

# Coral reef ecosystem health status of Paladan Islands, Indonesia: An assessment criteria using coral cover percentage

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**Abstract.** Widodo ERS, Katili AS, Ibrahim M. 2021. Coral reef ecosystem health status of Paladan Islands, Indonesia: An assessment criteria using coral cover percentage. *Indo Pac J Ocean Life* 5: 8-13. This study aims to analyze the health of coral reef ecosystems in Paladan Island waters, Tojo Una-una District, Central Sulawesi, Indonesia. This research is a quantitative descriptive study using roaming data collection techniques and measuring the overall length of coral reef cover in a 5x5 meter<sup>2</sup> plot. The research was conducted for 4 months using survey methods. The percentage of live coral cover and mortality index was calculated and categorized according to coral reef health criteria reported from literature. The result showed that coral reefs in the Paladan Island waters exhibit 72.9% live coral cover with an IMK value of 0.09. A comparison of this result with the standardized coral reef health criteria indicates that the percentage coral cover is within a healthy range (50-100%) with an IMK value of  $\leq 0$ , suggesting that coral reef conditions have not changed or deteriorated. Based on the value of coral cover obtained, it is suggested that the coral reef of Paladan island is still in good condition. The rapid assessment criteria reported here may be useful for monitoring of coral reef ecosystem health.

**Keywords:** Community activities, coral reef cover percentage method, coral reef ecosystem health, Paladan island

## INTRODUCTION

Biodiversity is a potential that enriches an area with biological resources. It has become a fact that the Indonesian region has a great biodiversity potential of which coastal environment is an important component. Based on data from the Indonesian Minister of Marine Affairs and Fisheries in 2020, Indonesian waters' total area is approximately 3,110,000 km<sup>2</sup>. This large area of water has made Indonesia one of the countries rich in natural marine resources including coral reefs.

Coral reef is a dynamic ecosystem with rich biodiversity and high productivity, therefore, the role of coral reefs is very important in preserving the coastal ecosystem. (Suryanti et al. 2011) demonstrate that, the important role of coral reef ecosystems includes spawning ground and, housing and foraging for various types of fish species. Coral reefs can also be a wave buffer, protecting the coast from erosion, coastal flooding, and other destructive events caused by the phenomenon of seawater (Amin 2009).

The role of coral reef ecosystems is very strategic in supporting the availability of fishery resources and is one of the main pillars that contribute to the existence of coastal communities. According to Amrullah (2014), the dominant livelihood of coastal communities is fishermen who depend on coral reef resources for food and as source of income. Degraded coral reefs affect fish populations and as well as the livelihood of the coastal communities.

The coral reef ecosystem is currently one of the most threatened ecosystems because coral reef creatures have a very low tolerance ability to environmental stressors, and they can only survive in places where the conditions are favorable. The ecological boundaries of coral reefs are currents, sunlight, water clarity, depth and salinity (Zewanto et al. 2017).

Indonesia's coral reefs are under threat by human activities and natural phenomena. Human activities that damage coral ecosystem are fishing using bombs, cyanide, as well as several other types of destructive fishing gears. In contrast, the damage by natural phenomena involves earthquakes, tsunamis, drastic water temperature changes, and the abundance of coral-eating organisms such as the *Acanthaster planci* (Sahetapy et al. 2017).

Damage to coral reefs in Indonesia, one of which occurred in East Luwu District according to Ayyub et al. (2018), the estimated coral cover was 37%, impact that can occur due to the damage to coral reefs is the damage to the dwellings of the fish that live around coral reefs and can reduce the catch of reef fish by fishermen. meaning that the health of coral reefs is moderate (Reference). The damage reported herein was caused by activities of the coastal community of East Luwu District by catching fish using destructive fishing, bombing fish, and anesthesia.

Coral fringing reefs surround Paladan Island, so the Paladan archipelago is known as a rock fishing spot in the Tojo Una Una area, however, the unregulated use of fishing gears such as trawls and explosive bombs have

