CORAL REEFS SPATIAL TRANSFORMATION VERSUS ANTHROPOGENIC ON SMALL ISLANDS, OUTER ZONE SPERMONDE ARCHIPELAGO

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ABSTRACT: Spermonde islands divided into four zones, the one zone is outer zone or barrier reef zone that begins from a distance of about 30 km from the coast of Makassar. It is consisting of ± 121 islands. The objective of this research was to analyze coral reefs transformation and anthropogenic impact. Distribution of shallow water ecosystem by using data for 41 years. They are Landsat MSS, TM, ETM, and OLI-TIRS of 1972, 1981, 1993, 2002, and 2013. The image processing are gap fill, atmospheric correction, geometric correction, image composite (true color), water coloumn correction, unsupervised classification, reclassification, accuracy assessment, and post classification. The result of analysis coral reefs transformation that occurred during 1972 to 2013 showed live coral area decreased approximately, dead coral, rubble and sand increased. The coral reef destruction on the outer zone was largely caused by human activities. These were indicated by a lot of lose fragments of rubble which were typical apparences resulted from destructive activities such as explosives fishing by bombs and chemicals.

1. INTRODUCTION

1.1 Background

Spermonde islands located in the Makassar Strait, South-West side of the peninsula of Sulawesi Island. It is known as island communities Sangkarang islands consisting of ± 121 islands. Spermonde islands divided into four zones e.g outer zone, middle outer zone, middle inner zone and inner zone. The outer zone or barrier reef zone is begins from a distance of about 30 km from the coast of Makassar. Eastern section can reach a depth of 40-50 m, while the western part of this zone has a steep contour directly (drop off) to a depth of over 100 m. The ecosystem of shallow water in Spermonde Archipelago has been directly threatened by human activities and by rising sea surface temperatures. The coral reef in the Coral Triangle Asia has been directly threatened by human activities and natural threats. The coral reef destructions happened in small Island, Spermonde Archipelago from human activity and by rising SST (COREMAP II). Lanyukang Island is one of eight small islands in outer zone, Spermonde Archipelago which has high potential ecosystem especially coral reef distribution. Therefore, spatial dynamic mapping and spatial prediction model of coral reef are needed to create good spatial planning for coastal area. Satellite or airborne remote sensing has increasingly been employed to map coral reef communities worldwide (Green et al. 1996; Andrefouet and Guzman 2005). While a range of these studies have used high spatial resolution data, e.g. IKONOS (Anders et al. 2013; Andrefouet et al. 2003; Riegl and Purkis 2005; Elvidge et al. 2004), Quickbird(Anders et al. 2013; Elizabeth et al. 2013; Mishra et al. 2006), Worldview (Elizabeth et al. 2013), and CASI (Elizabeth et al. 2013; Mishra et al. 2006). There are studies using medium spatial resolution data, e.g. Landsat (Brian et al. 2014; Damaris et al. 2013; Palandro et al. 2008). Thematic map can be used as a reference for spatial dynamics and habitat distribution of coral reef.

1.2 Objectives

The objective of this research was to analyze coral reefs transformation and anthropogenic impact.

2. METHODOLOGY

2.1 Study Area

Lanyukang is one of the islands in the Spermonde Archipelago, Pangkep District, Indonesia. Lanyukang has a land area of 6 ha which located 40 Km from Makassar.

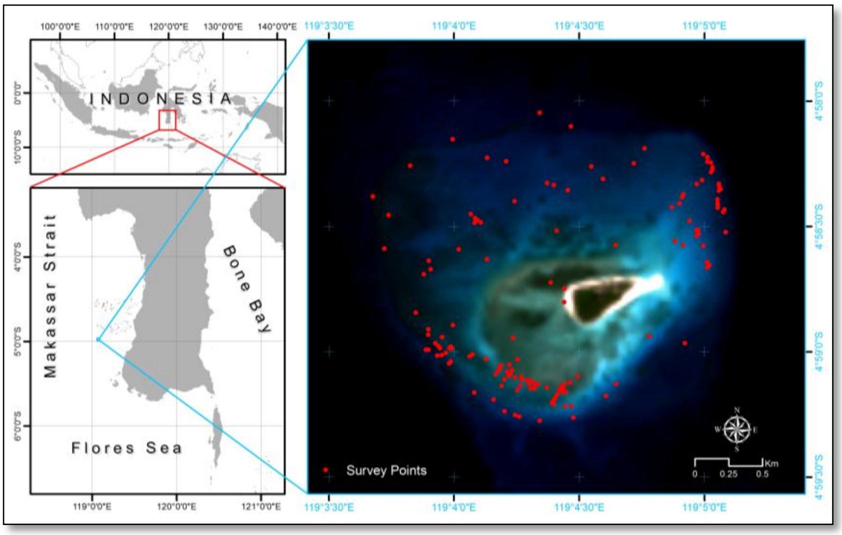

Figure 1. Study area in Lanyukang Island, one of the small islands in Spermonde Archipelago, Indonesia and selected are as ground truth point in coral reef (red point)

2.2 Data

Identification of bottom types in Lanyukang Island using Landsat image selected Landsat MSS, TM, ETM, ETM+, and OLI-TIRS to the years 1972, 1978, 1981, 1990, 1993, 1996, 1999, 2002, 2005, 2008, 2011 and 2013. The Landsat MSS data have four spectral bands, with a spatial resolution of 60 m. Landsat TM data have seven spectral bands, with a spatial resolution of 30 m for bands 1-5 and 7. The Landsat ETM data consisted of eight spectral bands with a spatial resolution of 30 m for bands 1-7. The Landsat 8 OLI-TIRS data have nine spectral bands with a spatial resolution of 30 m for bands 1-7 and 9. The following table shows the types of data (Table 1).

