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Data Integration Through WebGIS to Inform Spatial Status of Coral Reefs in Lampung Province, Indonesia

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Abstract

Data integration of structured ecosystem monitoring is crucial to support decision making for better marine ecosystem management. Coral reef monitoring data had been carried out in several separated studies in Lampung Province. However, lacks data integration among scientists and institutions making them inefficient as a basis of science for ecosystem management and decision making. This study was aimed to integrate available coral reef data in the last 15 years in Lampung Province and inform the spatial status of coral reef cover through WebGIS. Secondary data of coral reef study in the last 15 years were acquired from published articles and online-available-institutional reports. Data were then converted to digital mode prior to publishing them in the form of a website database through WebGIS. Results suggested that there were four main areas of coral reef studies in Lampung Province, namely Lampung bay, Krakatau, Bakauheni, and Lampung west coast. One-way ANOVA analysis of the last 5-year coral data shown there were no spatial differences on coral cover the four areas. Coral cover in Lampung west coast was generally in good shape at 56.13±1.74% and was higher compared to those in Lampung bay, Bakauheni, dan Krakatau regions, at 46.57±2.23%, 36.48±1.58%, and 35.6±3.69%, respectively. All coral data was published through WebGIS at https://sll.itera.ac.id/research/webgis . It is recommended this WebGIS could serve as a reference to conduct long-term coral reef monitoring in Lampung since it provides coordinates and coral reef status as baseline data for further analysis of coral reefs ecosystem.

Keywords: Coral Reefs, Lampung, WebGIS.

1. Introduction

Indonesia has a significant coral reef cover areas and is one of countries with the World's highest marine biodiversity. Indonesia coral reef cover is 51.020 km^2 representing 17.95% of the World's coral reef cover (Wilkinson, 2002). According to data from 520 stations in 56 location across the nation, the status of coral reef cover categorized in an excellent condition was 6.9%; a good condition was 35.5%; a medium condition was 35.3%; and a bad condition was 32.3% (Chou *et al.,* 2002). Furthermore, two-third world's coral species is found in Indonesia where it is home of 569 out of 845 coral species of Scleractinia ordo or hard coral (Giyanto *et al.,* 2017)

Sumatera is one of the largest islands in Indonesia, located in the western Indonesian archipelago. The coral reef cover in this island ranks second following Sulawesi island with coral cover at 478.587 ha based on satellite imaginary data analysis (Giyanto *et al.,* 2017). Lampung Province is situated in the most southern part of Sumatera island, with coordinates from 4º 15' S to 6º 15'S and 103º 15' E to 105º 39' E. Coral reef cover data in this region has been documented in several separated articles and institutional reports. However, data integration on coral reef data among scientists and institutions within the region is lacking and difficult to access, especially institutional reports. In addition, traditional printed maps are still commonly used to display ecosystem monitoring. This method has disadvantages including multiple format information and ununified coordinates system and scales (Quynh, Phuong, & Phuong, 2016).

To acquire a holistic perspective in ecosystem and environment management, monitoring data should be integrated comprehensively in a platform *(Agurto et al.,* 2018; Schmidt, Aden, Kleppin, Pesch, & Schröder, 2010). Web Geographic Information System (WebGIS) is one of the platforms that could serve this objective (Suhelmi, Yulius, & Purbani, 2013). In addition, this platform could be utilized to monitor

status and trend of environmental changes and it has ability to display and share information from map data so that its application could be easy and open access to wider community and scientists (Schmidt *et al.,* 2010; Quynh *et al.,* 2016). The application of WebGIS to assist the environment and ecosystem management has been documented in marine protected area management (Quynh *et al.,* 2016; Agurto *et al.,* 2018); fisheries management (Suhelmi et al., 2013); sea anemone biodiversity (Fautin, 2008); and biodiversity management (Geri, La Porta, Zottele, & Ciolli, 2016). As far as this, no data integration has been carried out in Lampung Province related to environmental management, especially in coral reefs ecosystem. This research aimed to integrate the available coral reef monitoring data in Lampung Province in the last 15 years into WebGIS and inform the spatial status of coral cover in Lampung Province through WebGIS.

