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Smart Island Lemukutan Through WebGIS Based Benthic Habitat Data Collection

Zan Zibar[1,*], Robin Saputra[1], Adityo Raynaldo[1], Supriyatno[2], Budhi Agung Prasetyo[3], Risko[4] Hendrawan[5]

[1]Study Program of Marine Science – Faculty of Natural Science and Marine – OSO University, West Kalimantan, Indonesia
[2]Technology and Information Technical Implementation Unit – OSO University, West Kalimantan, Indonesia
[3]Marine Environmental Science, Institute Technology of Sumatra, South Lampung, Indonesia
[4]Departement of Marine Science and Fisheries – Politeknik Negeri Pontianak, West Kalimantan, Indonesia
[5]Departmen of Marine and Fisheries, North Borneo Province, Indonesia

*Corresponding author e-mail: zanzibar@oso.ac.id

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Abstract
Benthic habitats provide a variety of functions, both ecological and economic, for life in coastal areas and small islands. Smart islands or smart islands are currently being implemented in a number of small island developing countries with one of the challenges being technology based. One technology that can be used in management, including monitoring and supervision of resources, is the Geographic Information System (GIS). The synergy of GIS data and the help of the latest multimedia software technology is necessary to help display an interactive and easily accessible, in this case, webGIS technology. This research was carried out on Lemukutan Island which consists of 6 research stations, each of which has a distribution of coral reef location points based on coordinates. Based on the results of the analysis of the percentage of benthic habitats in the study locations ranging from bad to good categories. Furthermore, the data from field observations and analysis results are displayed on the Lemukan Island smart island website and can be accessed at https://webgissmartisland.com. Regular monitoring of coral reefs is very important and needs to be done to help input data for Smart Island Lemukutan so that it becomes a catalyst in realizing a smart island ecosystem in West Kalimantan Province by providing benthic habitat maps via webgis services and actualizing technological development in coastal areas and small islands. smart island based through the smart destination concept by integrating benthic habitat information via WebGIS services.

Keywords: Smart Island, Lemukutan, Benthic Habitat, WebGIS

1. Introduction

Benthic or shallow water habitat is part of the coastal area which includes coral reef and seagrass ecosystems with high productivity. This ecosystem provides environmental services because it can support life (Prayuda, 2014; Yasir Haya & Fuji, 2019). Benthic habitats provide a variety of functions, both ecological and economic, for life in coastal areas and small islands. Among these functions, one of them is as a source of germplasm and biodiversity for marine life, protection of beaches from waves, as well as tourism functions (Prawoto & Hartono, 2018). Data collection on seabed habitat is very important to know the type of seabed habitat, thereby providing a reference collection of habitat types, diversity of objects making up the waterbed to enable the availability of a habitat database (Lima et al., 2019).

Lemukutan Island is an island administratively located in Sungai Raya Kepulauan District, Bengkayang Regency, West Kalimantan Province. Lemukutan Island has potential marine resources including coral reefs, seagrass and macroalgae which inhabit bottom water habitats (Gusmawati & Sanova, 2018). Good benthic habitat management requires the support of valid data as a basis for formulating policies and developing technology and management of small islands and coasts. One of the data needed is the basic cover of benthic habitat obtained using a certain method (Fadhillah et al., 2021). Benthic habitat conditions can be monitored using a variety of methods, including the Line Intercept Transect (LIT), Point Intercept Transect (PIT), and Underwater Photo Transect (UPT) methods. Line Intercept Transect (LIT) is a method used in coral reef surveys developed by *Australian Institute of Marine Science* (AIMS) dan *The Great Barrier Reef Marine Park Authority* (Wahib & Luthfi, 2019). Indirect benthic habitat monitoring activities can be carried out using remote sensing or aerial photography. One of the methods used is object-based classification (OBIA) with the SVM algorithm on Sentinel-2 imagery with the results of benthic habitat classification in the 12 and 9 benthic habitat classes showing that the living coral class (KH), the rubble + seagrass (RL) class algae (Mastu et al., 2018).