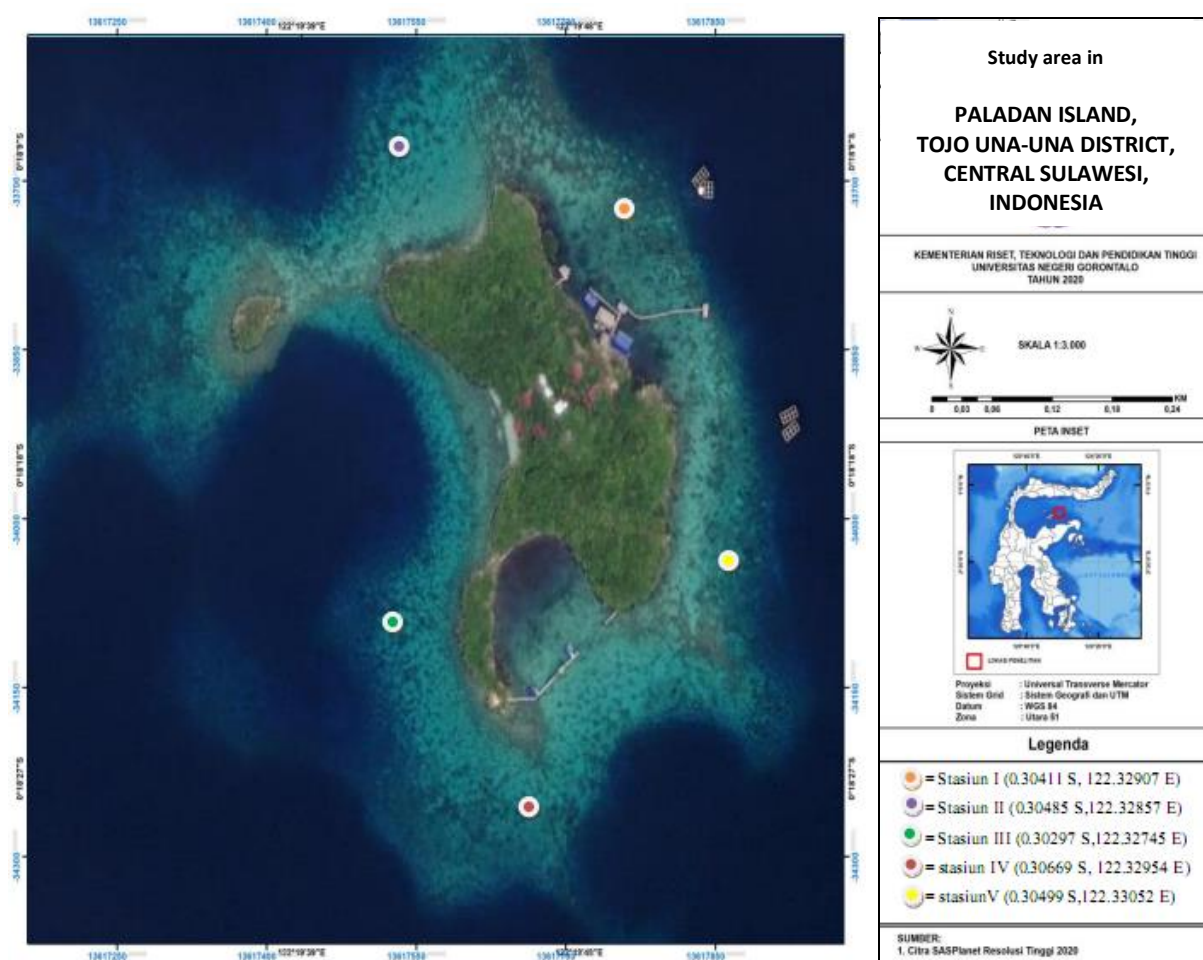
resulted in several coral reef ecosystems around Paladan Island experiencing the threat of damage (Suryanti et al. 2011), this is appropriate with the statement of Abrar et al (2012), where the decline in coral reefs in Indonesia is caused by various factors, including sedimentation, pollution originating from land such as industrial and domestic waste disposal, coral mining for building materials or other physical damages such as overexploitation of marine resources, and distractive fishing practices.

Based on observations made by researchers, the management of tourist attractions for Paladan Island is faced with various threats from ecological aspects, namely a decrease in environmental quality due to pollution and damage to coastal ecosystems. This fact shows that the management of natural tourism areas that do not pay attention to ecological aspects can affect the stability of the ecosystem, especially the coral reef ecosystem in the Paladan Islands by calculating the percentage of coral reef cover around the island. The method of calculating the percentage of coral reef cover has become the standard in determining the health of coral reefs (Ayyub et al. 2018).

