Coral reef destruction of Small island in 44 years and destructive fishing in Spermonde Archipelago, Indonesia

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Abstract: Coral reefs are among the most diverse and threatened ecosystems on the planet. The most commonly stated for developing coral reef remote sensing techniques is to asses and or to monitor the status of these ecosystems. The study site was selected one of small island in inner zone Spermonde archipelago, Indonesia. We used Landsat MSS, Landsat TM, Landsat ETM, and Landsat OLI data to examine changes in the coral reefs of inner zone island in the Spermonde Archipelago from 1972 to 2016. The image processing are gap fills, atmospheric correction, geometric corrections, image composites, water column corrections, unsupervised classifications, and reclassification. Some of component change detection procedure was applied to define change. The results showed significant changes in 44 years. Disturbed coral reefs are typically characterized by loss of coral cover by increase in the abundance of dead corals and rubble. Local factors such as destructive fishing is direct destruction of inner zone island. While the impact of local threats may be reduced through management action, global threats to coral reefs are likely to increase in severity in the coming years.

Keywords: Coral reef, destruction, small island, Spermonde archipelago, Landsat

1. Introduction

1.1 Background

Coral reefs ecosystem is very sensitive to environmental impacts related to human activity on coastal and marine areas. Human impacts, direct and indirect have been recognized as a higher threat than the natural disturbances. The major causes of coral reef degradation in Indonesia are blast fishing, sewage, industrial pollution and cyanide fishing [13]. One indication of a good ecosystem health is coral reef ecosystem resilience rate, explicitly the ability of an ecosystem to recover from a damaged condition to be better [12]. Resilience rate of coral reef ecosystem is one important indication to the manager in well and right managing coral reef from disturbances and estimate the length of the process of rstoration and rehabilitation of coral reefs ecosystem [4], especially for coral reef ecosystem, one of the factor that influence the resilience rate is the availability of hard substrate in a bottom waters as a settlement for coral larvae. 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. Ballang Lompo is one of small islands in inner zone, Spermonde Archipelago which has high potential ecosystem especially coral reef distribution. Therefore, spatial dynamic mapping of coral reef are needed to develop geodatabase and create good planning for coastal area. There are studies using medium spatial resolution data, e.g. Landsat [1, 3].This results is important for planners and scientists because it can be used to simplify the management planning and change detection in Ballang Lompo island.

1.2 Objectives
The objective of this research was to spatial analysis of coral reefs transformation for 44 years and anthropogenic impact.

2. Methodology

2.1 Study Area
Ballang Lompo is one of the islands in the Spermonde Archipelago, PangkepDistrict, Indonesia. Ballang Lompo has a land area of 8 km2.

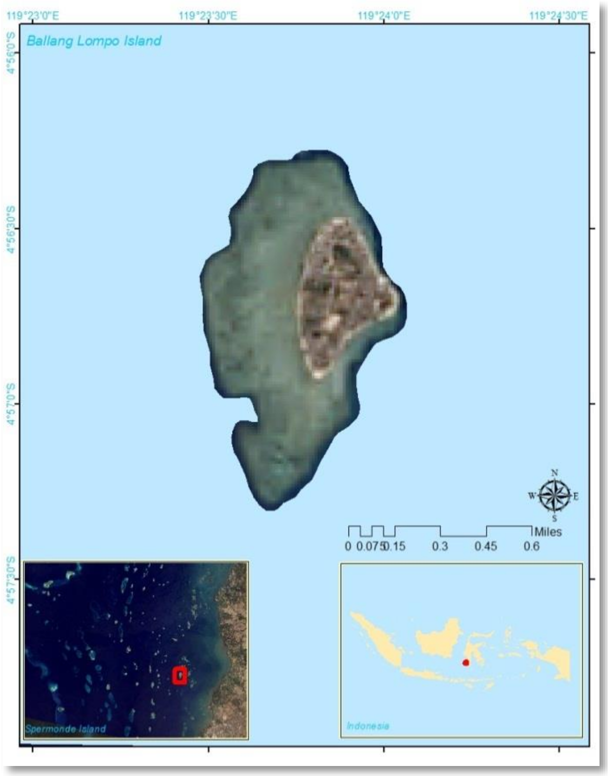


Figure 1. Study area in Ballang Lompo Island, one of the small islands in inner zone Spermonde Archipelago, Indonesia

