixel, because later on from the value of carbon stock from the results of laboratory tests analyzed per leaf and then totaled based on the number of leaves available. When the measurement leaves over estimate it will produce a carbon stock value that is too high, and under estimate will produce a carbon stock value that is too low. So that it will affect the representative relationship of pixel values to the condition of carbon stocks in the field.

Accuracy test results using standard error that shows the highest accuracy is 59.98% in the red green band regression results with carbon stock. Standard error 1.58 so that the condition of carbon stock in the field has a difference of almost 1.58. Good enough accuracy is assisted with precisely the choice of band ratio used. However, the standard error approaching one is large enough to see the highest carbon stock results of just over 2.4 and not exceeding 4. This is influenced by the radiometric image of the Planet which is not very good with the analysis carried out on small underwater objects that cause no accuracy so good.

Not only that, the use of tools when the field also affects, such as GPS and the size of the quadrant used. Garmin 64S GPS is used to get seagrass coordinates in the field that are used as samples. Handheld GPS can receive and track satellite signals with positioning accuracy of 0 to 3 meters [6]. Handheld GPS has low accuracy and precision, plus the accuracy used for the location of seagrass coordinates in the field is 5 meters because of the length of time needed to achieve 3

meter accuracy. The amount of time needed can be caused by delays in the ionosphere and atmosphere because satellite signals slow down as they pass through the atmosphere; satellite height and receiver; the problem of satellite clocks and receivers where the built-in clock receiver is not as accurate as atomic clocks on GPS satellites on board therefore, there is a slight error in time; and orbital errors (known as ephemeris errors) which are inaccuracies from the satellite reporting location. Determining the location (coordinates) of seagrass samples during the day also greatly affects the low accuracy (up to 5 meters). This can happen because during the day the sun irradiation angle approaches 90° so that positive and negative atoms collide with each other which affects the signal travel so that it takes a long time to achieve a low error.

The mapping is done with a band ratio that has the highest accuracy and the smallest standard error, that is the red green band ratio. The mapping results using a red green band ratio have the strongest relationship compared to other band ratios. Based on the carbon stock estimation map, the area of seagrass that has low carbon ($< 1,1552 \text{ gC} / \text{m}^2$) covering an area of $1475,55 \text{ m}^2$. Medium carbon ($1,1552 - 2,2578 \text{ gC} / \text{m}^2$) covering $10.789,768 \text{ m}^2$. High carbon ($> 2,2578 \text{ gC} / \text{m}^2$) covering $4.675,304 \text{ m}^2$. The total amount of carbon stock at Nirwana Beach is $3.776,42 \text{ gC} / \text{m}^2$ or $3,78 \text{ kgC} / \text{m}^2$.

