Geographica: Science and Education Journal
GSEJ
Website: http://usnsj.com/index.php/geographica
Email: geographica_gsej@usn.ac.id

ESTIMATION OF MANGROVE CARBON STOCK USING NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI) IN PROBOLINGGO, EAST JAVA

AUTHORS INFO

Dea Vega Emelia
Marine Science, University of Brawijaya,
Malang, East Java
deavega46@gmail.com

ARTICLE INFO

ISSN: 2716-4837
Vol. 3, No. 2, December 2021
URL: http://usnsj.com/index.php/geographica

Suggestion for the Citation and Bibliography
Citation in Text:
Emelia (2021)
Bibliography: Emelia, D. Vega. (2021). Estimation of Mangrove Carbon Stock Using Normalized Difference Vegetation Index (NDVI) in Probolinggo, East Java. *Geographica: Science and Education Journal GSEJ, 3*(2), 92-98.

Abstract

Probolinggo has the characteristics of the north coast of Java with large mangrove potential. The total area of mangrove forest in Probolinggo is 476.6 ha with a research area of 75 ha covering Pilang, Ketapang, and Pesisir villages. This study aims to estimate the amount of mangrove carbon stock using Normalized Difference Vegetation Index (NDVI) from sentinel-2A data as a vegetation index. A Sampling of data was carried out using a stratified random sampling method and the data collected included trunk diameter, tree height, and mangrove identification using Mongmang software. There were six mangrove species, *Rhizophora apiculate, Rhizophora mucronata, Rhizophora stylosa, Avicennia marina, Avicennia alba,* and *Soneratia alba*. The results of the estimated carbon stock are divided into 4 classes from low to high which are marked in green to red. The value of carbon stock ranged from 95.96 tons/ha to 7089.50 tons/ha. The results obtained by Pilang Village have high biomass and carbon stock values marked in red on the map. The results of the accuracy-test using *standard error estimation* (SE) get a small accuracy result of 10%.

Keywords: Carbon Stock, Mangrove, NDVI, Probolinggo

A. Introduction

The global warming that is happening now has become a hot issue in various countries. The planet earth that we now live in is getting hotter and causes various impacts and phenomena. Quoted from National Geography (2021), the global average temperature has now increased by 1.6°F or 0.9°C since 1906. In the last few decades, industrial and human activities have led to gradually accelerating climate change, and also has negative impacts on other parts of the planet, like changes in ecosystems and desertification, rise in sea level, flooding, and drough (Santos and Bakhshoodeh, 2021).

Mangroves are one of the tropical coastal ecosystems that are able to live and grow in areas that are always waterlogged with high salinity levels (Muarif, 2017). According to Setiawan (2013), mangroves themselves have a physical function to maintain shoreline stability, protect from abrasion and erosion, accelerate land expansion from mud that is entangled and carried by currents, hinder the rate of sea intrusion, protects areas behind mangroves from waves, strong winds and tsunami. Mangroves are also widely known as the world's Blue Carbon. Blue Carbon

itself according to Verisandria et al. (2018), CO2 uptake by coastal ecosystems such as mangroves and seagrass. The function of mangroves outside the biophysical function is large forest biomass. Carbon absorption by mangroves is known to be higher than land plants. Some studies also state that the optimality of carbon absorption by mangroves is 77.9% (Heriyanto and Subiandono, 2016).

When discussing the carbon stock in plants, it is very close to biomass. Biomass are basically divided into two, namely Aboveground biomass and Belowground biomass such as roots and sediments. As much as 60% of the total biomass in trees is stored in the aboveground such as in the trunk. Meanwhile, we can define biomass as the total organic matter stored in a tree, be it twigs, leaves, branches, bark, and roots which can be expressed in tons per unit area (Iswandar et al., 2017).

Remote sensing can be used as an alternative in calculating carbon stocks in mangrove vegetation. The use of satellite image data with sensors that are sensitive to green plants can be processed to find out the estimated carbon in mangrove forests. According to Utari et al. (2020), also explained that the estimation of carbon stock in the mangroves can be done by looking for the relationship between image pixel values and biomass.