2.2 Data
Identification of bottom types in Ballang Lompo Island using Landsat image selected Landsat MSS, TM, ETM, and OLI-TIRS to the years 1972, 1984, 1990, 1996, 2002 and 2016. 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 typesof 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_2	MSS	60	1984-10-26	122/063
3	Landsat_4	TM	30	1990-12-16	114/063
4	Landsat_5	TM	30	1996-04-28	114/063
5	Landsat_7	ETM	15	2002-06-24	114/063
6	Landsat_8	OLI-TIRS	15	2016-02-04	114/063

Classification bottom types consisting of five classes(live coral, seagrass, mix bottom, rubble and sand) were examined by Landsat MSSwhich have a 60 meter. There are six classes (dead coral, live coral, seagrass, mix bottom, rubble and sand) for Landsat TM, ETM, and OLI which have a 30 meter and 15 meter spatial resolution.

2.3 Image Processing

The image processing was composed of five main steps including: (1)geometric correction, (2) fusion, (3) preliminary analysis, and (4) image classification. Landsat satellite imagery t=1972, t=1984, t=1990, t=1996, t=2002 and t=2016 were being corrected in radiometric aspect and geometric aspect by rectify/resampling pixel position in image, and geo-referencing the image into the selected projection system. Optical band of imageries had 30 m and 60 of spatial 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, thiswas 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.

2.4 Ground Truth

Ground observation was important in order verify image interpretation result. Data from ground truth will increase the total image interpretation/classification accuracy [5]. Ground truth also occurred to collect field data such as area observation and interviewing local people about historical trend of previous land usage. Ground truth wasconducted to determine the actual habitat on the ground. The result of ground truth was compared with the result of classification image.

2.5 Accuracy Assessment

Accuracy assessment was being conducted by Kappa coefficient (κ) for accuracy assessment which relies on image training area. Accuracy test was used to make any calculation matrix for each error (confusion matrix) on any kind of coral reefs resulting from the analysis satellite imagery. The following is a table of confusion matrix form (Table 2).

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 2 helped make mathematical notation easy to understand.

Table 2.Confusion matrix

Classified to class	**Reference (sample point)** 1	2	K	**Row Total (N_{i+})**	**User's Accuracy**
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_{+j})	N_{+1}	N_{+2}	N_{+K}	N	
Producer's Accuracy	N_{KK}/N_{+1}	N_{22}/N_{+2}	N_{KK}/N_{+K}		

2.6 Post Classification
A post-classification change matrix function was applied between 1972 to 1984, 1990 to 1996 and 2002 to 2016.