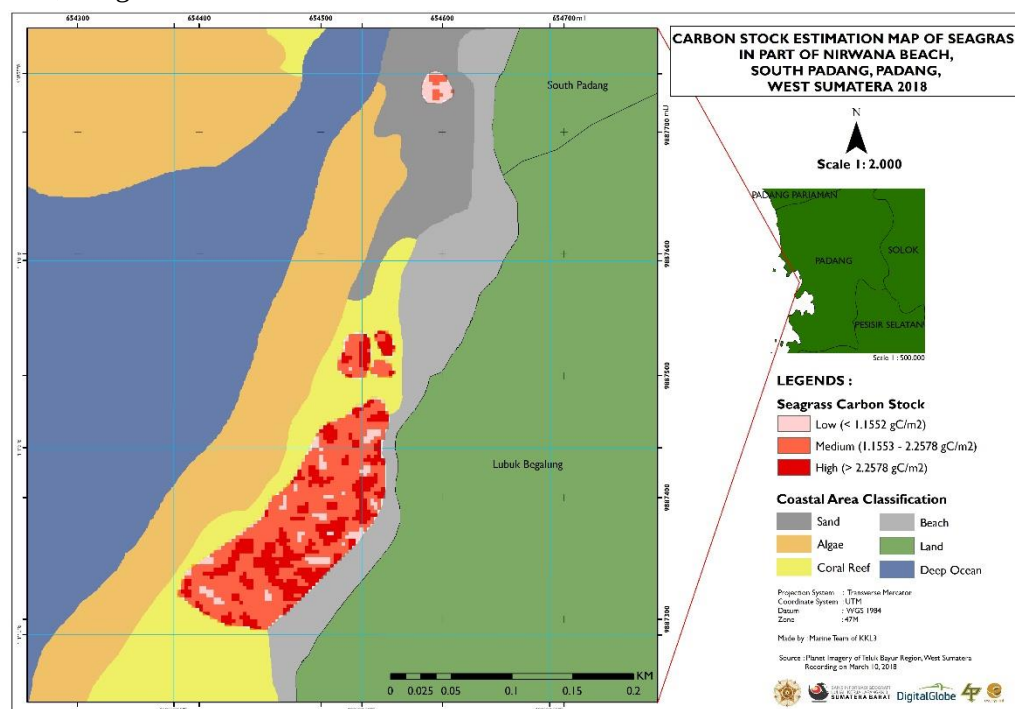


Figure 3. Carbon Stock Estimation Map of Seagrass

Based on the results of the mapping, it can be seen in this region that it has a moderate carbon stock which is quite wide. Nirwana Beach Area which is close to industry and urban areas which is also used as a place of trade causes the vast carbon stock in the region. Due to the large amount of non-organic waste that accumulates affects the existing carbon stock [15]. Not only that, according to [17] the depth of less than 0.5 m in seagrasses in this region caused at the time of the lowest ebb, seagrasses were often exposed to the sun so that it would reduce the carbon stock in seagrass leaves. Regional conditions that are also sometimes used by fishermen to stop ships will also cause low carbon stocks in seagrasses.

The mapping that is done requires the help of live digitation because it is very similar to the spectral reflection of seagrass with macroalgae. This is because in this region, there are no significant or distinctive differences that can help digitally interpret. Live digitation is very helpful also because in the mapping area it has an area that is not so wide. But this causes the

mapping results to have rather rough boundaries between the results of the mapping class, such as coral algae and others.

4. Conclusion

The results of the best Planet image image accuracy test are red-green, obtained through the standard error estimate which shows the accuracy is 59.98% in the red green band regression results with the carbon stock value and shows a standard error of 1.58 which means the condition of carbon stock in the field has a difference of up to almost 1.58 (a fairly high error) which is not affected by the radiometric image of the Planet that is not so good accompanied by an analysis carried out on a small underwater object that causes accuracy is not very good.

Seagrass carbon stock mapping is carried out with the best band ratio transformation, which has the highest accuracy and the smallest standard error, namely the red green band ratio. The mapping results show the extent of seagrasses that have low carbon ($<1.1552 \text{ gC / m}^2$) covering an area of 1475.55 m², medium carbon ($1.1552 - 2.2578 \text{ gC / m}^2$) covering an area of 10,789,768 m², and high carbon ($> 2.2578 \text{ gC / m}^2$) covering an area of 4675.304 m² with the total amount of carbon stock at Nirwana Beach is 3,776.42 gC / m² or 3.78 kgC / m².

Based on the results of the study, the author recommends estimation of carbon-based pixels, it is recommended to use radiometric quality images that are good so that the estimated carbon stock is close to accurate because the estimation of carbon stocks is based on the reflection value of objects recorded by remote sensing sensors. Radiometric correction must be taken into account because there are problems due to saturation that obscures the pixel value both from the influence of the background around the seagrass because the quadrant size is 1x1 meters while the pixel size of the Planet image is 3x3 meters, as well as the influence of the intensity of light entering the water. This makes the regression graph show a negative relationship. In addition, determining the coordinates of seagrass samples carried out during the day takes a long time to achieve a low error, so it is recommended to determine seagrass coordinates in the field in the morning so that data collection in the field can be done effectively and efficiently in terms of power and time and error as low as possible as desired.