Table 1. Types of data

No	Satelite	Sensor	Resolution (m)	Acquisition	Path/Row
1	Landsat_1	MSS	60	1972-10-28	122/063
2	Landsat_3	MSS	60	1978-11-02	122/063
3	Landsat_2	MSS	60	1981-10-26	122/063
4	Landsat_4	TM	30	1990-12-16	114/063
5	Landsat_4	TM	30	1993-12-16	114/063
6	Landsat_5	TM	30	1996-04-28	114/063
7	Landsat_7	ETM	15	1999-09-20	114/063
8	Landsat_7	ETM	15	2002-06-24	114/063
9	Landsat_7	ETM	15	2005-09-04	114/063
10	Landsat_7	ETM	15	2008-08-19	114/063
11	Landsat_7	ETM+	15	2011-09-05	114/063
12	Landsat_8	OLI-TIRS	15	2013-10-04	114/063

Classification bottom types consisting of four classes (live coral, rubble and sand, dead coral with algae, and sand) were examined by Landsat MSS and TM data which have a 60 meter and 30 meter. There are eight class (coral cover

0-24.9%, 25-49.9%, 50-74.9%, 75-100%), dead coral, rubble, rock, and sand) for Landsat ETM, ETM+, and OLI which have 15 meter spatial resolution.

2.3 Image Processing

The image processing was composed of five main steps including: (1) gap fill, (2) geometric correction, (3) fusion, (4) preliminary analysis, and (5) image classification. Landsat Image delivered to the user may consist of some error, which may be caused by atmospheric, or sensor condition when capturing data from the earth surface. The Landsat 7 ETM+ scan-line corrector is a mechanism designed to correct the under sampling of the primary scan mirror, failed on May 2003This research used Gap method with Frame and Fill Software developed by Richard Irish in affliction with NASA Goddard Space Flight Center. The working principle of this software is filling the gap Landsat with the other Landsat image, which has different sections Gap. The varying pixel sizes of the different images were changed into a common map grid based on a reference image/map.

Evenly-distributed GCPs (Ground Control Points) were selected in different images and registered with the reference images/maps. A RMS (Root Mean Square) error of less than 0.5 pixels was accepted for the transformation. Resampling was performed by converting different pixel sizes into the same final image pixel sizes. Multisensor fusion is used to achieve high spatial and spectral resolutions by combining images from two sensors, one of which has high spatial resolution and the other one high spectral resolution. Image fusion between multi-spectral and panchromatic Landsat 7 ETM, and Landsat 8 OLI-TIRS images was done to achieve higher spatial resolution 15m. After satellite images were geometrically corrected, preliminary analysis methods could be applied for image enhancement, composite RGB, and cropping.

Image classification is a technique in processing a pixel of the image that has spectral reflectance appearance, which identified to separated objects that contained in the image satellite, and grouped then into certain characteristics in accordance with the real condition. Formerly, this was done by a masking technique to eliminate some of the area that was not needed. This research used Unsupervised Classification of ISOCLASS algorithm applying schema of habitat condition. They are rock and dead coral, mix bottom (sand and rubble), rubble, dead coral (DC), and live coral (coral cover 0-24.9%, 25-49.9%, 50-74.9%, 75-100%).

2.4 Ground Truth

Ground truth was conducted to determine the actual habitat on the ground. The result of ground truth was compared with the result of classification image. This method used transect quadrant 10 x 10 m^2 at each point of observation (sampling) which had been determined, then the percentage of each habitat of shallow water cover was assessed.

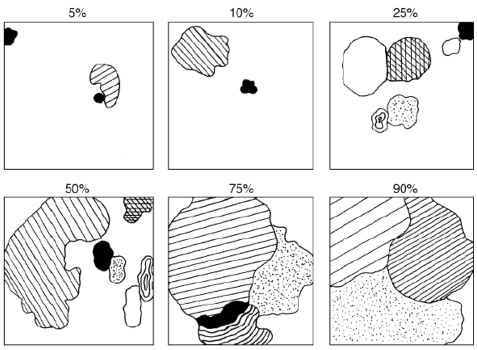

Figure 3 Estimation standart of coral cover, Rodgers (1994).

The field survey was limited by reflection of the bottom habitat which was detected by sensor satellite. The results of the were sea observation categorized based on Gomez and Yap, 1988 (Table 2).