The city of Probolinggo was chosen as the research location based on the mangroves in several areas of Probolinggo where there has not been much research done. The planting of mangrove seedlings has been started since last year and continued until this year, in the East Java area, it's there are several selected cities, including Sidoarjo, Sampang, and Probolinggo (Maskur, 2021). This research uses Sentinel-2A satellite imagery carried out in the Probolinggo area, the area of Probolinggo mangrove forest covers districts and cities in 2015 accounting for an area of 476.76 ha (KKP, 2016). In this study, the mangrove area studied was approximately 75 ha, including Pesisir, Ketapang, and Pilang villages.

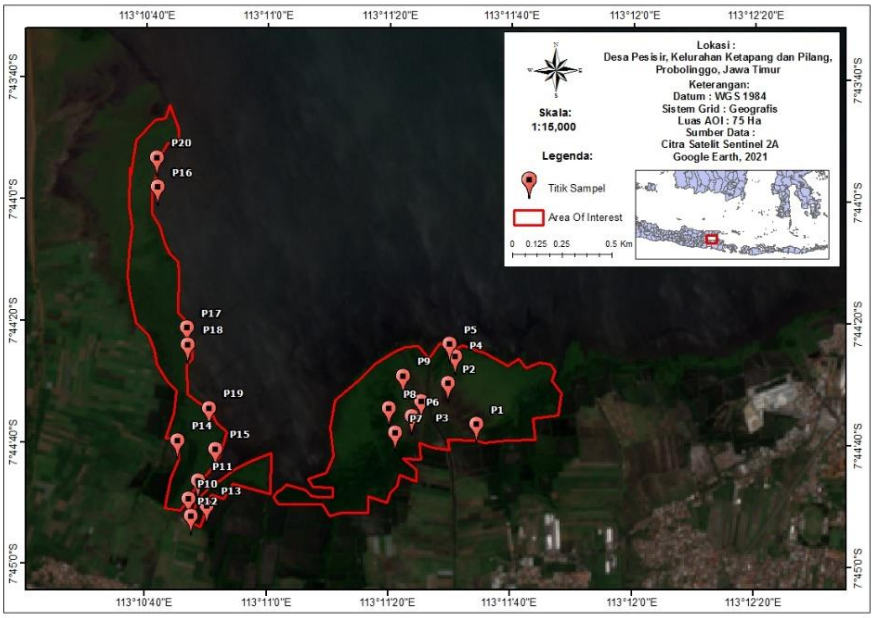

Figure 1. *Research Area*

B. Methodology

This study uses satellite imagery Sentinel-2A with the application of vegetation index NDVI (*Normalized Difference Vegetation Index*) to explore the value of carbon stock. There are several reasons for choosing Sentinel-2A as data for this research because the mission of Sentinel-2A is to determine land change, mapping green areas, mapping risks and biophysical variables such as chlorophyll content, leaf leaf index (Fletcher, 2012). In addition, sentinel-2 consists of sentinel-2A and sentinel-2B, the merging of these two images allows for clearer data collection, and the movement of polar orbits on sentinel-2A also allows for the same image to be taken in 5 days. According to Ulfa et al. (2019), the presence of a multispectral sensor (MSI) can be used to measure the reflection of the 13 channels in Table 1.

Table 1*. Characteristics of Sentinel-2A Satellite Imagery*

Band Sentinel-2A	Wavelenght (µm)	Spatial Resolution (m)
Band 1-*Coastal Arerosol*	0,433-0,453	60
Band 2-*Blue*	0,458-0,523	10
Band 3-*Green*	0,543-0,578	10

Band 4-*Red*	0,650-0,680	10
Band 5-*Vegetation Red Edge*	0,698-0,713	20
Band 6-*Vegetation Red Edge*	0,733-0,748	20
Band 7-*Vegetation Red Edge*	0,765-0,785	20
Band 8- NIR	0,785-0,900	10
Band 8A-*Vegetation Red Edge*	0,855-0,875	20
Band 9-*Water Vapour*	0,930-0,950	60
Band 10- SWIR-*Cirus*	1,365-1,385	60
Band 11- SWIR (*Shortwave Infrared*)	1,565-1,655	20
Band 12- SWIR (*Shortwave Infrared*)	2,100-2,280	20

