Blue Carbon Degradation on Coral Reefs as Impact of Climate Change: Case Study at Samalona Island, Makassar City, South Sulawesi

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Abstract

Climate change is one of the global environmental hazards that can threaten humans and nature. Climate change can affect changes in temperature and rainfall. This research aims to estimate how much blue carbon potential can be absorbed by coral reefs on Samalona Island, and the effect on climate change. The collection of climate data for the last five years and Live Coral data for the last four years sourced from previous studies, added with field observations to obtain Live Coral data using the quadrat transect method. The identification results showed that there were 33,22% Live Coral, 50,56% Dead Coral, 7,44% Others, 8,78% Algae. To determine the blue carbon value, by multiplying the Live Coral data by the area of Samalona Island. The results are converted into square meters and multiplied by 7,72 x 10^-5 kg/m², this is the blue carbon value of Acropora Aspera. To determine the effect, simple regression was used with SPSS software. The results found that the interpretation value of blue carbon on temperature is 0,666 and on rainfall is 0,264, which shows that the relationship between blue carbon and temperature is strong and weak on rainfall.

Keywords: Coral Reefs, Blue Carbon, Climate Change

INTRODUCTION

Climate change is one of the global environmental hazards that can threaten humans and nature. Climate change can affect temperature and rainfall increases as well as tropical storms (IPCC). Climate change refers to change in global temperatures and weather patterns over a long period of time/over time. Since the 19th century, human activity has been a main factor in climate change, especially through the burning of fossil fuels, resulting in increased concentrations of greenhouse gases (United Nations). The impacts are very diverse, starting with ecosystem damage (Kadek *et al*., 2023), decreasing biodiversity (Darwin, 2011), to human health (Susilawati, 2021).

Coral reef ecosystems are usually found in coastal areas or waters that are exposed to sunlight and located in tropical waters, such as Indonesia (Hoegh-Guldberg *et al*., 2007). One of the areas in Indonesia that is famous for the abundance of coral reefs is Samalona Island (Edinger *et al*., 1998). Samalona Island is a small island located about 7 km from the city center of Makassar, South Sulawesi. This island has an area of approximately 2,34 hectares and is surrounded by various types of coral reefs (Amalyah *et al*.,2016).

Coastal ecosystems, including coral reefs, provide many important roles, one of them is to absorb and store large amounts of blue carbon from the atmosphere and ocean (McLeod *et al*., 2011). On coral reefs, photosynthesis is carried out by Zooxanthellae algae that live in the polyp tissue, converting carbon dioxide (CO2) and sunlight into organic carbon. This organic carbon is then stored in the coral tissue and forms calcium carbonate minerals that form the coral skeleton (Gattuso *et al*., 1999).

Blue Carbon refers to coastal ecosystems that absorb and store large amounts of carbon from the atmosphere and oceans that are now recognized for their role in mitigating climate change (IPCC). This absorption and storage occur naturally, especially in the absorption of CO2 (carbon dioxide) (McLeod *et al*., 2011).

The Research conducted by Muhammad Ainal Yusri *et al*. (2017) aimed to measure the carbon dioxide (CO_2) levels stored in various types of coral reefs at Lhok Mee Beach, Banda Aceh. This research utilized a Carbondioxide Meter. The

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types of coral studied included *Acropora elegantula*, *Acropora aspera*, *Acropora grandis*, and *Platygyra sinensis*. The results revealed that the ability of coral reefs to absorb and store carbon varied, with the highest carbon storage observed in *Acropora grandis* and the lowest in *Acropora elegantula*. This study confirms the significant role of coral reefs as natural carbon sinks, contributing to global warming mitigation.

Based on the problem, the focus in this research is to estimate how much blue carbon potential that can be absorbed by coral reefs and to determine the effect on climate change. The location of this research is on Samalona Island, Makassar City, South Sulawesi. We hope that the results of this research can be useful for people in maximizing the role of coral reefs around us, including in dealing with climate change problems.

MATERIALS AND METHODS

The method used in this research was data collection with the parameters of rainfall and air temperature in South Sulawesi for the past 5 years from The Hasanuddin Meteorology and Climatology Station, live coral data for the past 4 years from previous research, complemented by field observation data conducted in the last year. After the data is collected, it will be analyzed using simple linear regression to determine the effects, utilizing SPSS software.