Table 2 The criteria of coral cover

Percentage of coral cover (%)	Condition

75 - 100	Excellent
50 - 74.9	Good
25 - 49.9	Fair
0 - 24.9	Poor

Source: Gomez and Yap, 1988

2.5 Accuracy Assessment

Accuracy test was used to make any calculation matrix for each error (confusion matrix) on any kind of habitat shallow water cover resulting from the analysis satellite imagery. The following is a table of confusion matrix form (Table 3).

Table 3 Confusion matrix

Classified to class	**Reference (sample point)**			**Row Total (N_{i+})**	**User's Accuracy**
	1	2	K		
1	N_{11}	N_{12}	N_{1K}	N_{1+}	N_{11}/N_{1+}
2	N_{21}	N_{22}	N_{2K}	N_{2+}	N_{22}/N_{2+}
K	N_{K1}	N_{K2}	N_{KK}	N_{K+}	N_{KK}/N_{K+}
Column Total (N_{+i})	N_{+1}	N_{+2}	N_{+K}	N	
Producer's Accuracy	N_{KK}/N_{+1}	N_{22}/N_{+2}	N_{KK}/N_{+K}		

Source: (Congalton 1999)

Image validation was counted based on the above table such as *Overall Accuracy* (OA), *Producer's Accuracy* (PA), and *User's Accuracy* (UA). OA is a percentage of sample units that were classified accurately. PA and UA are ways of representing individual category accuracies instead of just the OA. PA is a percentage of probability average of a sample unit that refers to distribution of each class that had been classified in the field, while UA is a percentage of sample unit that actually represented the classes in the field. The confusion matrix in Table 3 helped make the transition of equation and mathematical notation easy to understand.

2.6 Post Classification

A post-classification change matrix function was applied between 1972 to 1978, 1978 to 1981, 1990 to 1993, 1993 to 1996, 1999 to 2002, 2002 to 2005, 2005 to 2008, 2008 to 2011, and 2011 to 2013 classification results.

3 RESULTS AND DISCUSSIONS

3.1 Coral Reef Transformation

Geometric correction process was done to obtain good accuracy image position of each class in coral reef and the real world. In this study, geometric correction process was performed using 7 point GCP. The result of geometric correction shows that the average RMSE obtained from Landsat images was 0.02. Our results show that for this shallow water, coral reef change can be seen by comparing the coral reef maps at different time series. The results of changes in the coral reef areas during the six acquisition years are represented in Table 4.

Table 4. Areal estimates of major bottom types in 1972, 1978, 1981, 1990, 1993, and 1996

Classes	**Areal of Lanyukang Island (Ha)**					
	1972	**1978**	**1981**	**1990**	**1993**	**1996**
Live coral	420.71	413.98	414.63	345.45	329.46	297.42
Dead coral	2.58	4.80	6.64	35.63	41.96	49.72
Rubble	7.38	18.82	20.67	15.30	23.13	33.40
Sand and rubble	-	-	0.74	56.81	58.64	72.78
Sand	74.01	65.63	60.19	48.20	48.02	48.96

Statisfically, the change detection obtained from the classified scenes of 1972 to 1996 reveal a significant decrease in the live coral, while dead coral with algae and rubble are increasing every year.

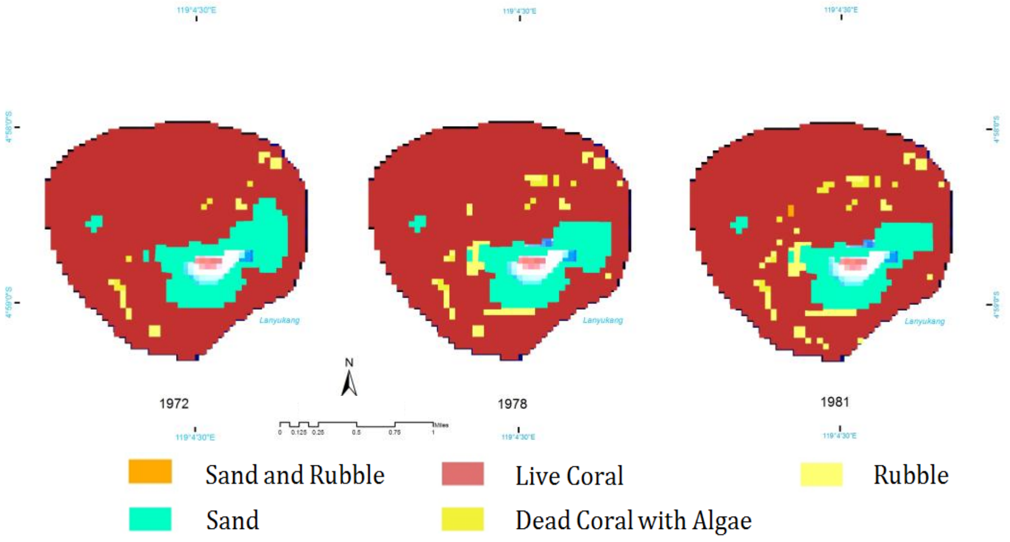

Figure 4. Coral reef classification of 1972, 1978, and 1981 (spatial resolution 60 meter)