(Source: Ulfa et al., 2019)

Determination of the sample point is based on the stratified random sampling method. This is based on natural forests that have large variations in conditions, this method aims to reduce variations in mangrove forests. The stratified random sampling method is carried out by dividing the area into smaller and uniform layers (Wibisono, 2018), strata division is carried out using NDVI index. The Normalized Difference Vegetation Index (NDVI) is an index that is often used in temporal and spatial depictions of land cover and vegetation. To get the NDVI value, a red channel that is sensitive to chlorophyll pigments is needed and a Near-Infrared channel that absorbs the reflectance of mesophyll in leaves (Purnamasari et al., 2021). NDVI algorithms are used for this study as in.

$$NDVI = \frac{[NIR - RED]}{[NIR + RED]} \quad \text{..... (1)}$$

Field data collection needs to determine the location of sample points, with a total sample of 20 points. According to Purnamasari et al. (2021), the point distribution of samples 30 is divided into 1:1 to build the model and test the accuracy. So that's 10 points are used to test the accuracy, and 10 points are used to build a carbon stock estimation model. The data that needs to be taken include rod diameter (DBH), tree height, species identification, and canopy cover using the Mongmang application. The mechanism for collecting field data is to make a quadrant transect plot like Figure 2. with a size of 10x10 to count tree mangroves, 5x5 to count saplings, and 1x1 to count seedlings (Hartoko et al., 2013).

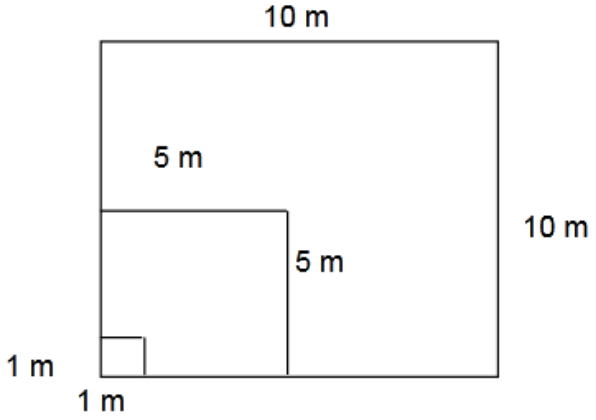

***Figure 2**. Quandrant Transect*

***Figure 3**. Transect installation and data collection*

The provisions for taking the parameters of mangrove stands according to SNI 7724:2011 (2011), are the measurement of the diameter of the height with the tolerance of the field conditions described in Figure 4.

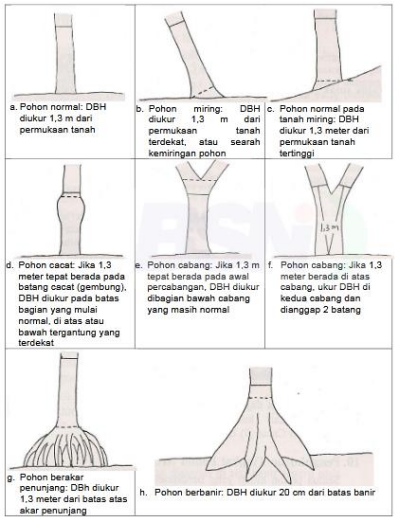

***Figure 4**. DBH data collection standard*

The calculation of the actual mangrove biomass was carried out using the allometric equation. This equation was developed by Komiyama et al. (2005), where the calculation focuses on the DBH and wood density values of each mangrove species, see equation 2.

$$Wtop = 0{,}251\rho\, DBH^{2.46} \quad \text{..... (2)}$$

The value of the wood density of each mangrove species is described in Table 2.