Smart islands are currently implemented in a number of small island developing countries or Small Island Developing States (SIDS). Smart islands are currently being implemented in a number of small island developing countries or Small Island Developing States (SIDS) where one of the challenges faced is technology-based. The absence of digital technology not only contributes to the digital divide, but it also deprives small island communities of opportunities to leverage digital solutions to gain better access to essential services (Domínguez et al., 2017). One tool that can be used in management, including monitoring and supervising resources, is a Geographic Information System (GIS). Geographic information systems are an important tool for spatial modeling in the analysis of various coastal issues. Therefore, a synergy is needed between GIS data and the latest multimedia software technology to help display interactive and easily accessible, in this case, webGIS technology. webGIS is a geographic information system distributed via computer networks for integration, disseminating and communicating geographic information visually via the world wide web (Jeong et al., 2011; Gros et al., 2023). Mustofa & Prasetyo (2020) stated that integrating coral reef data via webGIS is very important to support better marine ecosystem management decision making.

So far, research smart island Lemukutan through webGIS based benthic habitat data collection has never been carried out and is still in the development stage in several developed countries in the world, so this research is important and needs to be carried out for the development of webGIS-based smart islands on small islands in Indonesia.

2. Method

2.1. Time and Location of Reseacrh

This research was conducted on Lemukutan Island, Bengkayang Regency, West Kalimantan (Figure 1). The research location consists of 6 research stations where each station has a distribution of coral reef location points based on coordinates. Field data collection was carried out for 4 days in August 2023.

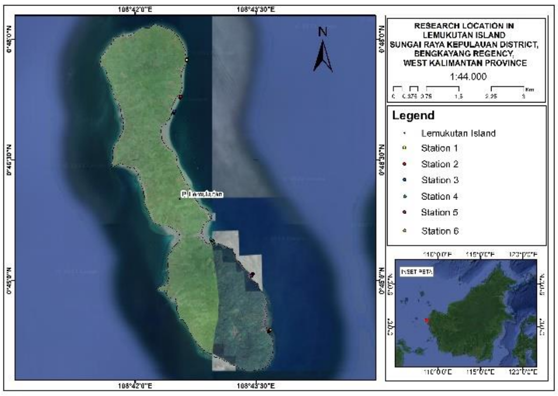

Figure 1. Research Location

2.2. Tools and Materials of Research

Field surveys observed benthic habitat using Garmin 78s and 64s handheld GPS, underwater cameras, roll meters, quadrant transects, underwater writing instruments (slates and pencils) and diving equipment, thermometers, refractometers. Benthic habitat identification was carried out using Coral Point Count with Excel extension (CPCe).

2.3. Data Collection

Benthic habitat data collection was carried out using a random sampling method where each monitoring point location was considered to be representative of the condition of coral reefs with the researcher's considerations when conducting field observations based on the representation of the life form characteristics of the benthic habitat (Marista, et al. 2023). Documentation of benthic habitats using the Underwater Photo Transect (UPT) method by diving with the camera in a vertical position above the frame until the display frame is fully loaded in the photo. The frame has a size of 58 cm x 44 cm placed on the transect line. One frame consists of one photo, so that on one transect, 50 photo frames from one transect at one station are obtained. The identified objects can be dominant habitats and mixed habitats (Giyanto et al. 2017; Kase et al., 2019). Habitat data and geographic position from GPS were input into the MS Excel program and displayed as spatial data with the ArcGIS program. Combining spatial and non-spatial data then goes into webGIS design. The spatial flow diagram of database development in WebGIS (Fadhila & Cahyono, 2017) is illustrated in Figure 2.

The method applied in this research website is the waterfall method. The waterfall method is a software development that has sequential stages and progress is described as a waterfall that continues to flow downwards through the planning, modeling, implementation and testing stages. The waterfall method has sequential stages, namely needs analysis, system design, coding and testing, program implementation and maintenance (Tristianto, 2018).