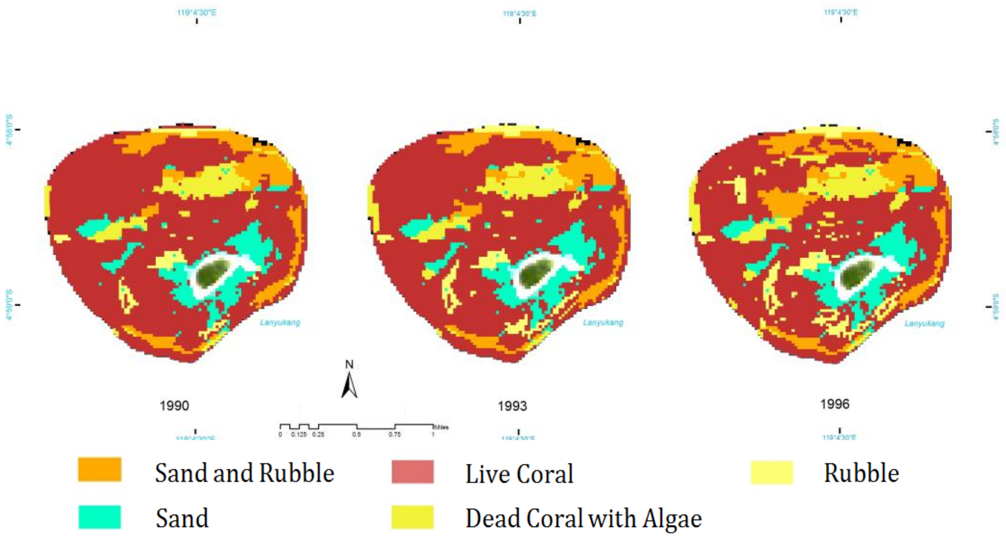

Figure 5. Coral reef classification of 1990, 1993, and 1996 (spatial resolution 30 meter)

One of the effects of fishing activities is decresing of live coral in 1999 to 2013. live coral cover > 75% is lost, as well as live coral cover 50-74.9%, 25-49.9 % , and < 24.9 %, while the dead coral , rubble , rock , sand and rubble is increase (Table 5).

Table 5. Areal estimates of major bottom types in 1999, 2002, 2005, 2008, 2011, and 2013

Classes	Areal of Lanyukang Island (Ha)

	1999	2002	2005	2008	2011	2013
Coral cover 0 - 24.9%	186.09	176.92	86.47	42.80	32.43	30.46
Coral cover 25 -49.9%	61.46	45.91	28.91	24.95	21.87	20.90
Coral cover 50-74.9%	21.25	13.64	10.22	9.73	9.95	10.14
Coral cover 75-100%	9.73	4.38	3.88	3.57	3.05	2.68
Dead Coral	48.77	53.39	61.24	61.20	67.34	66.64
Sand and Rubble	91.84	92.71	113.60	123.97	124.74	126.32
Rock	3.84	14.73	48.42	79.44	81.49	83.06
Rubble	37.70	59.00	107.94	114.33	119.01	119.48
Sand	43.88	44.04	43.95	46.43	46.47	47.31