2. Methods

This research was conducted in the three stages, including secondary data collection and integration, digital data conversion using Geographic Information System, and WebGIS development (Suhelmi, *et al.,* 2013; Herison, A., *et al.,* 2019). Secondary data were obtained from published articles in Google Scholar and institutional reports available online. Certain keywords were used for searching the published articles on Google. i.e. “coral reefs in lampung province”, “the status of coral reefs in lampung province”, and “the monitoring of coral reefs in lampung province”. The selected paper were used are in English and Indonesian, also also papers in range of 15 years back from 2020. All coral reef information in the published articles were extracted and mapped using point and polygon on GIS software.

Coral reef data in the last 15 years extracted from the articles and reports were coral reef sampling point coordinate, monitoring method, year, depth (meter), hard coral percentage (%), soft coral percentage (%), and total coral cover (%). These data were then integrated to digital data in GIS format file using QGIS 3.10 opensource software. In condition there were plotted coordinate data that were not corresponded to the coordinate points in map provided in the article sources, there were adjustment operated in addition to correct the coordinate data. The adjustment included re-position of coordinate marked in the articles to the correct position (such as point that miss placed on the land). The flowchart of the spatial database development in WebGIS is illustrated on Figure 1.

Spatial database development in WebGIS was carried out using qgis2web plugins in the QGIS 3.10 opensource software. Integrated data in GIS was then converted to website database and was published. Monitoring sampling points of coral reefs were categorized based on Gomez & Yap (1988) shown in Table 1. The last five year data were then analyzed using one-way ANOVA to evaluate the significance differences on coral reef cover in each major area.

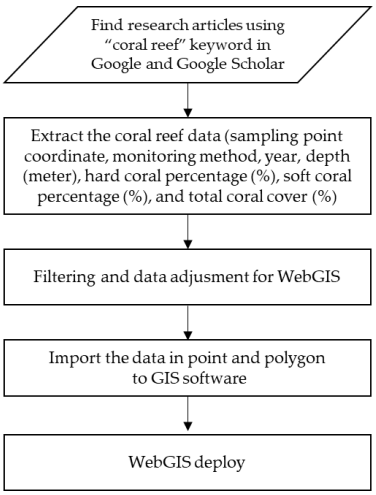

Figure 1. Flowchart of WebGIS coral reef database development

Table 1. Coral status categorized by Yap & Gomez (1988)

No.	Range	Status
1.	0 – 24,9%	Bad
2.	25 – 49,9%	Medium
3.	50 – 74,9%	Good
4.	75 – 100%	Excellent

3. Result and Discussion

In total, there were 115 sampling sites for coral reefs monitoring in Lampung Province from 2007 to 2019 extracted from published articles (n=47) and reports (n=68). The monitoring sites were mainly clustered into four regions, namely Lampung Bay, Bakauheni, Krakatau marine reserve, and Lampung West Coast (Figure 2). The most sampling points were conducted in the Lampung Bay region with 89 sampling sites while the least sampling points were in the Lampung West Coast with only three sites. No coral reef monitoring, as far as this, conducted in the East Coast of Lampung Province due to the unique characteristics of the region. The East Coast of Lampung Province was characterized by numerous rivers that could restrict coral development due to low water turbidity and unstable salinity (Hadi *et al.,* 2018). Zieren *et al.,* (1999) found that most coral reefs in Lampung province are mainly located in the south (Bakauheni, Lampung Bay, and Semangka Bay) and west coast Lampung in form of fringing reefs. Furthermore, he stated that the best coral reefs development might be in the west coast of Lampung province. Unfortunately, a very limited data available in this area.