2.4. Data Analysis

The percentage cover of each category of biota and substrate for each photo frame is calculated using the following formula (Giyanto et al., 2014; Malinda et al., 2020):

$L = \Sigma Li/N \times 100\%$……………………………………….(1)

Where :

L	=	Substrate cover percentage (%)
Li	=	The number of point categories
N	=	Random number of points

Coral reef ecosystem assessment criteria based on the percentage of live hard coral cover according to Dahuri (2001), can be seen in Table 1.

Table 1. Categories of Percentage Cover of Live Hard Coral

No	Range	Status
1.	0 – 25 %	Bad
2.	25 – 50 %	Medium
3.	50 – 75 %	Good
4.	75 – 100 %	Excellent

3. Results and Discussion

The percentage of benthic habitat at the research location shows the condition of benthic habitat spread across 6 research stations. All of these stations are spread over 3 bays, including China Bay, Melanau Bay and Surau Bay. The results of the percentage cover of the benthic category in the study location can be shown in Table 2. The percentage of benthic habitat at the research location shows the condition of benthic habitat spread across 6 research stations. All of these stations are spread over 3 bays, including China Bay, Melanau Bay and Surau Bay. The results of the percentage cover of the benthic category in the study location can be shown in Table 2. Factors that affect the low percentage of live coral are due to the influence of suspended particles originating from the mainland as well as human activities, namely going in and out and belaying fishing boats which results in rubbles, coral damage and dead coral. Burke et al. (2011) stated that coral reefs worldwide More than 60% are threatened by the growth of local activities such as land use practices that damage coastal ecosystems. Carlson et al. (2019) stated that land use and land cover can affect coral reefs through a number of processes including the disposal of nutrients through the soil, especially from activities sourced from the mainland which can be a source of sediment clumps and can affect coral reef life. Nugroho et al. (2018) stated that organic sediment content in the water column can significantly reduce coral diversity. The condition of coral reefs at the study location can be seen in Figure 3.

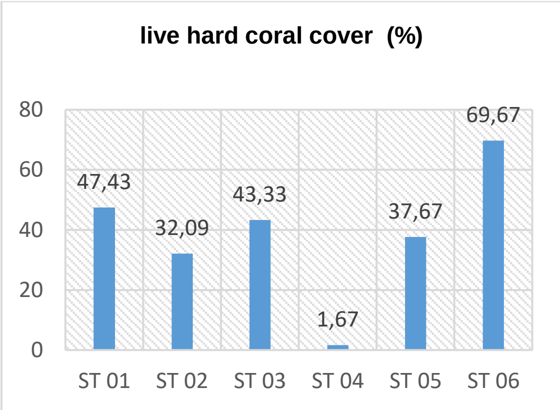

Figure 3. Live hard coral cover

There are 6 (six) forms of coral growth found at all observation stations, namely Acropora Branching (ACB), Acropora Tabulate (ACT), Coral Heliopora (CHL), Coral Massive (CM), Coral Submassive (CS), Coral Mushroom (CMR), Submassive Coral (CS), Coral Foliose (CF). Alcivar-Mendoza et al. (2021) stated that the loss of coral reef cover in many cases is caused by groups of algae that dominate the bottom of the waters for long periods. Mumby (2014) stated that catching herbivorous fish species will have an impact on increasing the number of algae that compete with coral and will disrupt its health. Burke et al. (2011) stated that human activities involving excessive fishing, destructive fishing and coastal development will cause pressure on coral reefs, thereby affecting the percentage of coral reefs.

The water temperature in the observation area at each station ranges from 29°C – 31°C and the salinity at all observation stations ranges from 27 ppt – 28 ppt. This condition shows a normal condition where coral reefs can still live and develop. The research results of Ding et al. (2022) obtained research results that changes in temperature and salinity due to climate change indeed pose a threat to the survival of coral reefs. From the results of the experiments carried out, it was found that the optimal survival conditions for coral reefs are 25 °C and 30–35 psu. When the temperature and salinity are too high or too low, the metabolism will be affected.

