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A MAPPING OF CHANGES IN CORAL REEFS CONDITION BASED ON DEVELOPMENT THE MARINE ECOTOURISM IN THE SOUTHERN PART COAST OF PADANG CITY – INDONESIA

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ABSTRACT: This study aims to determine changes in the condition of coral reef ecosystems using satellite imagery. The research method used is the Geographic Information System (GIS) approach using *Lyzenga* algorithm method with data of Landsat +ETM 7 in 1998, 2008 and Landsat OLI 8 in 2018. The results of this study indicate a decrease in the extent of coral reef conditions in 1998-2008 occurs in live coral cover covering 106.60 ha and the addition of area occurred in dead coral cover covering 147.97 ha. While the decrease of coral reefs condition in 2008-2018 occurs in dead coral cover covering 29.66 ha and the addition of area occurred in live coral cover covering 112.29 ha. Coral mortality index in Nirwana beach with an average 62.28 %, meaning very large coral deaths in this region. Coral mortality index in Cindakir estuary with an average 46.60 %, meaning quite large coral deaths in this region so that coral reefs need to be rehabilitated in these waters, which can be done in form of artificial coral transplants. The coral mortality index in Muara Dua bay average 39 %, meaning that coral mortality is quite large in this region, while the coral mortality index in Ujung Siboko bay average 44.65 %, this means quite a large number of coral deaths in this region, but this location has a very good soft coral and it is necessary to rehabilitate corals in these waters with the form of artificial coral transplants.

Keywords: Coral Reef, Coast, Satellite Imagery, Lyzenga, Padang City

1. INTRODUCTION

Indonesia has huge natural resources, especially natural resources derived from the sea, one of which is a coral reef, coral reef ecosystems that are extremely important for marine waters and habitats for fish and other marine life. Coral reefs are found in shallow aquatic environments such as exposure to continents and clusters of islands in tropical waters between latitude 30°N and 25°S [1-4]. Based statement on [5-6] coral reefs as a living place for various other tropical marine biota have very high and very productive species of biota. In general, the existence and condition of coral reefs greatly affect the wealth and diversity of reef fish. If the condition of the coral reef is good then the diversity of fish is high, and vice versa, if the condition of the coral reefs is bad then the diversity of the fish is low.

[7-11] explain that excessive utilization towards coastal and marine resources can cause damage to the ecosystems that are in particular coral reefs. These damages have a huge influence on both ecologically and economically. Where is it economically influential on fishermen's catch, while ecologically it can have an impact on the damage to other marine ecosystems. To control every activity so that economic and ecological aspects continue to run in a balanced manner, sustainable management is needed to preserve the sea.

Degradation of coral reef ecosystems will indirectly affect the imbalance of the surrounding ecosystem. Based on the report of the Department of Marine and Fisheries of West Sumatra Province [12-14], about 75% of the coral reefs in West Sumatra Province were damaged. The biggest cause of damage is due to coral bleaching or coral bleaching that occurs due to rising sea water temperatures in 2015-2016. While the remaining around 25% is in good condition. Other causes of damage to coral reefs are: 1) fishing activities that are not environmentally friendly; 2) increase in waste which causes pollution of the sea both from the activities of the ship (oil spill); 3) increase in household waste flowing into the sea; and 4) the marine tourism activities such as diving (Diving) and snorkelling can also put pressure on coral reef ecosystems. [15,16] added that diving tourism (Diving) is one of the eco-tourism activities of marine tourism which is very popular with the community, but the activities of divers (Diver) This certainly has a big impact on the condition of the coral reef ecosystem compared to Snorkelling

tourism only floats on the surface of the water and is on a coral reef.