3. Results And Discussions

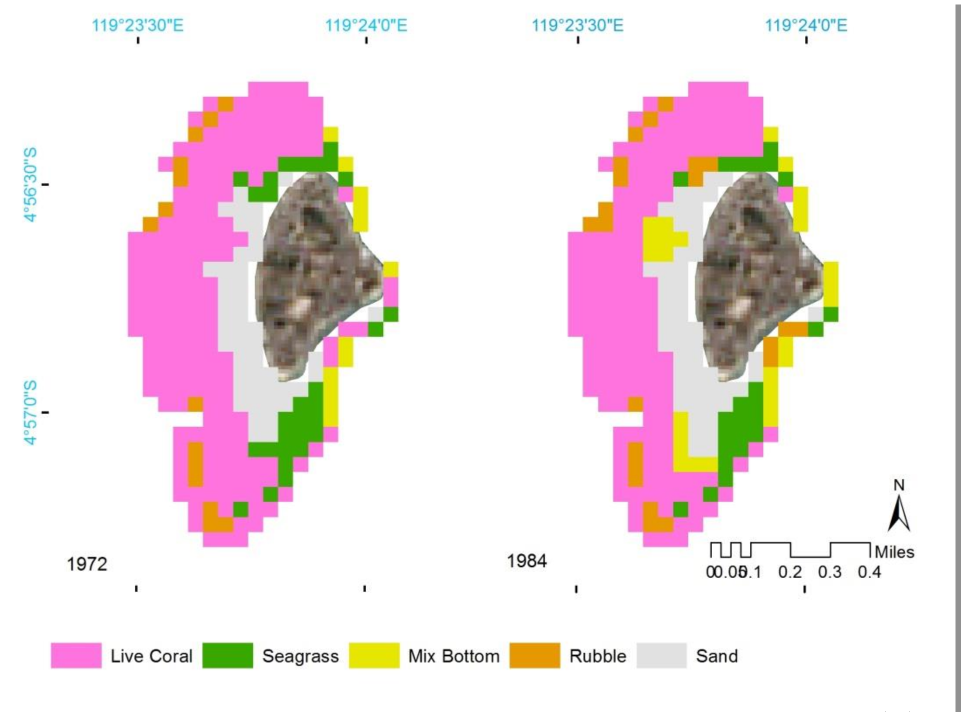
3.1 Image Interpretation of Coral Reef
Result of satellite image interpretation of coral reefs indicate six classes which were dead coral, live coral, seagrass, mix bottom, rubble and sand. Geometric correction process was done to obtain good accuracy image position of each class in coral reef and the 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 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 2015 in Ballang Lompois 75.69%. Generally, the difference between the classification results and reality in the field is caused by water clarity and spatial resolution of satellite-derived data.

Time-series analysis of MSS, TM, ETM and OLI-TIRS data has revealed a net loss of 54.26 ha of live coral in the region from 1972 to 2016. The results of changes in the coral reef areas during the six acquisition years are represented in Table 3. During the periods of 1972 to 1984, the area of live coral decreased at 8.49 ha. Periods of 1990 to 1996 area of live coral decreased at 8.28 ha and followed in during periods of 2002 to 2016, the area of live coral decreased at 10.40 ha. The area of dead coral and rubble had increased. The resulst of coral reefs dynamics showed that live coral decrease in each year and probably this condition will continue in future year.

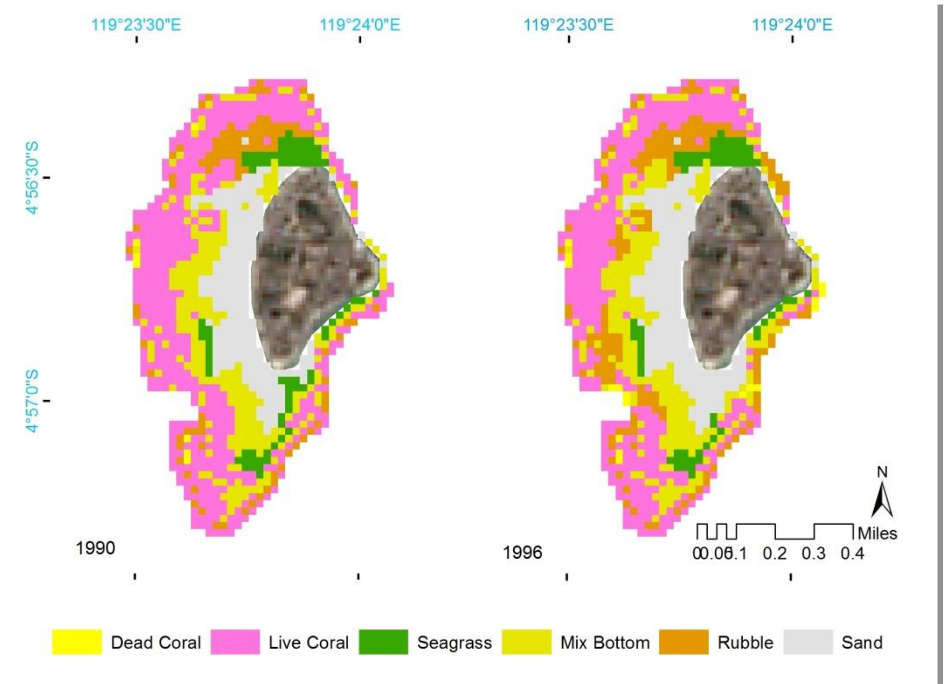
Table 3. Areal estimates of coral reefs in 1972, 1984, 1990, 1996, 2002,and 2016