Benthic Life Form data along with the sequence of types for each station point location based on their coordinate points can be accessed on the Lemukutan smart Island page available at https://webgissmartisland.com (Figure 4).

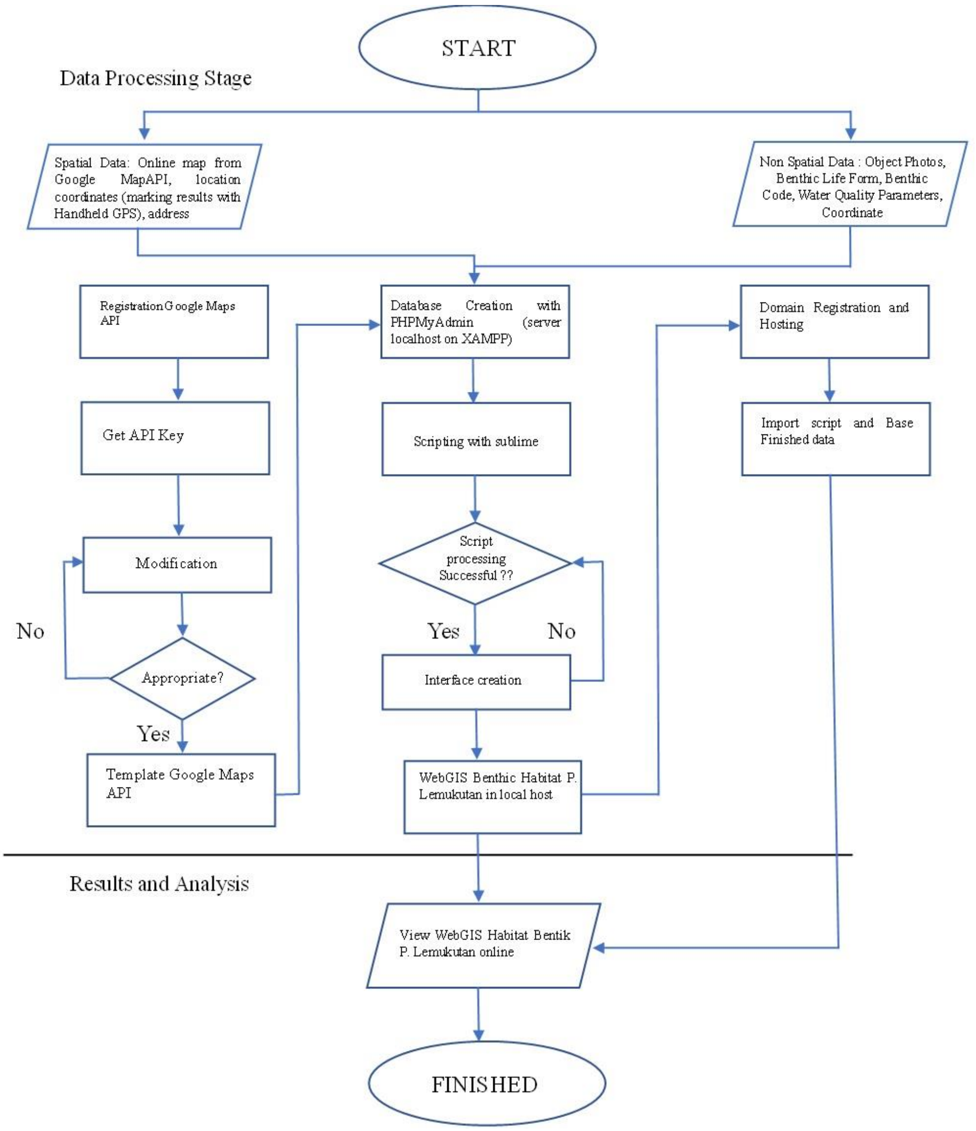

Figure 2. Flowchart of WebGIS coral reef database development

Table 2. Coral reef status in research location

Benthic Category	Location					
	ST 01	ST 02	ST 03	ST 04	ST 05	ST 06
Coral cover (%)	47,43	32,09	43,33	1,67	37,67	69,67
Recently Dead Coral (DC)	5,07	1,40	1,25	0	6,80	2,0
Dead Coral with Algae (DCA)	30,3	12,74	32,92	1,67	49,93	22,33
soft coral (SC)	0,33	0	2,50	0	0	0
sponge (SP)	0,40	2,47	1,25	0	1,33	0
Fleshy Seaweed (FS)	0,20	2,20	5,42	18,33	0,87	4,66
Others (OT)	0,13	0,27	3,33	2,22	0	0
Rubble (R)	0,40	0,87	0	1,11	0,80	0
Sand (S)	0,00	0	0	0	0	0
silt (SI)	3,60	13,74	3,75	44,44	0,73	0,67
Rock (RK)	12,14	34,22	6,25	30,56	1,87	0,67
Coral Reef Condition	Medium	Medium	Medium	Bad	Medium	Good