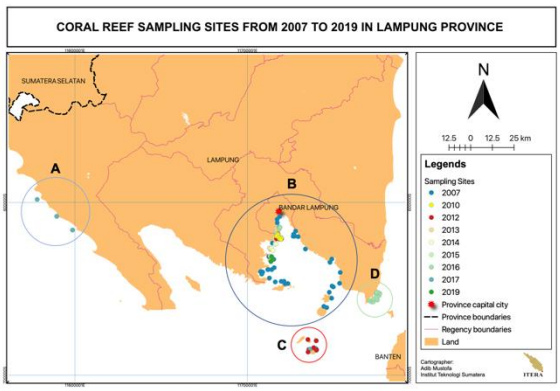

Figure 2. Total sampling points for coral reef monitoring in four regions in Lampung Province from 2007 to 2020, namely a). Lampung west coast, b) Lampung bay, c). Krakatau, and d). Bakauheni

Status and condition of coral reefs in Lampung Province in the last 15 years based on the available data is categorized in Table *2*. There were two government institutions that carried out coral monitoring in Lampung Province in the last 15 years, namely Provincial Government in 2007 with 44 sampling sites and Lembaga Ilmu Pengetahuan Indonesia (LIPI) or Indonesia Institute of Science in 2016 with 10 sampling sites. The number of sampling sites carried out by governmental institution were more numerous rather than those that were managed by individual/group university researchers. Funding constrain might contribute to the lower numbers of sampling sites managed by university researchers. Furthermore, most monitoring were conducted in separated works which lacks of integration and networks among institutions and researchers. Besides, various methods used in data collection precludes further analysis on the temporal trends of the coral reef status in Lampung Province.

The coral reef monitoring distribution recorded in 2007 was 44 points. It was mostly distributed along the coastline of Lampung Bay. From 2012 to 2015, the sampling points on coral monitoring were mostly gathered around near coastline of Hurun Bay to the south near Sari Ringgung Beach, Pesawaran Regency of Lampung Province. Also in 2012, there were several points distributed along Anak Krakatau Island. The monitoring in 2016 was mainly around Bakauheni Port distributed in several clusters consisting of Kandangbalak Island Rimaubalak Island and Panjurit Island. In the following year, the monitoring were shifted to the westcoast of Lampung Province where there were 7 points distributed along the coastline of Lampung Barat Regency and it is also located nearby a Marine Protected Area, namely Kawasan Konservasi Perairan Daerah/KKPD Ngambur and Betuah. Finally, coral reef monitoring in 2019 was conducted in Pahawang Island. All monitoring of coral reef from 2007 to 2019 was plotted Figure 3. In addition, the states of each coral reef were described on Table 2.

In general, coral cover percentage in Lampung west coast was in a good state at 56.13±1.74% and it was higher compared to those in Lampung Bay, Bakauheni, and Krakatau at 46.57±2.23%, 36.48±1.58%, and 35.6±3.69%, respectively. However, one-way ANOVA test shown there was no significant difference in the percentage coral cover among the four regions (Figure 4). Lampung west coast is suggested to have a better coral development than the other regions in Lampung Province *(Zieren et al.,* 1999). It might due to the region is less developed than Bakauheni (a Port linked Sumatera and Java island) and Lampung Bay (close to capital city with medium-to-high population). On the other hands, lacks of suitable substrates and local earth tremors occurred frequently which constrains coral development might contribute to the lower percentage of coral cover in Krakatau marine reserve *(Zieren et al.,* 1999). Interspecific competition with sponge was also reported as the other causes of lower coral cover in Krakatau region (Putra, 2020).

WebGIS on coral reef spatial status in Lampung Province is available at https://sll.itera.ac.id/research/webgis (Figure 5). It informs all data of coral reef covers from 1998 to 2019 from published articles and institutional reports, including soft coral cover (%), hard coral cover (%), total coral cover (%) and other supporting data, including the coordinates, year, depth (m), and data sources.