The potential of marine ecotourism in the coastal and marine areas of the city of Padang is very large seeing the vastness of the waters and the number of small islands. The potential of coral reef ecotourism in the coastal and marine areas of the city of Padang was carried out as an effort to strengthen existing marine tourism. This is needed as an input in the sustainable use of coastal and marine resources. In its management, integration between various parties is incorporated into a coordination that directs various activities in the coastal and marine areas. This is intended as a programmed effort to achieve goals that can support the various interests of the community, in order to maintain the environment and achieve adequate economic development.

With the development of Geographic Information System (GIS) technology using satellite imagery data, not only the appearance of the land area can be mapped, but also the appearance of the bottom waters. Mapping by utilizing satellite imagery data can cover a large area without having to make direct observations, including mapping the distribution conditions of coral reef ecosystems at the bottom of the sea. In processing satellite imagery for mapping coral reef ecosystems, there are several methods that can be used. One of them is the algorithm method Lyzenga [17] or better known as the depth-invariant index (water column correction) [18 –19]. Based on the background of the problem, the purpose of this study was to determine the condition of changes in coral reefs using satellite imagery data on the Southern coast and sea in Padang City.

2. RESEARCH METHODS

2.1 Research locations

The research carried out on water areas on the Southern coast of Padang City, for more details can be seen in Table 1 and Fig. 1 below.

Table 1. Research locations administration

No.	Location	Administration		UTM 47 S coordinates	
		village	sub-district	Eastern	North
1	Nirwana Beach	Gates Nan XX	Lubuk Begalung	654205.92	9886919.67
2	Cindakir *	North of Teluk Kabung		656924.18	9883481.49
3	Ujung Siboko *	The Southern of Teluk Kabung	Teluk Kabung Bungus	652399.15	9875654.58
4	Muara Dua*			651911.95	9874490.32

*Description: Toponymy naming the location of the study refers to the Map of “Rupa Bumi Indonesia” 0741 6444 - 6447 Padang. Agency of Geospatial Information/BIG, 2008.

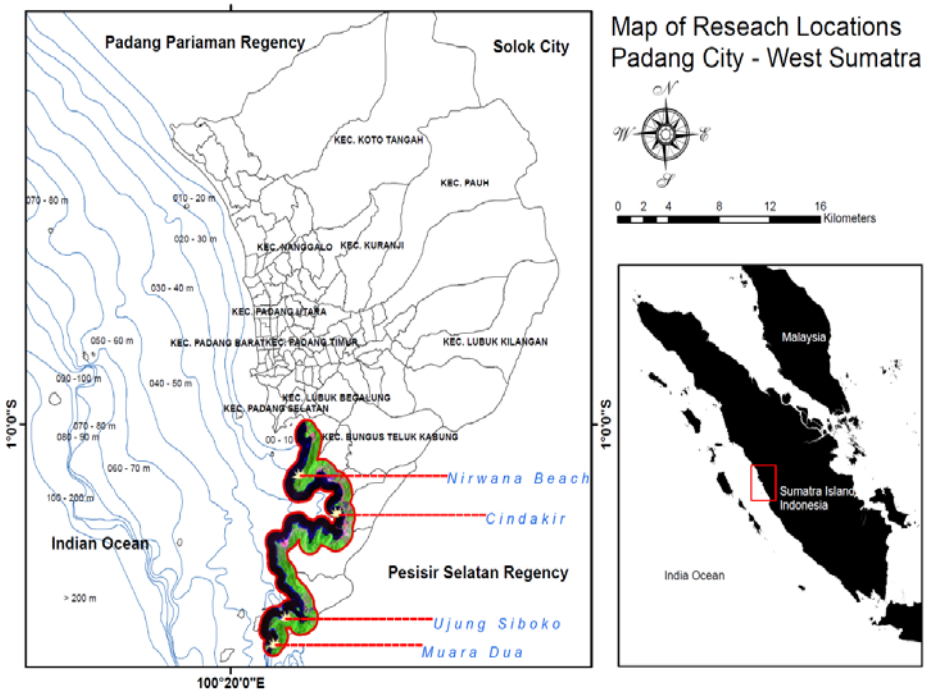

Fig.1 Map of Location Research

Determination of the sample is based on the survey field is done by determining the observation point using a GPS point and documented by digital underwater camera. The sampling method chosen was stopped and go, i.e observation of field data taken by looking at the existing conditions of coral reef ecosystems and visual appearance of the watershed in the field. The field survey data obtained is then used to carry out image processing.