References

- [1] Bjork, M., Short, F., Mcleod, E., & Beer, S 2008 Managing Seagrasses for Resilience to Climate Change. IUCN.
- [2] BSN. 2011. SNI 7724: 2011 Pengukuran dan Penghitungan Cadangan Karbon – Pengukuran Lapangan Untuk Penaksiran Cadangan Karbon Hutan (Ground Based Forest Carbon Accounting). Jakarta: Badan Standardisasi Nasional.
- [3] Chen H., et al. 2017 Simplified, rapid, and inexpensive estimation of water primary productivity based on chlorophyll fluorescence parameter F_o *Journal of Plant Physiology*, **211** 128–135.
- [4] El, S A 2011 Field Guide to Seagrasses of the Red Sea. IUCN.
- [5] Hartati, Retno 2017 Biomassa dan Estimasi Simpanan Karbon pada Ekosistem Padang Lamun di Pulau Menjangan Kecil dan Pulau Sintok, Kepulauan Karimunjawa *Jurnal Buletin Oseanografi Marina April 2017* vol 6 chapter 1 pp 74– 81. Hedley, J D, Harborne A R, and Mumby P J 2005 Simple and Robust Removal of Sunlight for Mapping Shallow Water Benthos *International Journal of Remote Sensing*, 26(10) pp. 2107-2112
- [6] Kamruzzaman, et., al 2014 Accuracy of Handheld GPS comparing with Total Station in Land Use Survey: A Case Study in RUET Campus *International Journal of Innovation and Applied Studies* ISSN 2028-9324 Vol. 7 No. 1 July 2014, pp. 343-352.
- [7] Kirk JTO 2011 *Light and Photosynthesis in Aquatic Ecosystems Third Edition*. New York: Cambridge University Press.
- [8] Latuconsina, M U 2002 Studi Kepadatan dan Laju Pertumbuhan Lamun Enhalus acoroide dan Thalassia hemprichii di Pulau Barrang Lompo dan Pulau Bone Batang. *Skripsi*. Fakultas Ilmu Kelautan dan Perikanan. Universitas Hasanuddin Makassar.
- [9] Lee, Z P, Marra, J, Perry, M J and Kahru, M 2014 Estimating Oceanic Primary Productivity from Ocean Color Remote Sensing: A Strategic Assesment *Journal of Marine Systems* 149: 50-59.
- [10] Mcleod, et al., 2011 A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO₂ *Journal The Ecological Society of America* 553.

- [11] Nellemann, C., et al., 2009 In Blue Carbon: A Rapid Response Assessment, edited by G. Grimsditch. Birkeland, Norway: United Nations Environment Programme, GRID-Arendal
- [12] Planet.com 2016 Planet Imagery Product Specification: Planetscope & Rapideye.
- [13] Planet Lab Inc 2018 Planet Imagery and Archive (<https://www.planet.com/products/planet-imagery/>)
- [14] Purnomo, et al., 2017 Keanekaragaman Spesies Lamun pada Beberapa Ekosistem Padang Lamun di Kawasan Taman Nasional Bali Barat. *Jurnal Seminar Nasional Masyarakat BioDiversity Indonesia* 236-240.
- [15] Putra, I A, dan Zulkifli Thamrin 2017 Potensi Penyimpanan Karbon pada Lamun (*Cymodocea serrulata*) di Perairan Pulau Poncan Sibolga Provinsi Sumatera Utara *Jurnal Fakultas Perikanan dan Kelautan UNRI*.
- [16] Setyawan, I E, et al., 2014 Pemetaan Profil Habitat Dasar Perairan Dangkal Berdasarkan Bentuk Topografi: Studi Kasus Pulau Panggang, Kepulauan Seribu Jakarta *Majalah Ilmiah Globë* Volume 16 No. 2 Desember 2014: 125-132.
- [17] Wetzel, R.G 2001 *Limnology Lake and River Ecosystem* Third Edition. Academic Press, London.
- [18] Wicaksono, P 2005 Ringkasan *Disertasi* Pengembangan Model Penginderaan Jauh untuk Pemetaan Stok Karbon Padang Lamun dan Hutan Mangrove.
- [19] Wicaksono, P & M Hafizt 2013 Mapping Seagrass from Space: Addressing the Complexity of Seagrass LAI Mapping. *European Journal of Remote Sensing*, 46:1, 18 – 39.
- [20] Wicaksono, P 2017 Karakteristik Respon Spektral Spektral Spesies Lamun Enhalus Acoroides dan Cymodocea Rotundata di Pulau Karimunjawa.