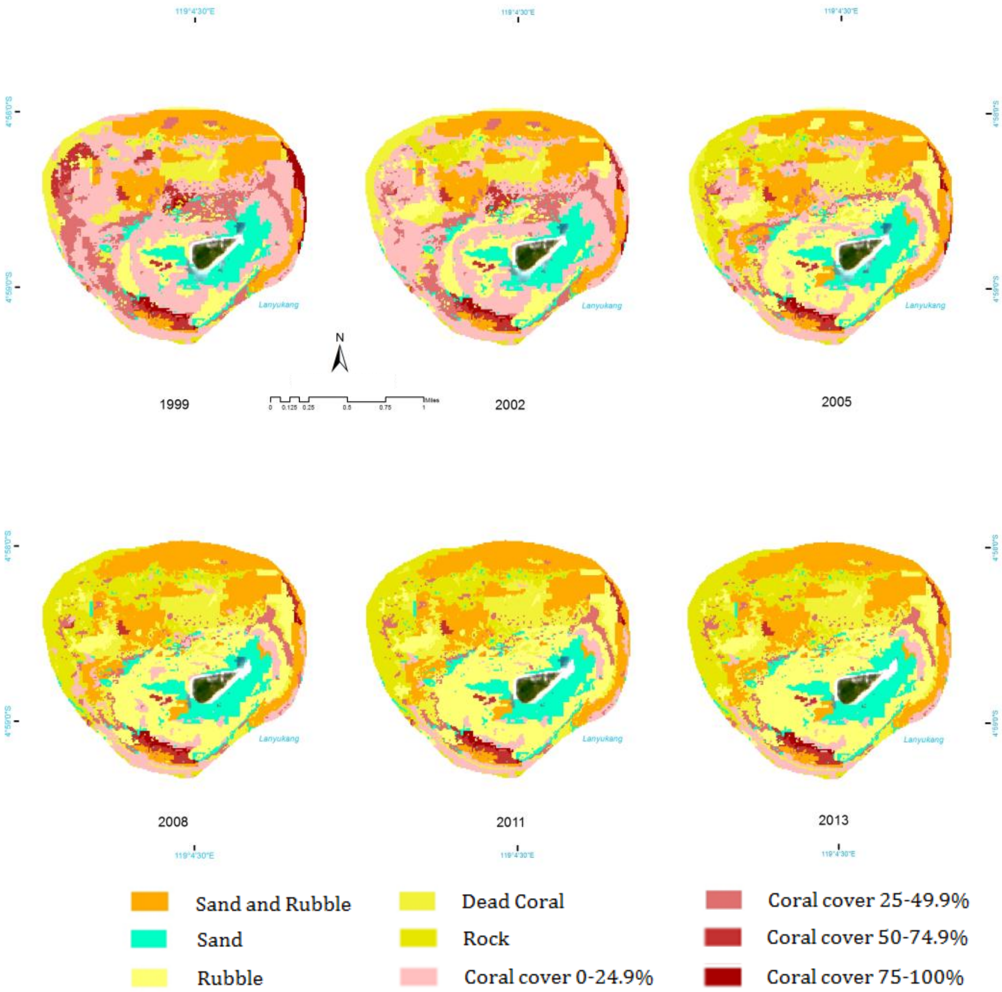

Figure 6. Coral reef classification of 1999, 2002, 2005, 2008, 2011, and 2013

Figure 7. Dominant bottom condition in Lanyukang island are rubble and dead coral covered with alga

Accuracy Assessment

The result of coral reef classification maps were checked with accuracy assessment method in order to obtain the level of map accuracy. As mentioned previously, standard map accuracy was more than 70%. It can be said that these map has been classified by representing good coral reef and ground area, which were then transformed into digital paper maps. confusion matrix of classification on image 2013 in Lanyukang is 85.54%. Generally, the difference between the classification results and reality in the field is caused by water clarity and spatial resolution of satellite-derived data.

Post Classification

The biggest dynamics of live coral on the island Lanyukang in 1972 to 1978 is live coral to rubble and live coral to dead coral. There is a recovery area from sand and dead coral to live coral in the north and east of island Lanyukang.

Table 6. Areal changes of bottom types in 1972 to 1978 and 1978 to 1981

Tahun	Areal changes of coral (Ha)				
	Live coral	**Dead coral**	**Rubble**	**Sand and rubble**	**Sand**
1972 -1978					
• Live coral	407,05	2,21	11,44	-	-
• Dead coral	-	2,58	-	-	-
• Rubble	-	-	7,38	-	-
• Sand	6,93	-	-	-	65,63
1978 - 1981					
• Live coral	409,55	1,84	2,58	-	-
• Dead coral	-	4,80	-	-	-
• Rubble	-	-	18,09	0,74	-
• Sand	5,07	-	-	-	60,19

Bottom cover condition from 1990 to 1993 is live coral to rubble and dead coral. This condition is dominant in the south and west of island Lanyukang. In 1993 - 1996, live coral to rubble , dead coral and rubble are in the north, south, west, of island (Figure 9). The dynamics of live coral in 1993 - 1996 on the island Lanyukang larger than 1990 - 1993 (Table 7).

Table 7. Areal changes of bottom types in 1990 to 1993 and 1993 to 1996

Tahun	Areal changes of coral (Ha)				
	Live coral	**Dead coral**	**Rubble**	**Sand and rubble**	**Sand**
1990 - 1993					
• Live coral	329,46	6,33	7,83	1,83	-
• Dead coral	-	35,63	-	-	-
• Rubble	-	-	15,30	-	-
• Sand and rubble	-	-	-	56,81	-
• Sand	-	-	-	-	48,02

Tahun	Areal changes of coral (Ha)				
	Live coral	**Dead coral**	**Rubble**	**Sand and rubble**	**Sand**
1993 -1996					
• Live coral	297,42	7,76	10,26	14,01	-
• Dead coral	-	41,96	-	-	-
• Rubble	-	-	23,13	-	-
• Sand and rubble	-	-	-	58,37	0,27
• Sand	-	-	-	0,41	47,61