The results of field observation obtained component of coral reef ecosystems that consist of the form [Hard corals (*Acropora* and *non-Acropora*), *Dead scleractinia, Algae*, Other fauna and abiotic] with the total number of sample observation of as many as 12 samples, of which 12 samples were used to input the classification process and test the accuracy of satellite images for the existence and status of the resulting coral reefs.

2.2 Analysis technique of satellite imagery

In this study, the technique used in the imagery sharpening procedure is by technique band combination. This band combination method is used to see the distribution of land cover and coastline boundaries more clearly, seen from the brightness value of the same surface material caused by topographic conditions, shadows, the intensity of sunlight and seasonal changes. [20] added the band combination used for analysis of land cover using Landsat imagery +ETM 7 in 1998, 2008 and Landsat OLI 8 in 2018 consisting of bands 4 (red), 3 (green) and 2 (blue). Band 4 has a high response to vegetation, band 3 has a response to the coastline and the band 2 is the most important band of coastal studies and bathymetric mapping. Whereas cropping is intended to limit the research location accordingly with research needs. In this study, empirically location in the buffer with a distance of 500 m from the shoreline towards the land and sea [21, 22]. These cuts also based because the scope of the first scene Landsat imagery is quite large (185 x 185 km).

2.3 Lyzenga algorithm

Lyzenga algorithm equation is used for extracting basic water information (Y) for information on the distribution of aquatic ecosystems. For this reason, we need two image spectral channels and a ki/kj ratio which is the coefficient ratio between the two channels (blue and green). [3] explained that the Lyzenga algorithm is influenced by channel i (blue channel) and j (green channel) pairs used. Blue and green channels have wavelengths with the best penetration among other canals. Based research [23] the Lyzenga algorithm can be applied first by calculating the water coefficient value (ki/kj). From the above equation, the ki/kj value is determined by the value of a, the value of a obtained by extracting digital values on the blue and green channels in the same geographical position on the mapping location in the form of polygon area taken in shallow water areas. Then it is calculated statistically to obtain the varian and covarian values for the blue and green channels so that a value is obtained and the coefficient ratio (ki/kj) is based on the equation above.

3. RESULTS AND DISCUSSION

3.1 Condition Classification of underwater

Supervised classification aims to group pixel values in imagery into several classes based on the location of the cropping area [20,11]. Location information cropping area based on the underwater appearance on the Southern coast in Padang city, and in digitizing as well field surveys were carried out in homogeneous areas with almost uniform colors in the Landsat imagery. The results of the classification of the underwater appearance year 1998, 2008 and 2018 (Fig. 3) are determined with a distance of 375 m from the coastline in the direction of land and 375 m towards the sea for the size of the buffer zone 750 m [20] with extensive cropping areas 5.240,97 ha. The changes in the extent of the appearance of the basic objects of the underwater on the Southern coast in Padang city can be seen in Tables 2, 3, and Fig. 2 below.

Table 2. Underwater appearance condition in 1998 - 2008.

Underwater appearance	Year		Changes (ha)	Rate
	1998	2008		
Live coral	*199.24*	*92.64*	*106.60*	*31%*
Dead coral	*151.33*	*299.30*	*147.97*	*44%*
Sedimentation/Sand	172.26	88.13	84.13	25%
Total	522.83	480.07	338.69	100%

Source: Data analysis, 2018.

Table 3. Underwater appearance condition in 2008 - 2018.