## MATERIALS AND METHODS

### Study area

Paladan Island is one of the islands located in Tōjo Una-Una District which is used as a beautiful underwater park tour. The components of the coral reef ecosystem in Paladan Island waters consist of biotic and abiotic components. The biotic component consists of Acropora, Non-Acropora, algae and other fauna, while the abiotic component consists of dead coral, sand, scattered corals, water, and rocks. The condition of coral reefs in the waters of Paladan Island has never before been assessed on the health of coral reef ecosystems. The need for an assessment of the health of coral reefs because there are tourism activities that can affect the condition of coral reefs. Human activities that can negatively impact waste (anchor) of ships, disposal of ship fuel into the sea, and disposal of waste from tourist canteens to the sea. Coral reefs are the measurement criteria to determine how the coral reef ecosystem is, namely measuring the cover of live coral reefs and dead coral reefs. Can be seen on the location map.



**Figure 1.** Study area in Paladan Island, Tojo Una-una District, Central Sulawesi, Indonesia with survey station (I-V)

## Procedures

The survey started from interviews to find out about community activities, observe the community's core activities in conserving coral reefs, and collect coral reef data to see the health status of coral reefs. At each sampling station, a 50m Roll Meter is placed and transect measurements are taken. Scuba diving equipment was used for the underwater survey and data was recorded using an underwater blackboard and pencil. Underwater cameras are used for documentation, boats for transportation, handfractometers, used to measure salinity, GPS is used to determine the location of research stations, thermometers for measuring temperature, compasses for determining cardinal directions.

The data collection technique is carried out using the line transect technique, with the following work procedures: (i) At each station, a transect line is made from the shoreline to the sea along the length of 50 M using a meter which is given a ballast so that the meter is under the surface of seawater and above coral reefs; (ii) Make a plot of 5m x 5m placed in a zigzag manner so that it can represent every coral reef in the observation location; (iii) Measure the length of coral cover and record the length of coral cover within the plot; (iv) Physicochemical data collection was carried out in the morning, afternoon and evening at each observation station.

### Coral reef cover

#### Primary data

For coral reef conditions, a survey method is used by making a line transect of 100m and making a plot measuring 5m x 5m and measuring the total length of the coral reef plotted. The advantage of this method is that it makes it easier to collect data in the field because it can represent the samples taken by the researcher.

Calculation of the percentage of live corals. The percentage of coral cover (%) is known using the Cox formula (1967), which is as follows:

$$\text{Percentage of coral reefs (\%)} = \frac{\text{Colony size length (cm)}}{\text{Transect length (cm)}}$$

The mortality index was determined using the formula of (English et al, 1997), which is as follows:

$$IM = \frac{DC}{(LC + DC)}$$

Where, IM = Mortality Index; DC = Percentage of dead coral cover; LC = Percentage of live coral cover.

### Secondary data

The secondary data were obtained from coral reef substrate components reported in previous studies and related agencies of the Coastal and Marine Resources Management Agency.

### Measurement of physicochemical parameters

The physicochemical parameters of the waters around Paladan Island were collected. The water temperature was measured with a thermometer, salinity with a, pH with a color litmus paper. The current velocity was measured by pimpong ball method.

### Community activities

Describe community activities as primary data to support other causes of damage to coral reefs caused by community activities described in the discussion.

## Data analysis

### Physical-chemical parameters of waters

The physicochemical parameters (salinity, temperature, pH, current velocity) for the water were analyzed descriptively and presented in form of tables or graphs and then evaluated base on KEPMEN LH No. 51 of 2004 of water quality standards for Indonesian marine waters (Table 1).

### Live coral cover

The percentage of coral cover obtained from this study was categorized base on the coral reef health criteria in table 2. The health of coral reef ecosystems was categorized according to the Minister of Environment Decree No.4 of Year (2004), where the coral cover value within the range of 50-100% is declared healthy while below this range is declared unhealthy or damaged. The dead coral reefs were identified base on the calculated IMK value  $\leq 0.0$ , which indicates either non-existent or experience little damage. The IMK value close to 1.0 indicates no change in the status of the coral reefs (English et al, 1997). All secondary data were obtained from previous studies on coral reef ecosystems. The field data were presented descriptively in form of figures and tables. The secondary data related to standards protocol were mentioned on a case-by-case basis to validate the research findings.

**Table 1.** Indonesian marine water quality standards

Physico-chemical parameters	Value
Salinity	30-34 ‰
Temperature	28-30 °C
pH	7-8.5
Strong currents	0.28-0.45 M/Scnd

Note: Keputusan Menteri LH No.51 Tahun 2004

**Table 2.** Categories of coral reefs

Coral reef category (%)	
Bad	0-24.9
Moderate	25-49.9
Healthy	50-74.9
Very Healthy	75-100

Note: Keputusan Menteri LH No.4 Tahun 2004

## RESULTS AND DISCUSSION

### Percentage of coral reef cover and mortality index in Paladan Island Waters

Based on the results of coral reef observations on the island of Paladan, the following coral reef cover and mortality index were obtained in Table 3.