Table 2. Wood density of each mangrove species

No	Species	*Wood Density* (g/cm^3)
1	*Avicennia alba*	0,587
2	*Avicennia marina*	0,67
3	*Bruguiera gymnorhiza*	0,764
4	*Bruguiera parviflora*	0,772
5	*Ceriops tagal*	0,837
6	*Lumnitzera recemosa*	0,88
7	*Sonneratia alba*	0,509
8	*Sonneratia ovala*	0,37
9	*Rhizophora apiculate*	0,843
10	*Rhizophora mucronata*	0,814
11	*Rhizophora stylosa*	1,04
12	*Xylocarpus granatum*	0,851

The yield of biomass from the allometric equation, then the carbon stock value will be calculated. The carbon stock value is obtained from 50% of the mangrove biomass (Rahmattin and Hidayah 2020), the equation can be written as follows.

$$C = 0{,}5\, Wtop \quad \text{..... (3)}$$

After the map is made, it will be continued for accuracy testing. This test is carried out to determine the level of accuracy of the map made. In this study, the accuracy-test used is *standard error estimation* (SE) with the accuracy-test equation 4 referring to (Frananda 2015), the following equation 4. where *y* is the field biomass, *y*' is the regression value of biomass and *n* is the number of samples.

$$SE = \sqrt{\frac{(y - y^1)^2}{n - 2}} \quad \text{..... (4)}$$

C. Findings and Discussion

From the results of the study, it was found that 6 species of mangroves grow in the Coastal Village, Ketapang and Pilang, Probolinggo. Among them are *Avicennia alba, Avicennia marina, Rhizophora apiculata, Rhizophora mucronata, Rhizophora stylosa and Soneratia alba.* The environmental conditions in the mangrove area of Ketapang Village are very dirty with the composition of the constituent substrate, namely mud, while for the other two villages, Pilang and Pesisir is quite clean with the constituent substrate dominated by silty sand.

The dominance of mangrove growth in the Probolinggo area is dominated by *Avicennia marina* and *Rhizophora mucronata* species. This is based on the condition of the mangrove forest area in terms of its growth, which is not natural and quite homogeneous. The government has intensified the planting of mangrove trees by supplying seeds with *Rhizophora mucronata* or *Avicennia marina* species so that these two species dominate the mangrove forest area of Probolinggo.

Statistical regression test was used to determine the effect of NDVI on biomass. Before the regression calculation, it is necessary to see whether the field data to be processed is normally distributed. The normality test is carried out to see if the data is normally distributed, where if the data is normally distributed the possibility of bias is small (Apriyono and Taman, 2013). From the normality test results P-value < 0.010, the data is not normally distributed, the data analysis technique that can be used is non-linear regression. Non-linear regression can be performed if the data is not linear and cannot be linearized (Forestriko and Hartono, 2016). After knowing the data is not normally distributed, the regression that can be used is nonlinear regression. The nonlinear regressions performed include exponential, polynomial, quadratic, and logarithmic.