Underwater appearance	Year		Changes (ha)	Rate
	2008	2018		
Live coral	*92.64*	*204.93*	*112.29*	*77%*
Dead coral	*299.30*	*269.64*	*29.66*	*20%*
Sedimentation/Sand	88.13	92.83	4.69	3%
Total	480.07	567.40	146.64	100%

Source: Data analysis, 2018.

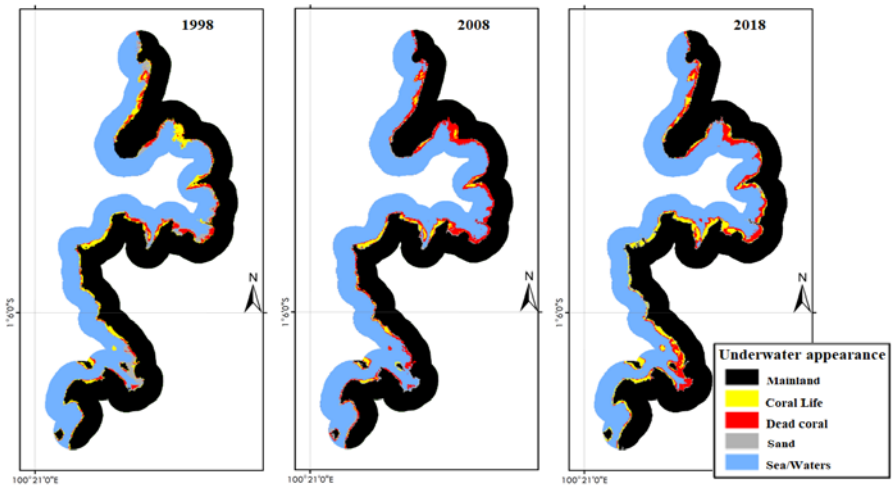

Fig. 2 Map of underwater appearance on the Southern coast of Padang City.

The results of the overlay to determine changes in the underwater appearance in time series on the Southern coast in Padang city showed a decrease in the extent of coral reef conditions in 1998 - 2008 occurred in the live coral cover of 106.60 ha (31%) and sedimentation of 84.13 ha (25%). The addition of the area occurred in the dead coral cover an area of 147.97 ha (44%). While the decline in the extent of coral reef conditions in 2008 - 2018 occurred in the dead coral cover an area of 29.66 ha (20%). The expansion of the area occurred in the live coral cover of 112.29 ha (77%) and sedimentation of 4.69 ha (3%).

3.2 The condition of coral reef ecosystems

Nirwana beach

In 1998 - 2008 the condition of coral reefs in the underwater of Nirwana beach was damaged, then in 2008 - 2018 the condition of coral reefs gradually improved, where one of the activities carried out by environmentalists and local government is to plant some artificial coral reefs at the Nirwana beach. Damage to the coral reefs in Nirwana Beach is indicated to be caused by the activity of fishermen and tourists in which the Nirwana beach area is one of the locations of marine ecotourism and is also a proposed conservation zone in Padang City [25,25]. Observation of coral reefs at Nirwana beach was carried out at 2 locations underwater appearance, i.e 1 observation for live corals in the Northwest (1°01'31.41"-100°23'08.24"), and observation 2 for dead coral in the Southern (1°01'22.28"-100°23'12.67").

The location of coral reefs measurements in the Northwest part of Nirwana beach is about 200 m from the coast. From the coast to the underwater the shape of a *flate*. Starting from the bottom slope of the water around 35° with a branched coral substrate that has died, but on a structure that is compact or not scattered. At this location, cracks 1-2 m are found which extend along the coastline. Live coral is still found to a depth of 17 m. Cover of live hard coral was 14.20% which consisted of 3.67% *Acropora* and 10.53% *non-Acropora*. Coral species found at this location are *Montipora sp*, *Sponge sp*, *Halineda sp*, *Acropora sp*, *Halimeda*, *Pocillopora sp*, *Porites sp*, and *Pocillopora damicornis sp*, the dominance of *montipora sp*. This location is quite potential as a dive site and can be developed better, with a note that it is necessary to rehabilitate coral reefs at this location.