The average coral reef cover value obtained, was 72.9% for all transect. This value is in a good category because it is in the range of 50-75%, in accordance with the Minister of Environment Decree No. 4 of 2004. While the dead coral cover in Paladan Island waters from stations I, II, III, IV, and V is in the range of 0-19.7%. If averaged, the value of dead coral cover was 9.9%.

The coral reef condition in Paladan Island waters was 72.9% life coral reef. This value is within the healthy category (50-100%). The dead coral reefs account for only 9.9% of all sampling stations. The total percentage of coral cover is less than 100% suggested. This is due to the different geographical conditions at each station and the shape of the coral reefs that resemble small islands below sea level, so that the total value of each station does not reach 100%.

The IMK value of coral reef conditions in Paladan Island is 0.12. This mortality index value is classified as low, suggesting that the health condition of coral reefs is not affected.

### Physical-chemical factors of coral reefs in Paladan Island Waters

Based on the observations made at five stations for measuring physicochemical parameters, there are several influences on the research location, namely rain during chemical physics data collection. The chemical physics data obtained the following results.

The average physicochemical factor measurement can be explained as follows, the circulating salinity state is

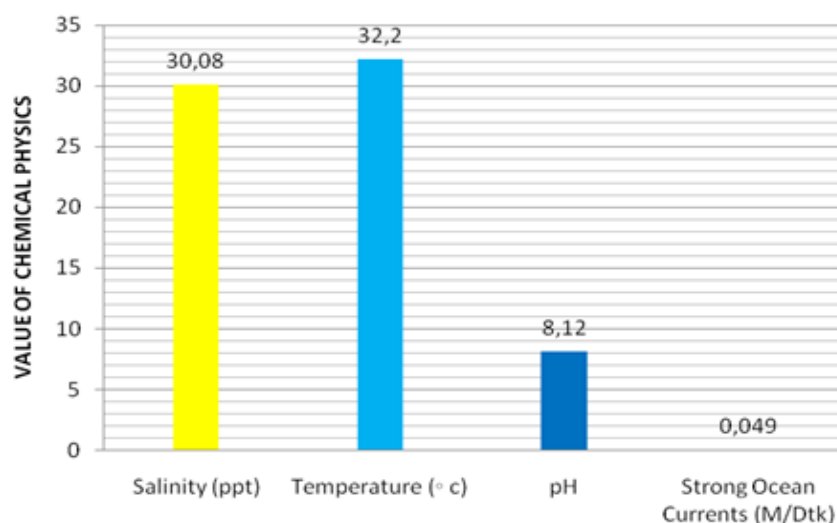
30.08%. Furthermore, the pH value in Paladan Island waters was 8.12%. The current strength in Paladan Island waters is 0.049 m/sec. The temperature in Paladan Island waters is 32.2°C. Referring to the Decree of the Minister of Environment No. 51 of 2004 concerning the Quality Standards for Indonesian Marine Waters that the physical conditions of Paladan Island waters for salinity, pH, and current strength in normal conditions of salinity are 30-34‰, pH 7-8.5, and current strength is 0.28-45 m/sec. Meanwhile, the temperature is still in the normal range.

### Discussion

The coral reef cover found estimate for stations I, II, III, and V is in the range of 51.1-87.7% (Figure 2). The average coral reef cover value obtained, was 72.9% for all transect. This value is in a good category because it is in the range of 50-75%, in accordance with the Minister of Environment Decree No. 4 of 2004. While the dead coral cover in Paladan Island waters from stations I, II, III, IV, and V is in the range of 0-19.7%. If averaged, the value of dead coral cover was 9.9%.

**Table 3** Percentage of coral reefs and coral reef mortality index in Paladan Island, Tojo Una-una District, Central Sulawesi, Indonesia

Location of coral reefs	Percentage of live coral reefs (%)	Percentage of dead coral reefs (%)	IMK
Island Paladan St I	87.1	10.6	0.11
Island Paladan St II	76.6	5.7	0.07
Island Paladan St III	84.8	0	0
Island Paladan St IV	64.7	13.6	0.17
Island Paladan St V	51.1	19.7	0.28
Average	72.9	9.9	0.12



**Figure 2.** Physicochemical properties of the seawater in Paladan Island, Tojo Una-una District, Central Sulawesi, Indonesia

The condition of coral reefs at station I is close to boat moorings, station II is a favorite place for fishing tourism, station III is a location that is difficult to reach by tourists because it is located behind Paladan Island, while stations IV and V are at boat moorings and locations. diving for tourists. From the previous explanation, the condition of coral reefs facing the threat of damage, namely at stations I, II, IV, and V.