Field Observation Data Collecting

This research was conducted in May 2024 on Samalona Island, South Sulawesi. The data collection method for field observations to obtain live coral data in the last year was conducted using the Underwater Photo Transect (UPT) method, which involved capturing images with an underwater camera and processing them using computer software (Giyanto *et al*., 2014). At each location, a 50 meter line was laid using a roll meter (Figure 3), followed by the use of 50 cm x 50 cm quadrat transect. The pattern of quadrat transect placement, observation, and photo capture every 5 meter is illustrated in Figure 2.

Figure 1. Map of the study area

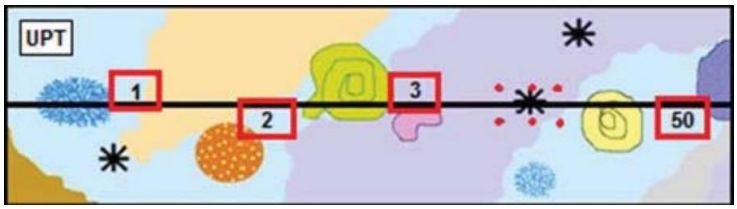


Figure 2. Illustration of the Underwater Photography Transect (UPT) method (Giyanto *et al*., 2014)

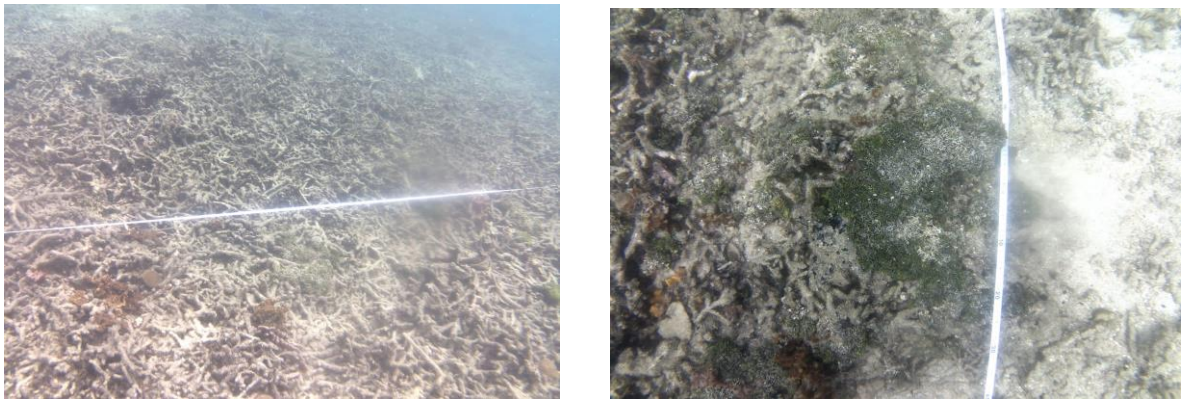


Figure 3. Roll meter unfolding

The underwater photos obtained were then imported and analyzed using the Coral Point Count with Excel extensions (CPCe) software. Each photo was assigned random points representing the percentage of coral types and other biota, with each random point identified. The identification was conducted with the assistance of the book Types of Corals in Indonesia (Suharsono, 2008). The analyzed and identified photos were subsequently exported into Excel format, where Microsoft Excel displayed data including coral types, percentages of hard coral, soft coral, dead coral, and other biota.

Coral Reefs Blue Carbon Analysis

This research employs a quantitative approach to estimate the Blue Carbon stored within the live coral ecosystem in Samalona Island. The calculation is based on the total coral reef area which is 4,62 hectares (Sudaryanto), the percentage of live coral over the past five years, and the specific carbon value represented by the species *Acropora aspera*, which is 7,72 × 10^-5 kg/m² (Ainal *et al*., 2017). The calculation formula used is:

$$BC = (A \times P) \times C$$

Note: *BC* = Total Blue Carbon (kg); *A* = Total coral reef area (m²); *P* = Percentage of live coral (in decimal, e.g., 50 percent = 0,5); *C* = Specific Blue Carbon value per square meter for *Acropora aspera* (kg/m²)

The coral species in Samalona Island are mainly *Acropora sp.*, *Porites sp.*, *Sinularia sp.*, and *Millepora sp.* (Ahmad *et al*., 2006). In this study, *Acropora aspera* was used as a reference for estimating coral blue carbon due to the availability of blue carbon data for this species from previous research. Although *Acropora aspera* does not dominate in population numbers, its presence remains significant in the coral reef ecosystem of Samalona Island. Therefore, the blue carbon estimation derived from *Acropora aspera* can provide a reasonably representative picture for calculating the total blue carbon of coral reefs in Samalona Island.