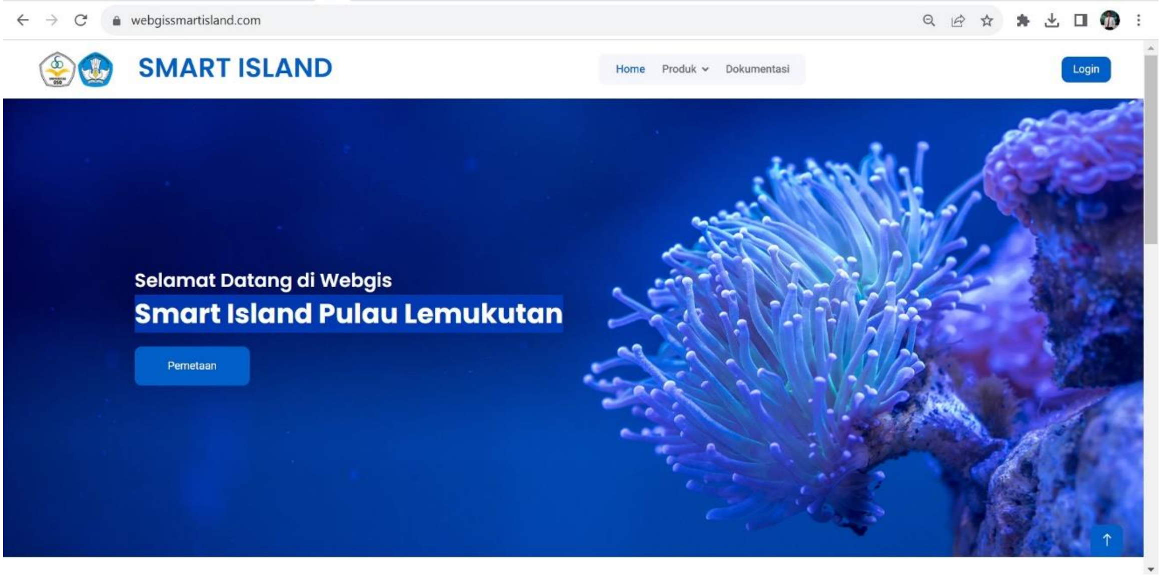

Figure 4. Home page of the Smart Island Lemukutan Website

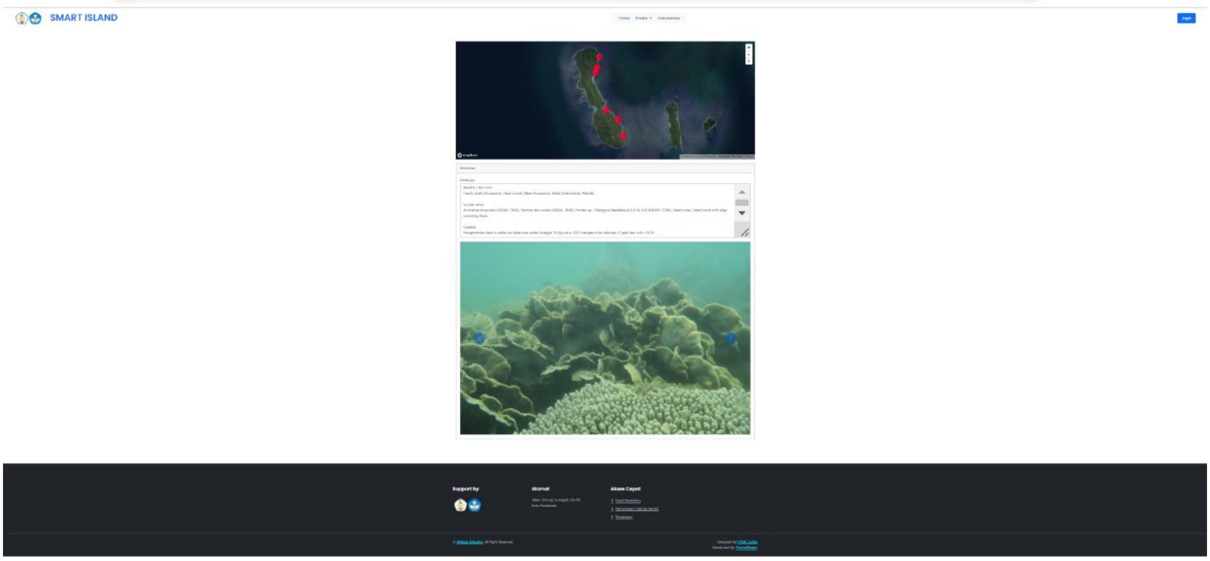

Figure 5. Smart Island Lemukutan WEBSITE homepage available online at https://webgissmartisland.com

Figure 5 visualizes the condition of benthic habitat at the research location taken based on coordinate points so that the images from this research can help manage benthic habitat, especially coral reefs, so that they are maintained for future generations. WebGIS Smart Island Lemukutan is expected to help build knowledge about the diversity, abundance, habitat and range of benthic habitat species on Lemukutan Island so that it can become an attraction for marine ecotourism activities in coastal areas and small islands. Lubis et al. (2017) stated that to help visualize landscapes in the field of planning and spatial planning to support the development of coastal areas and small islands, collaboration is needed between developers, industry, environmental NGOs and even computer experts in integrating data with a GIS approach and through WEBGIS services.

The presence of the Lemukutan smart island website is expected to contribute to reducing the digital divide and provide opportunities for small island communities to utilize digital solutions to gain better access to the benthic habitat conditions of Lemukutan Island, Bengkayang Regency, West Kalimantan. Randazzo et al. (2021) States that the application of WebGIS can help and make it easier for governments, researchers, environmentalists and the general public to interact with geographic information data through WebGIS services but requires the internet. Ease of access to this database will be useful in supporting future planning coastal area.

4. Conclusions

Smart Island Lemukutan through webGIS based benthic habitat data collection can be carried out by directly collecting benthic habitat at the research location, then benthic habitat cover data can be processed using the CPCe (Coral Point Count with Excel Extension) software with the percentage of benthic habitat at the research site starting from category bad to good. Furthermore, the data from field observations and analysis results are displayed on the smart island Lemukutan website and can be accessed at https://webgissmartisland.com. Regular monitoring of coral reefs can help input Smart Island Lemukutan to become a catalyst in realizing the Smart Island ecosystem in West Kalimantan Province, by presenting benthic habitat maps via webgis services and actualizing the development of technology for coastal areas and small islands based on smart islands through the smart destination concept by integrating benthic habitat information via webgis services.

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