Based on the survey result for each station, the overall percentage of live coral was 72.9%. This figure suggests that the health of the coral reef ecosystem in Paladan Island in stable condition. According to research by Ampou et al. (2020), coral cover within the range of 50-100% indicates healthy coral reef condition.

In calculating the mortality index, for the total cover value of dead coral, the mortality index value was 0.12. This value is classified as a mortality index value close to 0 or almost no dead coral reefs are found around the waters of Paladan Island. It can also be said that there is no change in the condition of living coral reefs. According to the statement of Ampou et al. (2020), a mortality index value that is close to 1 indicates a healthy coral reef system.

The forms of colonies in Palada Island waters are ACB (Acropora branching), ACS (Acropora submassive), ACE (Acropora Encrusting), CM (Coral massive), and CB (Coral Branching). This is following research conducted by Afni (2017) where this type of coral growth is in a sandy substrate with a depth of three-five meters above sea level. While the dead corals found in Paladan Island waters are coral reefs that are experiencing bleaching.

The low number of dead coral reefs in Paladan Island waters is influenced by the low threat experienced by the coral reef ecosystem. One of the biggest threats that can contribute greatly to the health of coral reef ecosystems is community activity. Farid et al. (2018) reported that community activities can contribute negatively to coral growth especially fish trawling activities. Additionally, the authors general observation was that the activities of residents in utilizing these waters are still minimal, since most of the residents of Paladan Island were engaged in gardening activities than those who are fishermen. According to the data obtained from the local government, the number of households in the supply village directly adjacent to Paladan Island is 975 households. It was also reported that 25 families are active farmers while 875 families are farm laborers who would earn a sum of 50 KK as ASN workers (Village Government Supply Data 2019). Based on the facts from the data, it is clear that the condition of the waters in the Paladan island area does not receive much influence from the activities of the residents.

Conversely, other threats could exist. In accordance with the author's observation, the presence of waste disposal from tourism activities on the island of Paladan could be a future threat if it is not properly managed. The garbage on Paladan Island is thought to impact and threaten existing coral reefs in the form of visible damage, although currently, it is still on a small scale. Garbage on the water surface may have negative consequences for coral reef creatures by preventing light from penetrating through the water surface (Farid et al. 2018). Yuliani et al. (2016)

stated that garbage floating on the sea surface prevents light from entering the seawater, consequently reducing metabolic activities that may result in coral death where such case was reported in the Lhokseudu area, Leupung sub-district, Aceh Besar district.

Further, underwater snorkeling and diving can threaten the existing coral cover conditions, especially for unregulated activities. Another threat that might occur is the damage to the morphological structure of the coral reef from the activities related to coral reef trade where corals are used as commercial objects. This fact is in line with the research presented by Ayyub et al. (2018) that uncontrolled human activities such as exploiting coral reefs for economic purposes can negatively impact coral reef ecosystems. Activities such as snorkeling and diving can accidentally cause damage to coral reefs especially by stepping on live corals fragile. According to the research of Akhmad et al. (2018), the snorkeling around tourism area of Karimunjawa National Park could increase vulnerability of corals trembling and leading to damage.

Another threat that is certain to occur is global warming. Global warming could be a major threat to coral reefs in the waters of Paladan Island. According to Latuconsina's (2010) statement, the global warming process begins by trapping greenhouse gas emissions such as carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrogen oxides (NO<sub>x</sub>), chlorofluorocarbons (CFCs), and other excess gases in the atmosphere, so that some of the geothermal heat is trapped and can cause an increase in temperature at the earth's surface which is called global warming. The impact that can occur due to an increase in the earth's surface temperature according to Salim's research (2016), an increase in the earth's surface temperature can cause coral bleaching due to the death of zooxanthellae algae which function as food providers for corals. This statement is evidenced by an increase in water surface temperature, namely 32.2°C, over time this temperature increase will continue due to human activities that can increase carbon dioxide emissions.