RESULTS AND DISCUSSION

The results of the field observations on Samalona Island were analyzed using CPCe software, showing the condition of the coral reefs ecosystem, which includes several main components: Hard Coral (HC), Rubble (R), Other Biota (OT), Sand (S), and Rock (RK), Rubble reaches more than half of the total substrate composition every five meter interval (Figure 4) and gives the final result that Dead Coral (Rubble) covers 50.56% of the total coral reefs ecosystem, while Live Coral/Hard Coral is only 33,22%. In addition, there is also Algae at 8,78% and Other Biota at 7,44% (Table 1).

The Blue Carbon mass in *Acropora aspera* is 7,72 x 10^-5 kg/m² (Ainal *et al*., 2017). Based on this value, the estimated Blue Carbon values for coral reefs on Samalona Island over the past five years consecutively are 1,272 kg, 1,373 kg, 1,245 kg, 1,230 kg, and 1,185 kg (Figure 6). These values indicate the degradation of Blue Carbon on coral reefs, indicating a degradation in the amount of live coral on Samalona Island (Figure 5).

Based on the collected data, rainfall and temperature data in South Sulawesi can be seen in Figure 7. These data serve as the basis for analyzing the relationship between Blue Carbon on

coral reefs and climate change (rainfall and temperature).

In Table 2 and 3, the focus is on the 'R' values as the coefficient of determination in regression. This research involves three variables: Blue Carbon as the 'x' variable or independent variable (the affecting factor), temperature as the ‘y1’ variable or dependent variable (the affected factor), and rainfall as the ‘y2’ variable. In this research, there are two dependent variables, which means regression analysis needs to be conducted twice.

Table 2 shows the results of the regression determinant coefficient is 0,666, with the 'x' variable is Blue Carbon and the 'y' variable is temperature. The 'R' value indicates a strong relationship between Blue Carbon and temperature. This means that changes in temperature values have a correlation with changes on Blue Carbon values.

The result of the regression determination coefficient with variable ‘x’ is blue carbon and variable ‘y’ is rainfall is 0.264 (Table 3). This means that changes in rainfall values have little effect on blue carbon values because the ‘R’ value shows a weak relationship between blue carbon and rainfall.

Table 1. Average percentage of coral reefs Data 2024

Category	Percentage(%)
Live Coral	33,22
Dead Coral	50,56
Other Biota	7,44
Algae	8,78
	100

Note : Live Coral = Coral (HC), Dead Coral = Rubble(R), Algae = Other Biota (OT), Other = Sand (S) and Rock (RK)