While the measurement of the coral at the Southern part of Nirwana beach is about 150 m from the coast. In shallow water, the shape of a

flate reaches to the edge. From the edge to a depth of 15 m the slope of the underwater is about 75° (very steep/slope) with the hard bottom substrate and broken coral fragments. At a depth of more than 15 m, the slope of the base is approximately 50° (still quite slope) with a sand bottom substrate and broken coral fragments. At this location, many *sponge* is found. Live coral is still found to a depth of 18 m. Cover of live hard coral 34.97% consisting of 9.33% *Acropora* and 25.63% *non-Acropora*. Coral species found at this location were *Acropora sp*, *montipora venosa sp*, *pocillopora sp*, *porites sp*, *favites sp*, *montipora sp*, *pocillopora damicornis sp*, and *sponge*. In the following Table 4 shows the results of monitoring of coral reef ecosystems in Nirwana beach.

Tabel 4. The observation of coral reefs in the underwater of Nirwana beach

LIFE FORM	% cover (point 1/Northwest)	% cover (point 2/Southern)
Hard corals (Acropora dan non-Acropora)	14.20	34.97
Dead scleractinia	66.80	57.77
Algae	11.13	1.90
Other fauna	7.87	2.33
Abiotic	0.00	3.03

Source: Data analysis, 2018.

The coral mortality index in Nirwana beach (points 1 and 2) with an average of 62.28%, meaning that there is a very large coral mortality in this area. Especially in the Northwest which has a mortality index of 66.60%, so it is necessary to rehabilitate corals in these waters, which can be done in the form of an artificial coral transplant. However, the condition of the ocean waves at this location is quite large because it borders directly with the Indian Ocean. So it needs to be studied in more precise types of transplants and locations that need coral rehabilitation.

Cindakir estuary

In 1998 - 2008 the condition of the coral reefs in Cindakir estuary was damaged, then in 2008 - 2018 the condition of the coral reefs continued to suffer damage especially in the Southern and Northern parts of the Cindakir estuary. Cindakir estuary waters are downstream of Cindakir river where the headwater is generally a waterfall at that location in the form of large rocks. Based on the research results of [22] sediments that settle on the Cindakir beach and estuary in the form of gravels a fairly large scale, so it is not carried away by the flow of water. Observation of coral reefs in Cindakir estuary was carried out at 2 locations of objects of the appearance of the underwater, i,e observation 1 for corals live in the Southern (1°3'15.18" and 100°24'21.37); and observation 2 for dead coral in the Eastern (10°3'12.86" and 100°24'25.29").

In Cindakir estuary also found *Thalasia* seagrass, but seagrass vegetation is generally covered by sediments similar to coral reefs [24]. The visible sediment originated from runaway water from the Cindakir river. It is estimated that the coral reefs in Cindakir estuary will decrease in the area because they are located on the side of the road and close to settlements, and also as a place for fishing boat backrest.

The Southern reef measurements of Cindakir estuary are about 150 m from the coast. The bottom slope of the waters starts at around 70° with hard bottom substrate and dead-branched coral fragments that have been covered with algae and sand. Live hard corals are still found to a depth of 18 m. 42.72% live hard coral cover consisting of 8.99% *Acropora* and 33.73% *non-Acropora*. Coral species found at this location are *Pocillopora sp*, *Montipora sp*, *Acropora sp*, *Porites sp*, *Cyphastrea sp*, *Favites sp*, *Hydnopora microconos sp*, *Favia sp*, *Montipora venosa sp*, *Pavona sp*, *Psammocora sp*, *Goniastrea sp*, *Psammocora sp*, and *Hydnopora sp.*