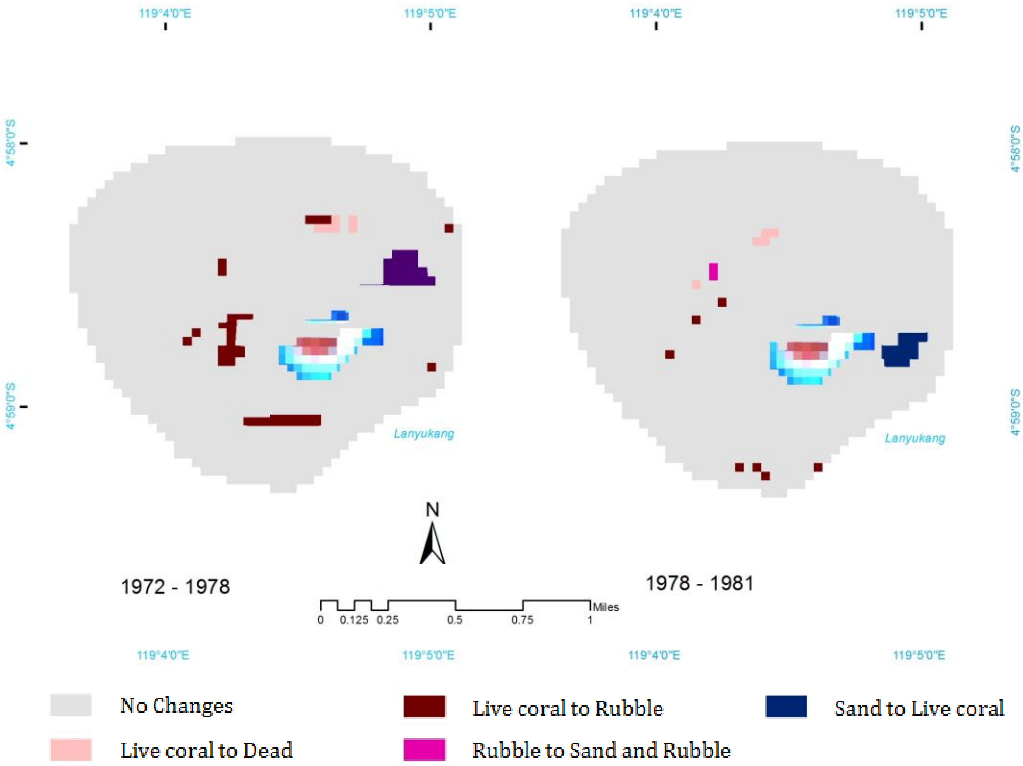

Figure 8. Post classification of coral reef of Lanyukang Island from 1972 to 1978 and 1978 to 1981

Live coral on the island has been damaged. The result of field survey show that live cover is dominated by coral cover < 24.9%, start from 1999 untill 2013 coral, sand and rubble (Table 8).

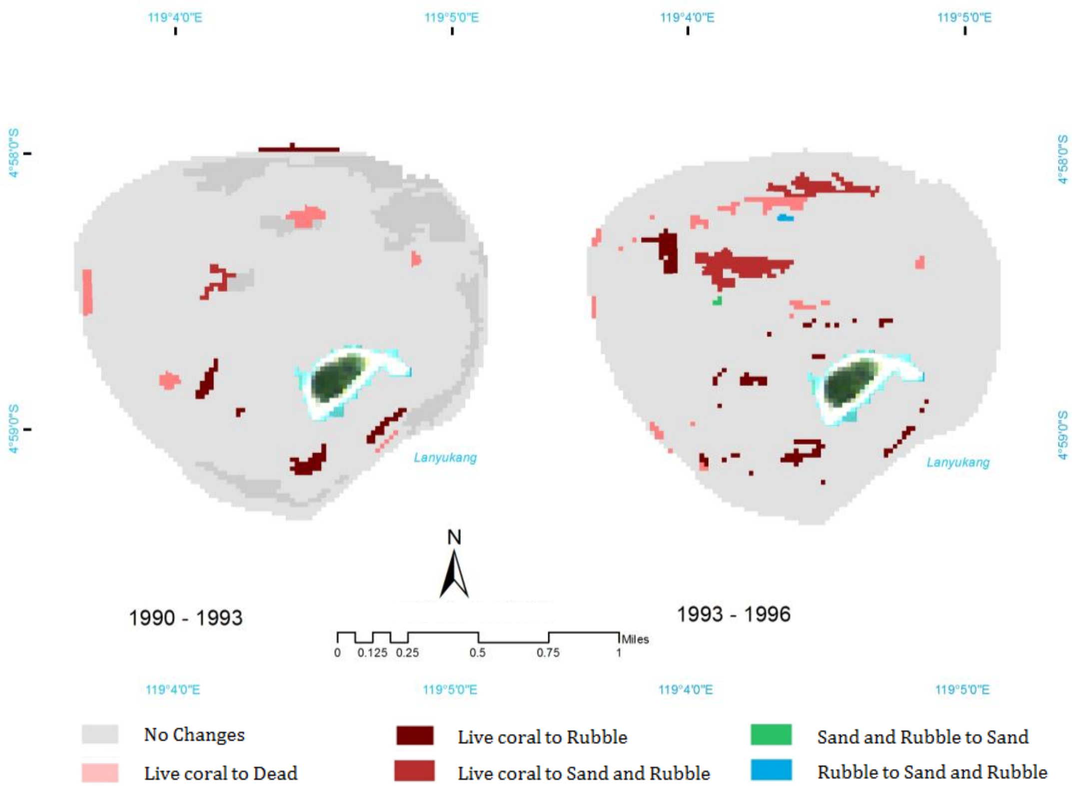

Figure 9. Post classification of coral reef of Lanyukang Island from 1990 to 1993 and 1993 to 1996