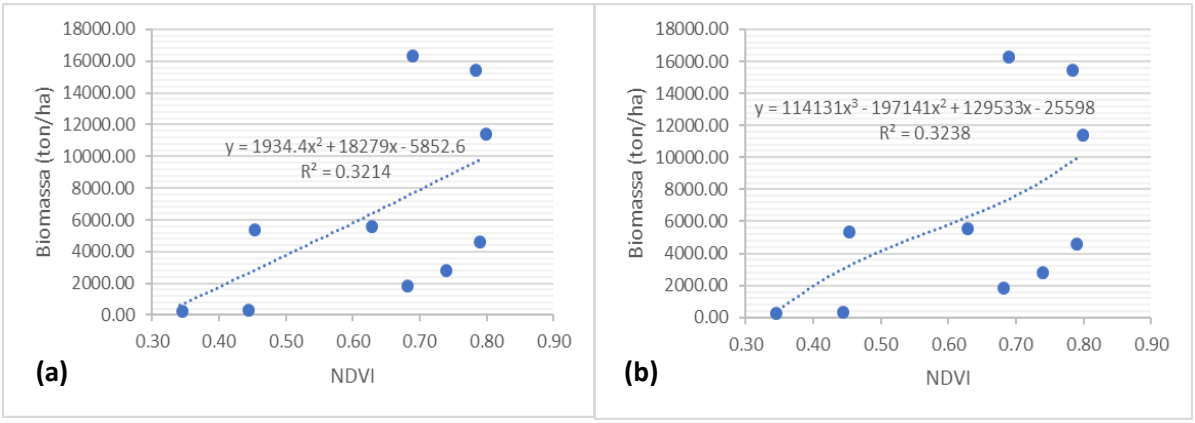

***Figure 5**. Grafik (a) Polynomial Regression and (b) Quadratic Regression*

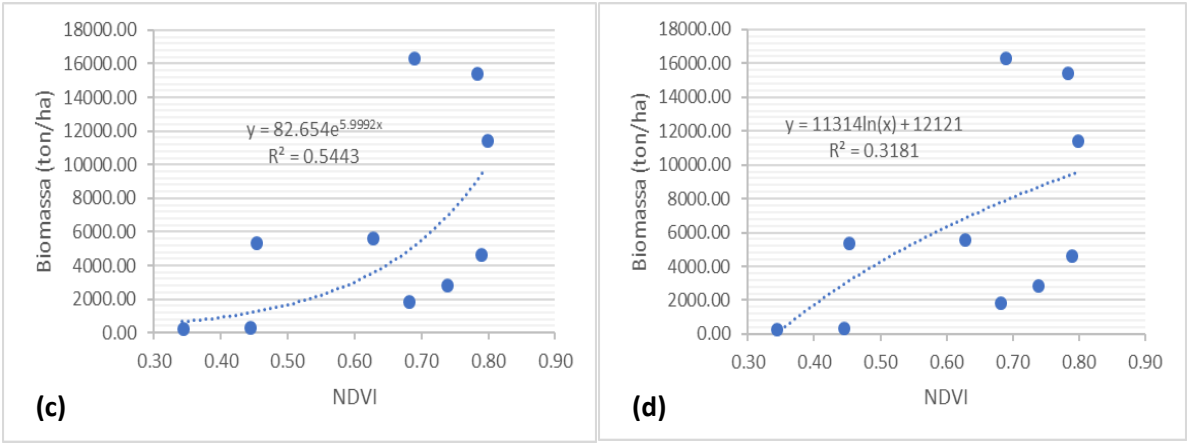

***Figure 6**. Grafik (c) Exponential Regression and (d) Logaritmic Regression*

The samples from the field data as many as 20 sample points, the sample used to build the regression equation is 10 sample points. The results of the statistical analysis carried out between NDVI and biomass obtained the largest R^2 with an exponential regression of 0.5443 compared to the others. With the resulting equation carbon $82.654e^{5.9992x}$, this equation will later be used to build a model for estimating carbon stocks. The estimated carbon stock is divided into 4 classes with the lowest to highest carbon stock value categories marked in green to red Figure 7. The SNI 2011 carbon stock estimation guide does not yet regulate the division of biomass class and carbon stock levels. The estimated value of carbon stock obtained in the Probolinggo Region (Pesisir,

Ketapang, and Pilang Villages) ranges from 95.96 tons/ha to 7089.50 tons/ha. Similar to the biomass density map, the largest estimated carbon stock is in Pilang Village.