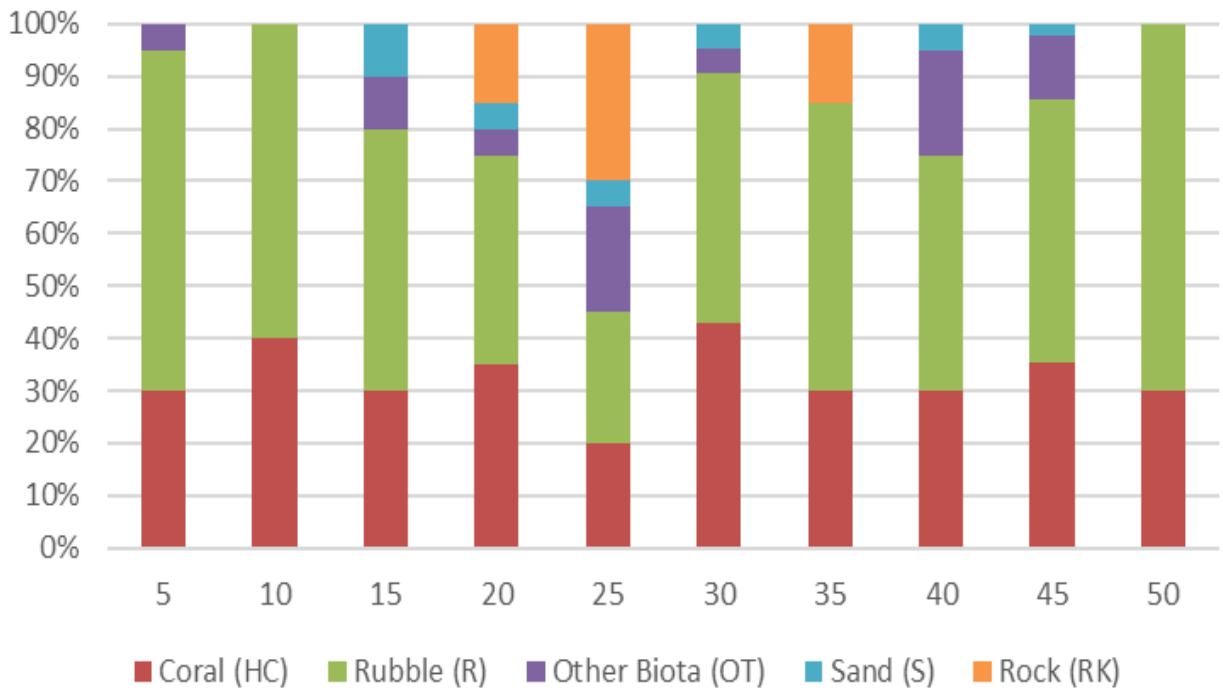


Figure 4. Coral reefs Data every 5 meters

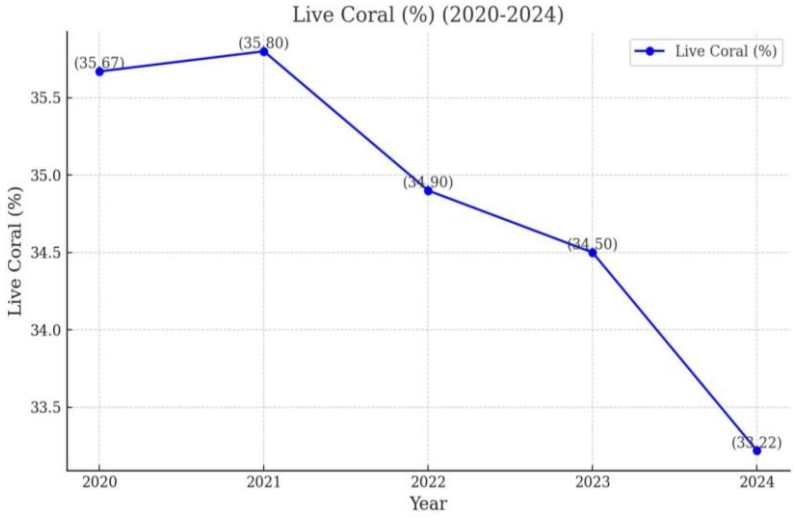


Figure 5. Percentage of live coral in Samalona Island, South Sulawesi 2020-2024. Source: Sudaryanto

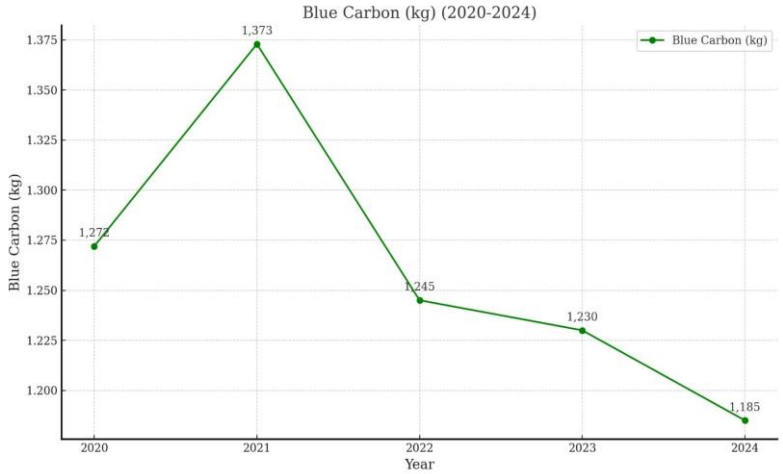
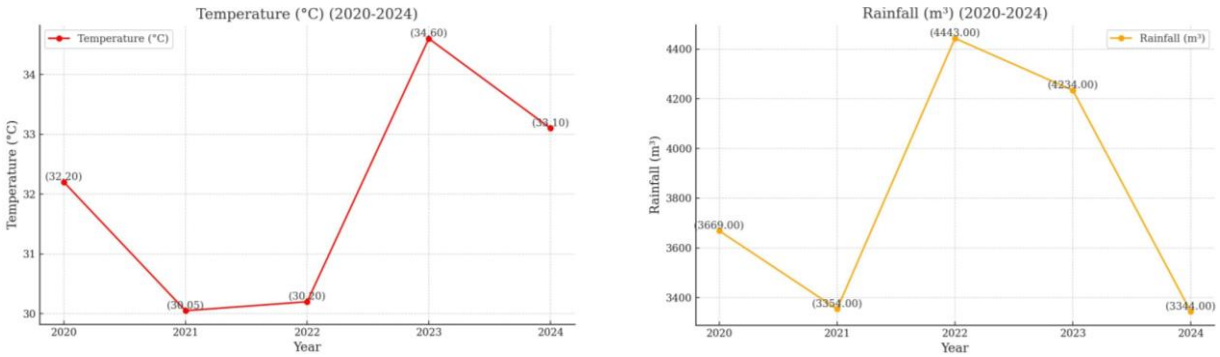