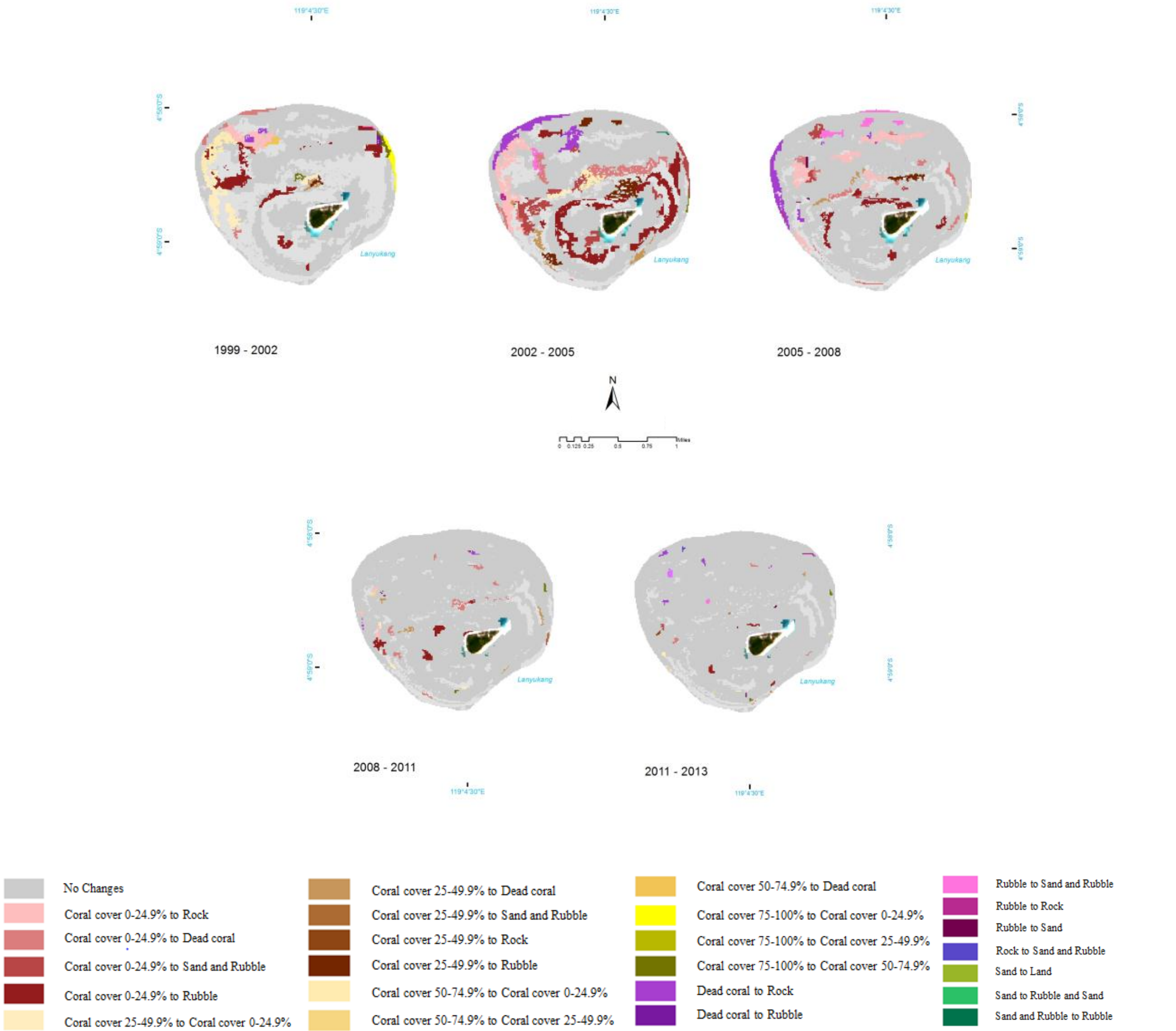

Figure 10. Post classification of coral reef in Lanyukang island from 1999 to 2002, 2002 to 2005, 2005 to 2008, 2008 to 2011, and 2011 to 2013

Table 9. Areal changes of bottom types in 1999 to 2002, 2002 to 2005, 2005 to 2008, 2008 to 2011, and 2011 to 2013.