Table 2. Coral reef status in Lampung Province from 2007 to 2019

Year	n	Bad	Medium	Good	Excellent	Source
2007	44	19	21	4	0	Pemprov Lampung & PT Taram (2007)
2010	12	0	5	6	1	Hartoni *et al.,* (2012) and *Titaheluw et al.,* (2015)
2012	13	0	4	5	4	Novriadi et al. (2013), Putra (2020) and Rozirwan *et al.,* (2014)
2013	10	3	5	2	0	Barus *et al.,* (2018)
2014	8	2	2	4	0	Aditya (2015)
2015	3	2	0	1	0	Utomo *et al.,* (2016)
2016	12	2	8	2	0	LIPI (2016) and Seprizal *et al.,* (2019)
2017	7	1	2	4	0	Herison (2017) and Ferdiansyah *et al.,* (2019)
2019	6	0	2	3	1	Putra (2019)
Total	**115**	**29**	**49**	**31**	**6**	

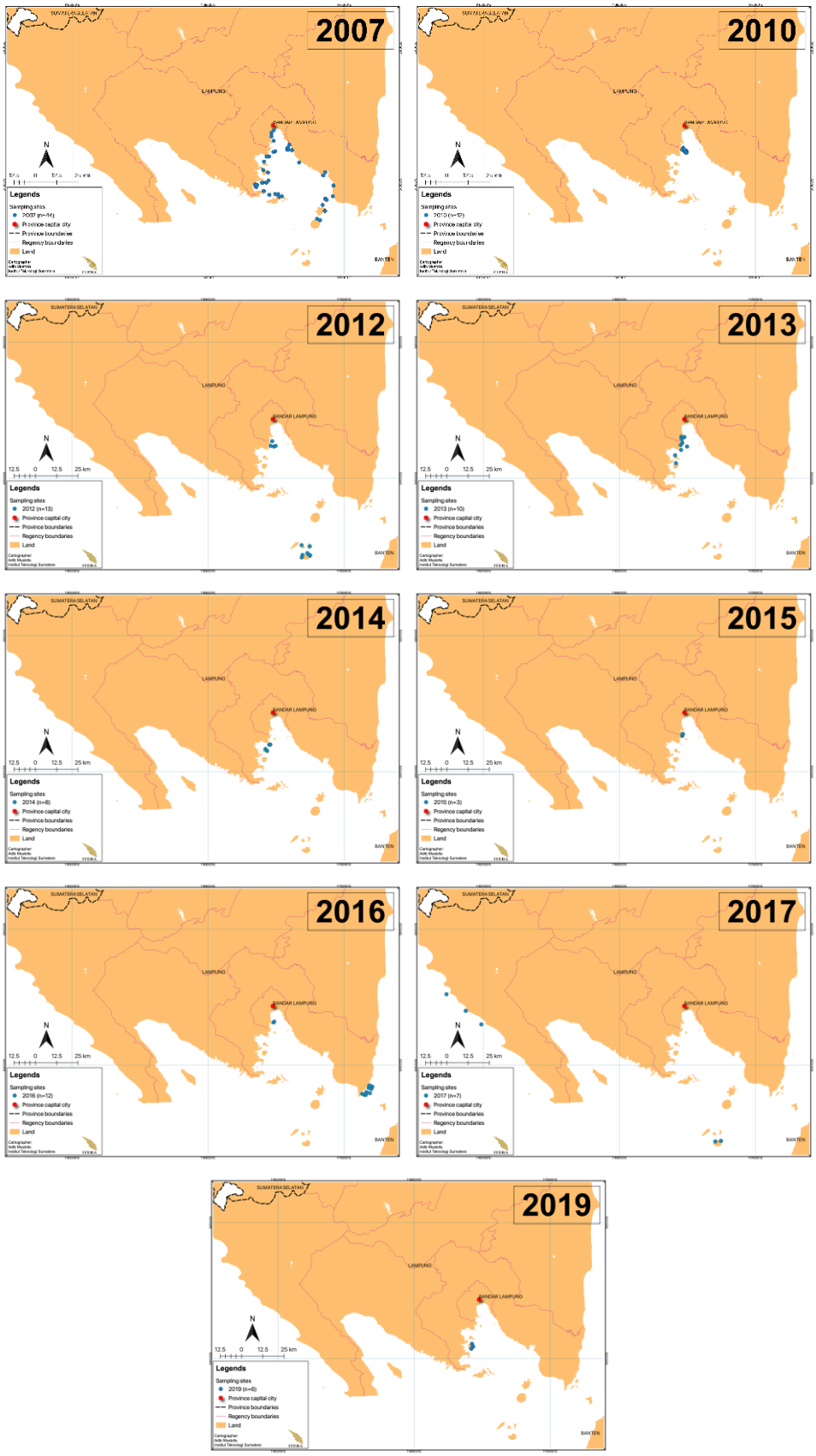

Figure 3. The distribution map of coral reef monitoring from 2007 to 2019

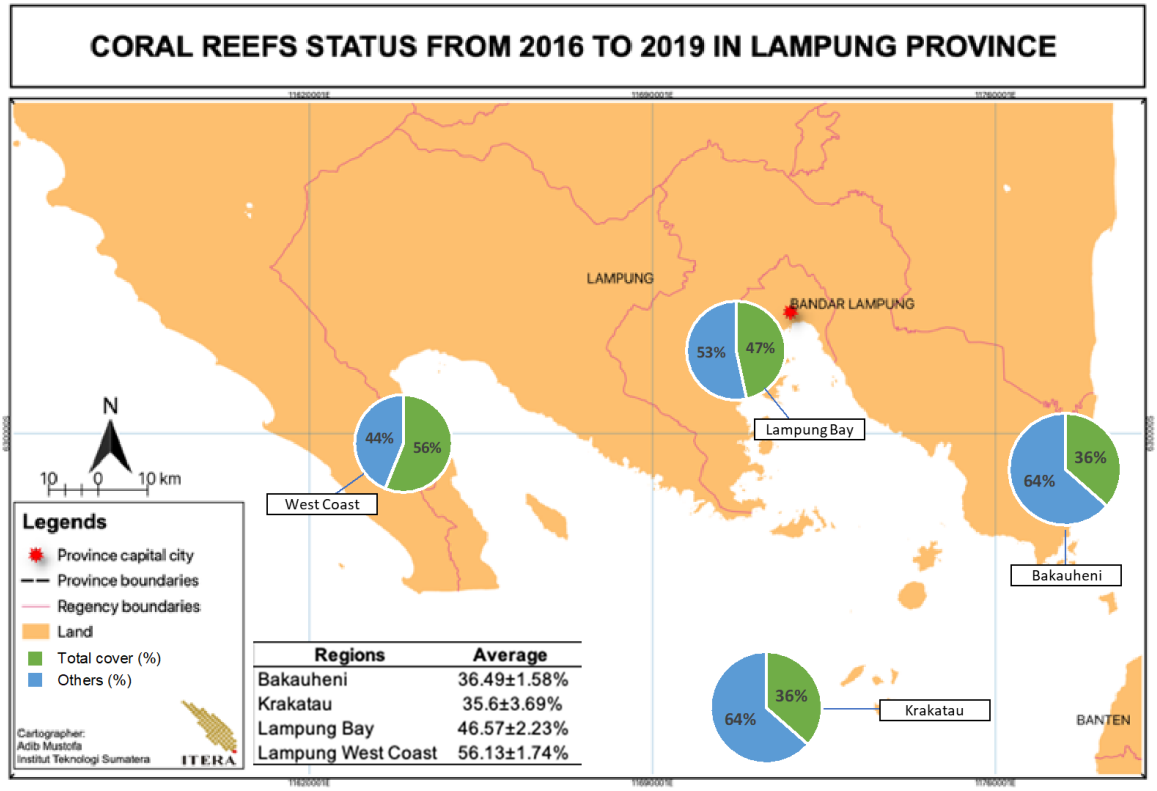

Figure 4. Coral reef cover in the four regions of Lampung Province from the last 5 year data