Figure 6. Blue Carbon analysis results of coral reefs on samalona island, south sulawesi 2020-2024



(a) (b)

Figure 7. (a) Average of temperature in South Sulawesi 2020-2024, (b) Average of rainfall in South Sulawesi 2020-2024. Source: The Hasanuddin Meteorology and Climatology Station

Table 2. Blue Carbon simple linear regression with temperature

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.666^a	.443	.257	1.67135

Table 3. Blue Carbon simple linear regression with rainfall

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.264^a	.070	-.241	563.94971

Based on Table 2 and Table 3, it can be seen that there is a relationship between Blue Carbon and the climate variables. The regression analysis between Blue Carbon and temperature in Table 2 has a value of 0.666, which indicates a strong relationship, suggesting that changes in Blue Carbon are closely related to significant variations in temperature. Meanwhile, Table 3 shows that the regression analysis between Blue Carbon and rainfall has a value of 0.264, indicating a weak relationship, meaning that changes in Blue Carbon are not strongly linked to changes in rainfall levels.

CONCLUSION

Observations results show that there are 33,22% Live Coral, 50,56% Dead Coral, 7,44% Others, and 8,78% Algae on Samalona Island in 2024. Blue Carbon values over the last five years respectively was 1,272 kg, 1,373 kg, 1,245 kg, 1,230 kg, and 1,185 kg. Analysis of the effect of Blue Carbon on coral reefs on climate change using SPSS software showed a regression determinant coefficient of 0,666 on temperature and 0,264 on rainfall. This indicates that changes in Blue Carbon on coral reefs have a significant role in temperature changes but have a less significant effect on rainfall patterns. These results show the importance of maintaining coral reef ecosystems because changes in Blue Carbon storage have the potential to worsen global temperature conditions, which can have an impact on marine ecosystems and human life in coastal communities.

REFERENCES

Kadek, V.C.D., Pradesti, R., Nurlaela, S., Murnisari, Y., Suryanda, A., & Aulya, N.R. 2023. Dampak Perubahan Iklim dan Aktivitas Manusia terhadap Kerusakan Ekosistem Terumbu Karang dan Biota Laut di Sekitarnya. *Panther*a : *Jurnal Ilmiah Pendidikan Sains dan Terapan*, 3(1):7-12.

Darwin P. Lubis. 2011. Pengaruh Perubahan Iklim terhadap Keanekaragaman Hayati di Indonesia. *Jurnal Geografi*, 3(2):109-116.

Susilawati. 2021. Dampak Perubahan Iklim terhadap Kesehatan. *Electronic Journal Scientific Environmental Health and Disease*, 1(2):25-31.

Intergovernmental Panel on Climate Change (IPCC). 2014. Climate Change 2014: Synthesis Report. Geneva, Switzerland: IPCC.

United Nations. (n.d.). What is Climate Change?. Retrieved January 15, 2025, from https://www.un.org/en/climatechange/what-is-climate-change.