Years	Areal changes of coral (Ha)								
	Coral cover				Dead coral	Rubble	Rock	Sand & Rubble	Sand
	0 - 24.9%	25-49.9%	50-74.9%	75-100%					
1999 - 2002									
• Coral cover 0 - 24.9%	152,00	-	-	-	4,38	19,96	9,20	0,56	-
• Coral cover 25 -49.9%	13,43	45,91	-	-	1,19	0,92	-	-	-
• Coral cover 50-74.9%	8,50	-	11,28	-	1,47	-	-	-	-
• Coral cover 75-100%	2,99	-	2,36	4,38	-	-	-	-	-
• Dead coral	-	-	-	-	46,35	0,73	1,69	-	-
• Rubble	-	-	-	-	-	37,39	-	0,31	-
• Rock	-	-	-	-	-	-	3,84	-	-
• Sand & Rubble	-	-	-	-	-	-	-	91,84	-
• Sand	-	-	-	-	-	-	-	-	43,68
2002 - 2005									
• Coral cover 0 - 24.9%	80,87	-	-	-	17,87	41,09	18,05	19,05	-
• Coral cover 25 -49.9%	1,68	28,91	-	-	5,01	10,26	0,05	-	-
• Coral cover 50-74.9%	3,91	-	9,73	-	-	-	-	-	-
• Coral cover 75-100%	-	-	0,49	3,88	-	-	-	-	-
• Dead coral	-	-	-	-	38,27	0,09	15,03	0,01	-
• Rubble	-	-	-	-	-	56,28	0,57	2,15	-
• Rock	-	-	-	-	-	-	14,73	-	-
• Sand & Rubble	-	-	-	-	-	0,32	-	92,40	-
• Sand	-	-	-	-	-	-	-	-	43,95
2005 - 2008									
• Coral cover 0 - 24.9%	42,31	-	-	-	8,14	10,61	20,81	4,60	-
• Coral cover 25 -49.9%	-	24,64	-	-	1,80	2,47	-	-	-
• Coral cover 50-74.9%	0,49	-	9,73	-	-	-	-	-	-
• Coral cover 75-100%	-	0,31	-	3,57	-	-	-	-	-
• Dead coral	-	-	-	-	51,25	-	9,89	0,09	-
• Rubble	-	-	-	-	-	101,24	0,31	5,68	0,71
• Rock	-	-	-	-	-	-	48,42	-	-
• Sand & Rubble	-	-	-	-	-	0,00	-	113,60	-
• Sand	-	-	-	-	-	-	-	-	42,88
2008 - 2011									
• Coral cover 0 - 24.9%	31,43	-	-	-	4,68	4,83	1,41	0,44	-
• Coral cover 25 -49.9%	0,99	21,57	-	-	2,00	0,08	-	0,31	-
• Coral cover 50-74.9%	-	0,30	9,43	-	-	-	-	-	-

Years	Areal changes of coral (Ha)								
	Coral cover				Dead coral	Rubble	Rock	Sand & Rubble	Sand
	0 - 24.9%	25-49.9%	50-74.9%	75-100%					
• Coral cover 75-100%	-	-	0,52	3,05	-	-	-	-	-
• Dead coral	-	-	-	-	60,66	-	0,54	-	-
• Rubble	-	-	-	-	-	114,10	0,11	-	0,12
• Rock	-	-	-	-	-	-	79,43	0,01	-
• Sand & Rubble	-	-	-	-	-	-	-	123,97	-
• Sand	-	-	-	-	-	-	-	-	46,36
2011 - 2013									
• Coral cover 0 - 24.9%	29,91	-	-	-	0,94	1,30	-	0,28	-
• Coral cover 25 -49.9%	0,56	20,72	-	-	0,29	-	0,22	0,07	-
• Coral cover 50-74.9%	-	0,18	9,77	-	-	-	-	-	-
• Coral cover 75-100%	-	-	0,37	2,68	-	-	-	-	-
• Dead coral	-	-	-	-	65,41	-	1,21	0,72	-
• Rubble	-	-	-	-	-	118,18	0,31	0,33	0,18
• Rock	-	-	-	-	-	-	81,31	0,18	-
• Sand & Rubble	-	-	-	-	-	-	-	124,74	0,00
• Sand	-	-	-	-	-	-	-		46,03

3.2 Coral Reef Transformation Versus Antropogenic

In this decade, there are a lot of damage of coral reefs as a result of people's behavior in coastal areas. They use bombs and chemicals toxic to catch reef fish. The fact is decresing live coral cover on the island Lanyukang in 1999 until 2013. In 2013 showed that live coral cover 75-100% is decrease , as well as live coral cover 50-74.9%, 25-49.9%, and < 24.9%, while the dead coral, rubble, rock , sand and rubble are increase (Table 24). Based on the results of interviews with local people, they reported that initially Lanyukang Island is round, and then there is abrasion on the west side of the island which addition of sand on the east side. This is change of island from round to elongate. Lanyukang island only inhabited by 14 families_ about 40 people. All people of Lanyukang island is fishing, they have small boats for fishing and the name is lepa lepa katinting in the local language. Island people using corals and sand from coastal areas to be used as a material for building their homes. But the greatest threat to coral reefs on the island Lanyukang is damage caused by the activity of people who come from other islands around the iLanyukang island. Currently, the Society of Lanyukang island strive to prevent any activity of coral destruction that came from fisherman of another island in Spermonde Archipelago.

Blast fishing is considered to be one of the most destructive anthropogenic threats to coral reefs because of its pernicious effects. Despite national and local government policy to control these illegal methods, destructive fishing is still widely practised by local fishermen. The most reason why these practices are difficult to eradicate is weak government control and monitoring. This a serious problem and while many blast fishermen are aware of the destruction their practices entail, they argue that they have no real alternatives (Nurdin et al, 2015).

4. CONCLUSION

The results indicate that decreases in live coral areas resulted in increased areas of dead coral with algae and rubble during the forty one year period from 1972 to 2013. Live coral from 1972 to 2013 was decreased, while dead coral with algae and rubble were increased. Field observations on the shallow water of Lanyukang island revealed that coral reef habitat destruction was largely caused by human factors. This could be concluded because a lot of loose fragments of rubble that typically result from destructive activities such as explosive fishing (bombs) were found.

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