The Northeastern reef measurement location of Cindakir estuary waters is around 120 m from the coast (is in front of a rock wall). The bottom slope of the water from the edge to a depth of 7 m is around 45°. At a depth of 7-15 m, the slope is 70° with the hard substrate and broken coral and sand. While the depth of more than 15 m base slope of about 50° with a fracture substrate of dead coral and sand. Live hard corals are still found to a depth of 20 m. Live hard coral cover 31.37% consisting of 5.94% *Acropora* and 25.43% *non-Acropora*. Coral species found at this location are *Porites sp*, *Acropora sp*, *Montipora venosa sp*, *Favites sp*, *Astreopora sp*, *Montipora sp*, *Sponge sp*, *Hydnopora sp*, *Pocillpora sp*, *Pocillopora damicornis sp*, *Pavona sp*, *Psammocora sp*, *Goniastrea sp*, and *Chyphastrea sp*, the dominance of *montipora sp*. This location is quite potential as a dive site and can be developed for the better. The following Table 5 shows the results of monitoring of coral reef ecosystems in Cindakir estuary.

Tabel 5. The observation of coral reefs in the underwater of Cindakir estuary

LIFE FORM	% cover (point 1/Southern)	% cover (point 2/Northeastern)
Hard corals (Acropora dan non-Acropora)	42.7	30.9
Dead scleractinia	37.7	55.5
Algae	8.7	5.7
Other fauna	2.6	1.4
Abiotic	8.3	6.5

Source: Data analysis, 2018.

The coral mortality index in Cindakir estuary (points 1 and 2) with an average of 46.60%, means that there is still a large coral mortality in this area. Especially in the Northeast which has a mortality index of 55.5%, so it is necessary to rehabilitate corals in these waters, which can be done in the form of transplantation of artificial corals.

Ujung Siboko Bay

In 1998-2008, the condition of coral reefs in the waters of Ujung Siboko Bay was quite severe, then in 2008-2018 the condition of coral reefs gradually improved. The waters of Ujung Siboko Bay are a sub-system of mangrove ecosystems characterized by mud and sandy beaches which are located some distance from the Northern and Western coasts of the Southern coast of Padang City and are protected from the influence of muddy river mouths and are thought to still have the ability to soften the effects of the sea in the form of sea breeze and the onslaught of waves towards the mainland.

Observation of coral reefs in the waters of Ujung Siboko Bay was carried out at 2 locations of objects of the appearance of the underwater, i.e observation 1 for live corals in the Northwestern part of Ujung Siboko (10°7'28.08" and 100°22-01-01"); and observation 2 for dead coral in the Southern (10°7'29.03" and 100°22'10.87").

The location of the coral reef measurements in the Northwest of Ujung Siboko Bay is in front of the rock walls. The slope of the bottom waters in the sea slope boundary to a depth of 10 m is around 50° with a hard bottom substrate. At a depth of 10-25 m, a slope of about 85° with gorgonian and soft coral overgrown with good shape. At a depth of more than 25 m slopes of about 45° with sand substrate and broken coral fragments, *Achantaster placi* was found. Cover live hard coral 7.70 % which consists of 1.8 % *Acropora* and 5.90 % *non-Acropora*. Coral species found at this location are *Acropora sp, montipora sp, fungia sp, sponge sp, pocillopora sp,* and *astreopora sp*, the dominance of *montipora sp*. However, although the hard coral cover is quite low, soft coral conditions that are quite good and beautiful make this location very potential as a dive site and can be developed better, just like the location of the Pasumpahan island which is in front of the waters of Ujung Siboko.

The Southern reef measurement location of Ujung Siboko Bay has a slope of around 45° with a hard bottom, broken coral, sand and mud. Dominated by coral species of porites which can be found up to a depth of 8 m. Live coral is still found to a depth of 22 m. Cover live hard coral 43.33% which consists of 3.23% *Acropora* and 40.10% *non-Acropora*. Coral species found at this location are *montipora sp, porites sp, Acropora sp, pectinia sp, coeloseris mayeri sp,* and *favia sp*. The following Table 6 results of monitoring of coral reef ecosystems in Ujung Siboko Bay.