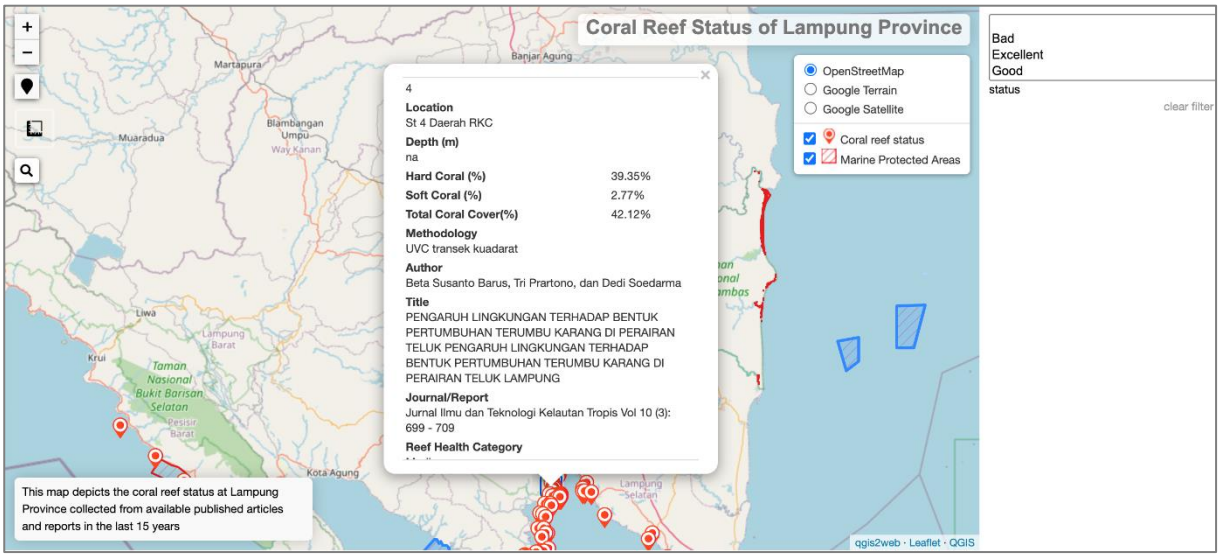

Figure 5. WebGIS interface on coral reef monitoring in Lampung Province available online at https://sll.itera.ac.id/research/webgis

4. Conclusion

In summary, coral reef status in Lampung province in the last 15 years varied from bad to excellent conditions. Most coral reef data were gathered in Lampung bay while there is coral data gap in Lampung west coast and Semangka bay. Data analysis from the last 5 year data shown no significance difference on the coral cover in the main four regions of Lampung Province, specifically Lampung west coast coral cover at a good shape, while Lampung bay, Krakatau, and Bakauheni coral cover at medium condition. For further stages, it is crucial to design environmental monitoring, including coral reefs monitoring, in more harmonized, structured, and standardized means. By doing this, long-term monitoring to evaluate the environmental impacts induced by various factors could be carried out and the data could be used for statistical analysis and modelling (Schmidt *et al.,* 2010). It then would allow policy makers to make decisions based on science so that better marine ecosystem management and policy could be acquired (Lindenmayer & Likens, 2009). Long-term monitoring is also cornerstone to evaluate responses to disturbances and provide baseline data to evaluate changes as response to management interventions.

The developed WebGIS informed each coordinates where scientists and institutions had worked on the coral reef monitoring in the last 15 years. It is recommended that the further coral reef monitoring could consider the coordinates provided in this WebGIS system as the baseline data. It will allow researchers to evaluate the temporal changes on the coral reef cover between the same coordinates over time periods.

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