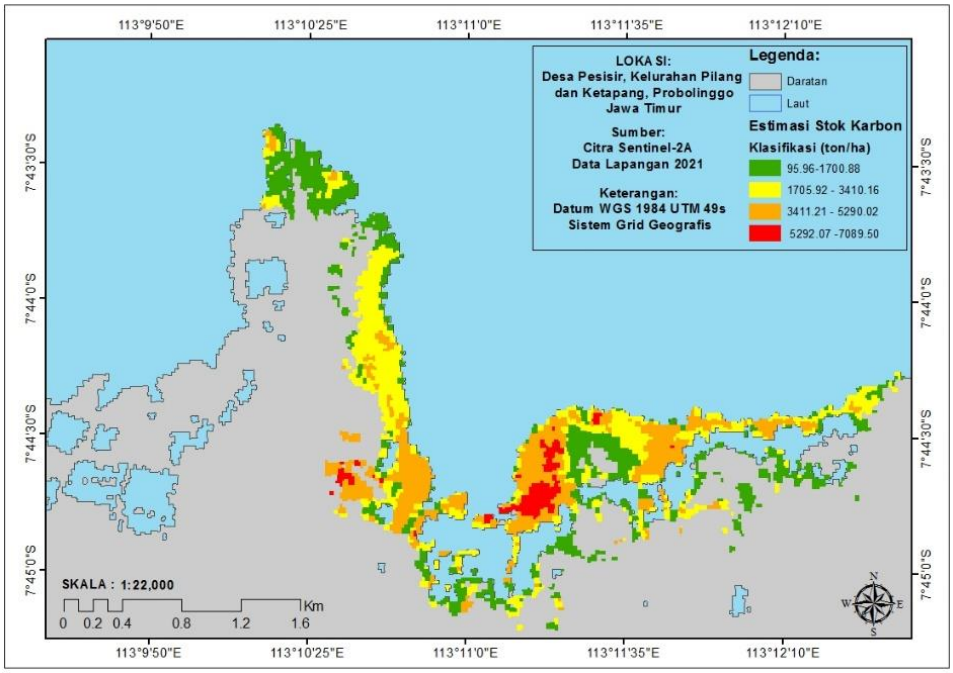

***Figure 7**. Map of carbon stock estimation in Probolinggo*

Determination of accuracy with this accuracy test method, namely the accuracy of the map results is declared good if the lower the value obtained from the results of the standard error (SE) calculation carried out (Forestriko and Hartono 2016). The results obtained from the standard error value of 14135851, when viewed from the results obtained, the SE value obtained is quite large. As for the accuracy test, it is expressed as a percentage, the accuracy level of the map is 10%. This can be caused by the use of a small sample as a model, but the research area is quite wide. According to Wicaksono et al. (2011), NDVI as a commonly used vegetation index, although not the best for estimating carbon stocks. Even though the detection of mangroves using the NDVI method is very good in terms of spatial, the data generated is in accordance with the actual field conditions.

D. Conclusion

The results of this study note that the effect of NDVI on the biomass value is known to be quite large from the r squared value of 0.5543. The accuracy value of the resulting carbon stock map is 10% with the estimated value of the resulting carbon stock ranging from 95.96 tons/ha to 7089.50 tons/ha for the study area with an area of 75 ha.

E. Acknowledgments (Optional)

The author would like to thank (1) Mr. Bambang Semedi and Mr. Dhira Khurniawan Saputra as mentors in this research (2) Raisa Tria Salsabela, M. Iqbal A, and Yoga Bagus F for assistance during fieldwork (3) Vianta Mandalika as who have assisted in the publication of this journal.

F. References

Apriyono, A., & Abdullah T. (2013). Analisa Overreaction Pada Saham Perusahaan Manufaktur Di Bursa Efek Indonesia (BEI) Periode 2005-2009. *Jurnal Nomina* 2(2).

Fletcher, K. (2012). Sentinel-2A ESA Optic High-Resolution Mission for GMES Operational Service. *ESA Communications*.

Forestriko, Hernandea F., and Hartono. (2016). Pemanfaatan Citra Landsat 8 Untuk Estimasi Stok Karbon Hutan Mangrove di Kawasan Segara Anakan Cilacap Jawa Tengah. 10.

Frananda, Hendry, Hartono, and Retnadi H. Jatmiko. (2015). Komparasi Indeks Vegetasi Untuk Estimasi Stok Karbon Hutan Mangrove Kawasan Segoro Anak Pada Kawasan Taman Nasional Alas Purwo Banyuwangi, Jawa Timur. *Majalah Ilmiah Globe* 17(2):113–23.

Hartoko, Agus, Ignatius B. H., and Angela M. D. Widayanti. (2013). Perubahan Luasan Hutan Mangrove Di Pulau Parang, Kepulauan Karimunjawa Menggunakan Citra Satelit. *Journal of Management of Aquatic Resource* 2(2):19–27.

Heriyanto, N. M., and Endro S. (2016). Peran Biomassa Mnagrove Dalam Menyimpan Karbon Di Kubu Raya, Kalimantan Barat. *Jurnal Analisa Kebijakan* 13(1):1–12.