Classes	**Areal of BallangLompo Island (Ha)**					
	1972	**1984**	**1990**	**1996**	**2002**	**2016**
Dead Coral	0,00	0,00	0,63	1,62	5,67	6,93
Live Coral	67,16	58,67	43,29	35,01	23,29	12,89
Seagrass	10,70	8,86	7,29	6,30	5,56	4,75
Mix Bottom	4,43	9,96	22,68	23,67	25,48	28,65
Rubble	5,17	8,12	9,54	15,57	21,77	28,45
Sand	16,97	18,82	18,45	19,71	19,64	19,73

Based on observations in the field, the coral reef habitat destruction in Ballang Lompo island largely from human activity.It proofed by many fragments of rock (rubble), andthe activities by explosives fishing such as bombs and chemicalsin shallow waters Ballang Lompo [2].



(A)



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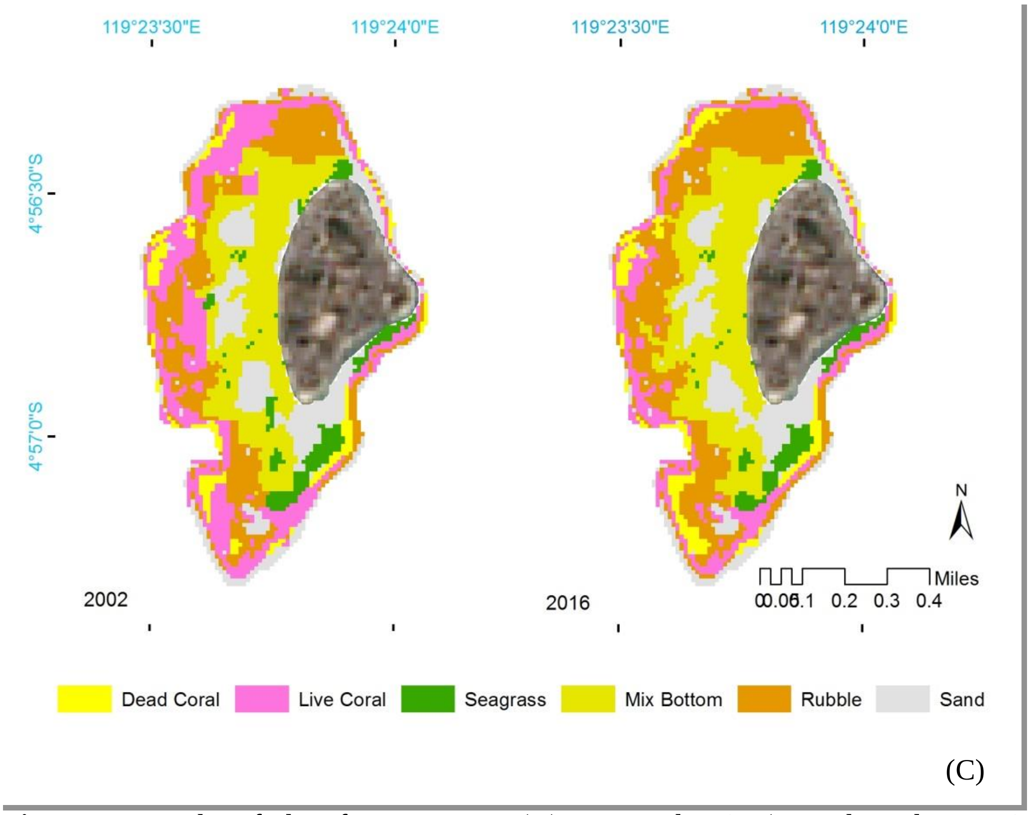

Figure 2. Coral reef classification maps: (A) 1972 and 1984 (Spatial resolution 60 meter), (B) 1990 and 1996 (spatial resolution 30 meter), (C) 2002 and 2016 (spatial resolution 15 meter).