Based on the discussion, it can be concluded that the health status of coral reefs in the waters of Paladan Island is in good condition, indicated by the low mortality index value, suggesting that the coral reefs in Paladan Island waters are not being damaged. Based on the measurement of physicochemical parameters, it can be concluded that salinity, pH, current strength, and temperature are in good condition to support coral reef life. Threats that can slowly destroy the coral reef ecosystem in Paladan Island waters are garbage, irresponsible visitor activity, and global warming.

## REFERENCES

- Abrar M, Bachtiar I, Budiyo A. 2012. Community structure and disease in corals (Scleractinia) in Lembata Waters, East Nusa Tenggara. *Ilmu Kelautan* 17 (2): 63-73. DOI: 10.14710/ik.ijms.17.2.109-118. [Indonesian]
- Afni N. 2017. Coral Reef Condition in Samatellu Pedda Island, Liukang Tupabbiring District, Pangkep District, South Sulawesi. [Thesis]. Science dan Technology Faculty, UIN Alaudin, Makassar. [Indonesian]

- Akhmad DS, Supriharyono, Purnomo PW. 2018. Community structure and disease in corals (Scleractinia) in Lembata Waters, East Nusa Tenggara. *Ilmu dan Teknologi Kelautan Tropis* 10 (2): 419-429. DOI: 10.29244/jitkt.v10i2.21495. [Indonesian]
- Amin. 2009. Coral reefs; Threatened Assets (Problems and Alternative Solutions to Rescue them). *Region I* (2): 1-12 [Indonesian]
- Ampou E, Widagti N, Nugroho S, Sangaji I. 2020. Status of coral reefs and reef fish in Gili Matra, Nusa Tenggara Barat. *Ecotrophic* 14 (1): 14-27. [Indonesian]
- Amrullah, Amrullah. 2014. Analysis of Coral Reefs Condition with Remote Sensing Approach in Liukang Tuppabiring District, Pangkep South Sulawesi. *Biotek* 1 (1): 1-14 [Indonesian].
- Ayyub FR, Rauf A, Asni A. 2018. Management Strategy of Coral Reef Ecosystem in the Coastal Area of East Luwu District. *Pendidikan Teknologi Pertanian*, Vol. 4 (2018) : S56-S65 [Indonesian].
- Cox GW. 1967. *Laboratory Manual of General Ecology*. MC Brown Company Publishers, Dubuque, Iowa.
- Decree of the Minister of Environment Number 4 of 2004 concerning Standard Criteria for Damage to Coral Reefs.
- English S, Wilkinson C, Baker V. 1997. *Survey Manual for Tropical Marine Resources*. ASEAN-Australian Marine Science Project: Living Coastal Resources. Australian Institute of Marine Science, Townsville, Australia.
- Farid M, Wahyu P, Supriharyono. 2018. Changes of coral reef cover in terms based of tourists number in Tanjung Gelam, Karimunjawa Islands using oil Landsat 8 satellite imagery. *J Maquares* 7 (1): 18-27. [Indonesian]
- Indonesian Minister of Marine Affairs and Fisheries Data. 2020. Indonesian Outer Sea Data 2020.
- Latuconsina H. 2010. The impact of global warming on coastal and ocean ecosystems. *Agrikan Agribisnis Perikanan* 3: 30-37. DOI: 10.29239/j.agrikan.3.1.30-37. [Indonesian]
- Sahetapy D, Widayati S, Sangadji. 2017. The impact of community activities on the coral reef ecosystem in the Katapang coastal area, western Seram District. *Triton* 13 (2): 105-114. [Indonesian]
- Salim D. 2016. Management of coral reef ecosystems due to bleaching and damage. *Kelautan* 5 (2): 1907-9931. DOI: 10.21107/jk.v5i2.870. [Indonesian]
- Suryanti, Supriharyono, Indrawan W. 2011. Coral reef conditions with Chaetodontidae fish as indicators in Sambangan Island, Karimun Jawa Islands, Jepara, Central Java. *Oseanografi Marina* 1 (1): 106-119. DOI: 10.14710/buloma.v1i1.2988. [Indonesian]
- Village Government Data Supply. 2019. *Job Data and Number of Households*.
- Yuliani W, Ali MS, Saputri M. 2016. Community management of coral reef ecosystems in the Lhokseudu area, Leupung District, Aceh Besar District. *Jurnal Ilmiah Mahasiswa Pendidikan Biologi* 1 (1): 1-9. [Indonesian]
- Zewanto I, Nasir M, Kurnianda V. 2017. Percentage of coral cover at Ulee Kareung Beach, Simpang Mamplam District, Bireuen District. *Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan Unsyiah* 2 (2): 302-309. [Indonesian]