Tabel 6. The observation of coral reefs in the underwater of Ujung Siboko Bay

LIFE FORM	% cover (point 1/ Northwest)	% cover (point 2/Southern)
Hard corals (Acropora dan non-Acropora)	7.7	43.3
Dead scleractinia	52.3	37.0
Algae	2.7	0.9
Other fauna	2.7	0.3
Abiotic	34.7	18.5

Source: Data analysis, 2018.

The coral mortality index in Ujung Siboko Bay (points 1 and 2) was 44.65%. This shows a significant amount of coral death in this area so that a striking change in living coral is seen in the form of dead coral around it. Especially what happened in the Northwest which has a mortality index of 52.3%, but this location has a very good soft coral and quite beautiful. Coral rehabilitation needs to be done in these waters, which can be done in the form of artificial coral transplants, in this case, coral transplants have been carried out in waters around Ujung Siboko Bay in Western part.

Muara Dua Bay

In 1998-2008, the condition of coral reefs in the waters of Muara Dua Bay was damaged after the construction of several resorts along the coast and fishing activities in the region are not environmentally friendly, because this area is closed and far from human activities. Furthermore, in 2008-2018 the condition of coral reefs continued to be damaged, especially in the Southen and Northwest, as was the case in 1998 - 2008. The waters of Muara Dua Bay are the location of marine conservation protected zones in the Southern part of Padang City which adjacent to the tourist sites of Swanadwipa and Sironjong Island, where the administration of Muara Dua Bay waters is the boundary between Padang City and Pesisir Selatan Regency.

Observation of coral reefs in Muara Dua Bay is only done at 1 location, i.e the North - Northeast (10°8'06.5" and 100°21'54.37"), because in the vicinity of coastal waters mostly in the form of sand. White sandy beach and there are chunks of dead coral whose shape is no longer clear. Distance from the beach about 50 m, the transect point is adjacent to the Jetti Swarnadwipa pier. The base substrate is hard and has been covered by montipora sp species which dominate at this location. The bottom slope of the water is about 40°. Live coral is still found to a depth of 17 m. The percentage of live hard coral cover is 21% which consists of 0.0% *Acropora* and 23% *non-Acropora.* The coral species found at this location were *Acropora sp, montipora sp and sponge sp, with montipora sp* dominance. The following Table 7 results of monitoring of coral reef ecosystems in Muara Dua Bay.

Tabel 7. The observation of coral reefs in the underwater of Muara Dua Bay

LIFE FORM	% cover (point 1/ North - Northeast)
Hard corals (acropora dan non-acropora)	46
Dead scleractinia	39
Algae	0.7
Other fauna	0.2
Abiotic	14.1

Source: Data analysis, 2018.

The coral mortality index in Muara Dua Bay area is 39%. This shows a significant amount of coral death in this area, so that a striking change in living coral is seen in the form of dead coral around it. Especially what happened in the North and Northeast. Coral rehabilitation needs to be done in these waters, which can be done in the form of an artificial coral transplant.

4 CONCLUSION

Changes in the underwater appearance for the condition of coral reefs at the waters of the southern coast in Padang City showed a decrease in the extent of the condition of coral reefs in 1998 - 2008 occurred in the living coral cover of 106.60 ha at a rate of 31 %. The addition of the area occurred in dead coral cover covering an area of 147.97 ha at a rate of 44 %. While the decline in the extent of coral reef conditions in 2008 - 2018 occurred in dead coral cover covering an area of 29.66 ha at a rate of 20 %. The expansion of the area occurred in the living coral cover of 112.29 ha at a rate of 77 % at a rate of 3% for the cropping area of 5,240.97 ha. Mortality index calculation results show that the Nirwana beach area has very large coral mortality (62.28 %), while the smallest mortality index for coral mortality is found in Muara Dua Bay (39 %).

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