3.2 Post Classification

The change matrix (Table 4) shows that 1972 to 1984 by 5.53 ha of live coral changed between to mix bottom, and 2.95 ha had changed to rubble. Deforestation rate during 2002 to 2016 was highest for live coral to rubble in Ballang Lompo Island by 7.06 ha. It could be observed that the changes from 1990 to 1996 show live coral and seagrass area decreased approximately 8.26 ha and 0.99 ha, while dead coral increased 0.99 ha, rubble increased 6.03 ha, and mix bottom increased 5.53 ha. Although the extent of shallow water may change from year to year due to varying human activity and oceanography parameters.

Table 4. Areal changes ofbottom types in 1972 to 1984, 1990 to 1996 and 2002 to 2016

Years	**Areal change of coral (ha)**					
	Live Coral	**Dead Coral**	**Rubble**	**Mix Bottom**	**Seagrass**	**Sand**
1972 to 1984		(C)				
Live Coral	58,67	0,00	2,95	5,53	0,00	0,00
Dead Coral	0	0,00	0	0	0	0
Rubble	0	0,00	5,17	0	0	0,00
Mix Bottom	0	0	0	4,43	0,00	0,00
Seagrass	0	0,00	0	0,00	8,86	1,84
Sand	0	0	0	0		16,97
1990 to 1996						
Live Coral	35,01	0,99	6,03	1,26	0	0

Years	**Areal change of coral (ha)**					
	Live Coral	**Dead Coral**	**Rubble**	**Mix Bottom**	**Seagrass**	**Sand**
Dead Coral	0	0,63	0	0	0	0
Rubble	0	0	9,54	0	0	0
Mix Bottom	0	0	0	22,41	0	0,27
Seagrass	0	0	0	0	6,30	0,99
Sand	0	0	0	0		18,45
2002 to 2016						
Live Coral	12,89	1,26	7,06	2,07	0	0
Dead Coral	0	5,67	0	0	0	0
Rubble	0	0	21,39	0,38	0	0
Mix Bottom	0	0	0	25,37	0	0,11
Seagrass	0	0	0	0,16	4,75	0,65
Sand	0	0	0	0,67		18,97

3.3 Coral Reefs Destruction

Coral reef damage are classified into three parts, specifically: (1) coral damage by biologial causes such as the existence of competition, predation, explosion of phytoplankton population, (2) coral damage by mechanism causes such as the existence of strong current, sedimentation, volcanism activities, change in temperature and salinity and sunlight penetration, (3) coral damage to human activities such as oil pollution, chemicals, taking the stony coral for industrial purposes and building, bombing, a collection of biota and etc [13]. Destructive fishing practices not only remove the resource itself (fish and invertebrate stocks) but also destroy the habitat [7,8, 9, 10, 11]. The detonated bomb’s shock waves not only kill fish and other organisms within the 1-5 meter blast radius, but also pulverize the skeletons themsels [6]. There are a lot of damage of coral reefs as a result of people's behaviour in coastal areas of small islands Spermonde Archipelago; include Ballang Lompo island in inner zone. They use bombs and chemicals toxic to catch reef fish. In 2016 showed that live coral is decrease, as well as live coral while the dead coral, rubble, mix bottom and sand. Local 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 Ballang Lompo is damage caused by the activity of people who come from other islands around the Ballang Lompo island. Currently, the Society of Ballang Lompo 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 reefsbecause 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 problemand while many blast fishermen are aware of the destruction their practices entail, they argue that they have no real alternatives [7, 8, 9, 10].