Iswandar, Meivi, Irma, D., and Viqqi, K. (2017). Dugaan Serapan Karbon Pada Vegetasi Mangrove Di Kawasan Mangrove Gempong Iboih, Kecamatan Sukakarya, Kota Sebang. *Jurnal Ilmiah Mahasiswa Kelautan Dan Perikanan Unsyiah* 2(4):512–18.

Komiyama, A., Sasitorn, P., and Shogo, K. (2005). Common Allometric Equations for Estimating The Tree Weight of Mangroves. *Jurnal of Tropical Ecology* 21(04):471–77. doi: 10.1017/S0266467405002476.

Maskur, F. (2021). Pulihkan Ekosistem Pesisir, Ini Target Tanam Mangrove 2021 | Ekonomi. *Bisnis.Com*. Retrieved March 20, 2021 (https://ekonomi.bisnis.com/read/20210116/99/1343873/pulihkan-ekosistem-pesisir-ini-target-tanam-mangrove-2021).

Muarif. (2017). Karakteristik Ekosistem Mangrove Di Kawasan Pesisir Kabupaten Natuna. *Jurnal Mina Sains* 3(2).

National Geography. (2021). Effect of Global Warming.

Purnamasari, E., Muhammad K., and Pramaditya, W. (2021). Comparison of Vegetation Indices for Estimating Above-Ground Mangrove Carbon Stocks Using PlanetScope Image. *Regional Studi in Marine Science* 44.

Rahmattin, Nur Al Fina E., and Zainul, H. (2020). Analisis Ketersediaan Stok Karbon Pada Mangrove Di Pesisir Surabaya, JawaTimur. *Juvenil* 1(1).

Santos, Rafael M., Bakhshoodeh R. (2021). Climate Change/Global Warming/Climate Emergency verus general climate research: comparative bibliometric trends of publications. *Heliyon 7.*

Setiawan, H. (2013). Status Ekologi Hutan Mangrove Pada Berbagai Tingkat Ketebalan. *Jurnal Penelitian Kehutanan Wallacea* 2(2):104–20. doi: 10.18330/jwallacea.2013.vol2iss2pp104-120.

SNI 7724:2011. (2011). Pengukuran Dan Penghitungan Cadangan Karbon –Pengukuran Lapangan Untuk Penaksiran Cadangan Karbon Hutan (Ground Based Forest Carbon Accounting). *Badan Standardisasi Nasional*.

Triana, V. (2008). Pemanasan Global. *Jurnal Kesehatan Masyarakat Andalas* 2(2).

Ulfa, K., Fadila, M., Danang, S. C., Kuncoro, A. P., Masnita, I. O., and Kiki, W. V. D. (2019). Analisa Pola Spektral Citra Sentinel-2A (Spectral Analysis Of Sentinel-2A Images). *Berita Dirgantara* 20(2):38–46.

Utari, D., Muhammad, K., and Frida, S. (2020). Above Ground Biomassa Estimation of Mangrove Using Wolrdview-2 Imagery in Perancak Estuari, Bali. *OP Conf. Series: Earth and Environmental Science 500*. doi: 10.1088/1755-1315/500/1/012011.

Verisandria, R. Joshian, S., Calvyn, S., Medy, O., Antonius, R., and Jety, R. (2018). Estimasi potensi karbon pada sedimen ekosistem mangrove di pesisir Taman Nasional Bunaken bagian utara. *JURNAL PESISIR DAN LAUT TROPIS* 6(1):81. doi: 10.35800/jplt.6.1.2018.20567.

Wibisono, G. n.d. Penaksiran Volume Pohon Komersil Melalui Metode Penarikan Acak Berlapis (Stratified Random Sampling) Berdasarkan Kelas Lereng Dan Kerapatan Tegakan Di PT. Limbang Genaca. *Jurnal Hutan Tropis* 2(2):65–69.

Wicaksono, P., Projo, D., Hartono, H., and Udi, M. N. (2011). Preliminary Work of Mangrove Ecosystem Carbon Stock Mapping in Small Island Using Remote Sensing:Above and Below Ground Carbon Stock Mapping on Medium Resolution Satellite Image. *The International Society for Optical Engineering* 8174(1B). doi: 10.1117/12.897926.