Hoegh-Guldberg, O., Mumby, P.J., Hooten, A.J., Steneck, R.S., Greenfield, P., Gomez, E., Harvell, C.D., Sale, P.F., Edwards, A.J., Caldeira, K., Knowlton, N., Eakin, C.M., Iglesias-Prieto, R., Muthiga, N., Bradbury, R.H., Dubi, A., & Hatziolos, M.E. 2007. Coral Reefs Under Rapid Climate Change and Ocean Acidification. *Science*, 318(5857): 1737-1742.

Tuo SHI, Xinqing ZHENG, Han ZHANG, Qifang WANG, and Xin ZHONG. 2021. coral reefs: Potential Blue Carbon Sinks for Climate Change Mitigation. Bulletin of chinese academy of sciences, 36(3): 270-273.

Edinger, E.N., Jompa, J., Limmon, G.V., Widjatmoko, W., & Risk, M.J. 1998. Reef degradation and coral biodiversity in Indonesia: Effects of land-based pollution, destructive fishing practices, and changes

over time. *Marine Pollution Bulletin*, 36(8): 617-630.

Amalyah, R., Hamid, D., & Hakim, L. 2016. Peran Stakeholder Pariwisata dalam Pengembangan Pulau Samalona sebagai Destinasi Wisata Bahari. *Jurnal Administrasi Bisnis*, 37(1):158-163.

McLeod, E., Chmura, G.L., Bouillon, S., Salm, R., Björk, M., Duarte, C.M., Lovelock, C.E., Schlesinger, W.H., & Silliman, B.R. 2011. A blueprint for blue carbon: Toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2. *Frontiers in Ecology and the Environment*, 9(10):552-560.

Ayunda, A.P., Akbar, A.A., Romiyanto, R., Jati, D.R., & Saziati, O. 2023. Potensi Karbon Biru Pesisir Kalimantan Barat. *Buletin Oseanografi Marina*, 12(3):313-324.

Gattuso, J.-P., Allemand, D., & Frankignoulle, M. 1999. Photosynthesis and Calcification at Cellular, Organismal and Community Levels in Coral Reefs: A Review on Interactions and Control by Carbonate Chemistry. *American Zoologist*, 39(1):160-183.

Intergovernmental Panel on Climate Change (IPCC). 2021. Climate Change 2021: The Physical Science Basis. Cambridge University Press.

Kohler, K.E., & Gill, M. 2004. Coral Point Count with Excel extensions (CPCe): A Visual Basic program for the determination of coral and substrate coverage using random point count methodology. *Computers & Geosciences*, 32(9):1259-1269

Alhusin, S. 2003. Aplikasi Statistik Praktis dengan menggunakan SPSS 10 Windows. Graha Ilmu. Yogyakarta

Bahar, A., Lanuru, M., & Nasrullah. 2019. Analisis kesesuaian wisata snorkeling dan menyelam berdasarkan parameter bio-fisik di daerah terumbu karang Pulau Samalona, Kota Makassar. *Torani : Jurnal Ilmu Kelautan dan Perikanan*, 16(6):427-437.

Yusri, M.A., Nurfadiah, M., T.P., M.D., Az-zahra, M.D., F., M. I., Umri, S., Fadli, M., Amaliyah, T., & Aditya, M.F. 2017. Terumbu karang sebagai carbon sink dan pengukuran CO_2 menggunakan Carbondioxide Meter. Perkemahan Ilmiah Remaja Nasional (PIRN), Aceh.

Giyanto, A.E., Budiyanto, A., Wibisono, I., Muttaqin, E., & Setiawan, F. 2014. Panduan monitoring kesehatan terumbu karang: Terumbu karang, ikan karang, megabentos, dan penulisan laporan. COREMAP CTI LIPI. Jakarta, Indonesia.

Suharsono. 2008. Jenis-jenis terumbu karang di Indonesia (Ed. 2). Pusat Penelitian Oseanografi–LIPI. Jakarta.

Ayunda, A.P., Akbar, A.A., & Romiyanto, R. 2022. Ekosistem Pesisir sebagai Penghasil Karbon Biru. *Journal Environmental Policy and Technology*, 1(1):13-29.

Rembet, N.W.J. 2012. Simbiosis zooxanthellae e dan karang sebagai indikator kualitas ekosistem terumbu karang. *Jurnal Ilmiah Platax*, 1(1): 110-140