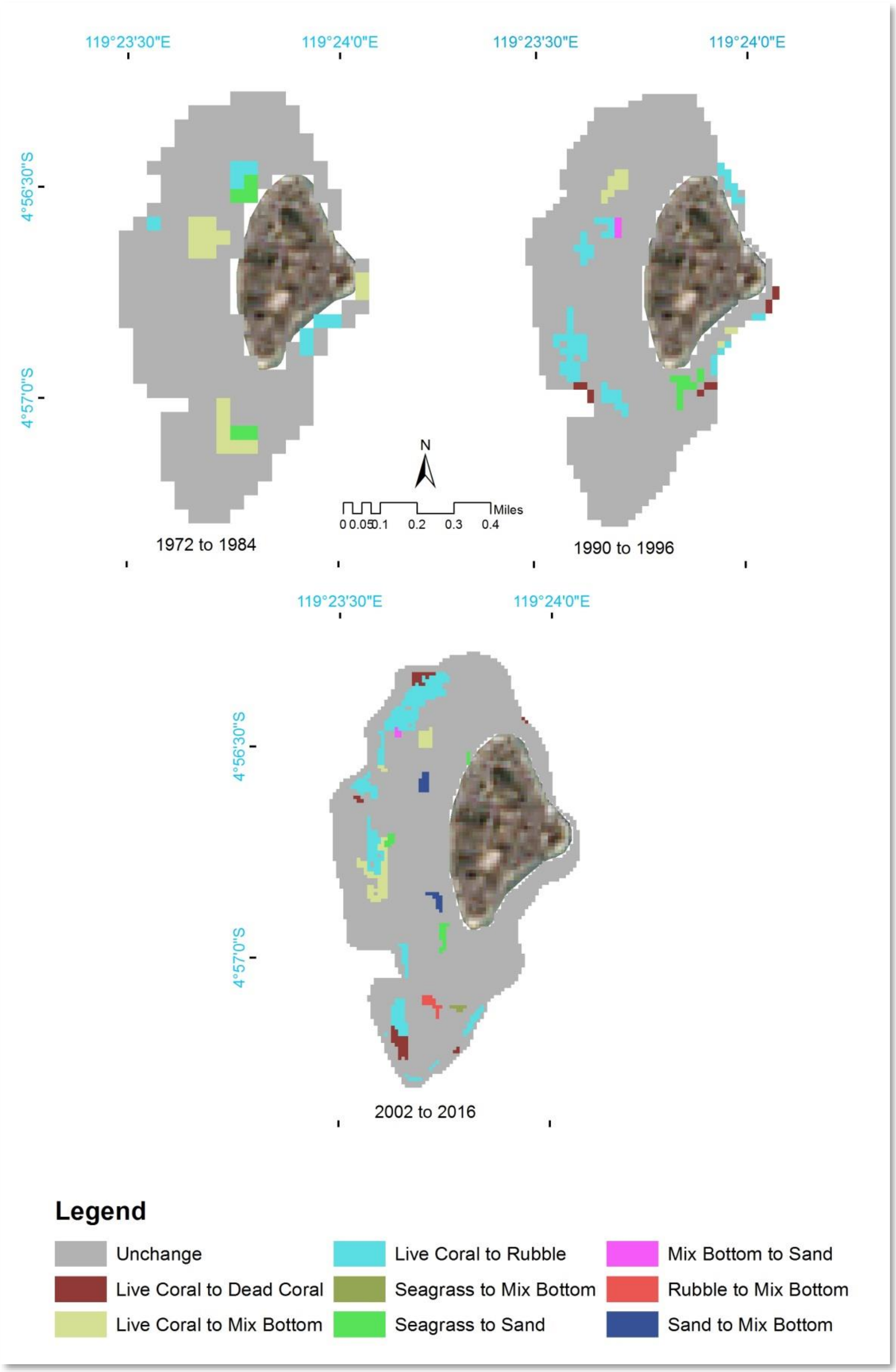

Figure 3.Post classification of coral reef of Ballang Lompo Island: from 1972 to 1984, 1990 to 1996 and 2002 to 2016

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 fouryears live coral decreasing resulted in period from 1972 to 2016. Live coral from 1972 to 2016 was decreased, while dead coral and rubble were increased. Field observationson the shallow water of Ballang Lompo 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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