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Distribution of benthic habitat using Landsat-7 Imagery in shallow waters of Sekupang, Batam Island, Indonesia

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Abstract. *Lubis MZ, Anurogo W, Hanafi A, Kausarian H, Taki HM, Antoni S. 2018. Distribution of benthic habitat using Landsat-7 Imagery in shallow waters of Sekupang, Batam Island, Indonesia. Biodiversitas 19: 1117-1122.* Shallow sea waters are one region that has high dynamics and an important role both economically and ecologically. Batam Island one of the islands in Indonesia is rich in the ocean in Riau Islands Province, Indonesia, and surrounded by small islands.We conducted classification and correction of water column using Lyzenga formula, to see benthic habitat in Sekupang waters, Batam Island, Indonesia. This research uses remote sensing method with Landsat-7 image data, on data recording that is dated December 16, 2016. The purpose of this study is to obtain information on the distribution and extent of sand, dark sea, and coral reefs on Batam Island shallow waters of Sekupang. By using the formula of Lyzenga algorithm, the value of ki/kj is 0.404, by looking at the color change corresponding to the channel. Research result of classification in the shallow coastal waters of the island of Batam in Sekupang with the area is sand with 27.64 % (3.443 ha), cloudy sea with an area of 30.94% (3.854 ha), and coral reefs with an area of 41.43% (5.161 ha).

Keywords: Benthic habitat, Landsat-7, Lyzenga

INTRODUCTION

Batam City is the island closest to Singapore, separated by a 15 km wide strait, and a free trade zone area (FTZ), part of the SIJORI region (Singapore, Johor (Malaysia) and Riau Islands (Indonesia). Shallow sea waters are one region that has high dynamics and an important role both economically and ecologically. Coral reefs and seagrass a significant component of the ecosystem constituents serve as a fish habitat, a place of tourism, coastal protection from wave hitting and stirring suspended material. The science and art that will produce information about an object and phenomenon with the analysis of data derived from various kinds of satellite images, without direct contact with the object or the observed (Lillesand et al. 2014).

Shallow water is an area of water that directly adjacent to the coastline that supports the growth of rooted plants such as seagrass beds. Clear shallow water areas are capable of accepting the penetration of sunlight to the bottom of the waters that make various ecosystems well-developed seagrass and coral reefs (Bates et al. 2010). The ecosystems in shallow water are potential ecosystems in the coastal area because they have high primary productivity (Dando 2010). Benthic habitat mapping using remote sensing technology to date continues to grow as it is supported by the availability of high-resolution images that are increasingly easy to obtain (Purkis and Pasterkamp 2004; Antoni et al 2018). In addition, these ecosystems play a role in absorbing carbon in the atmosphere (Kennedy et al. 2010).

The importance of the role of the ecosystem is needed to examine one of the basics, especially in the island of Batam, Indonesia which has a vast ocean area. Remote sensing technology in the monitoring of benthic habitats has an important role, primarily to monitor conditions such as coral loss due to human intervention as well as natural factors. Intensive monitoring requires substantial funds and long periods of time. By using remote sensing technology, coral reef monitoring activities are expected to provide reliable results with minimal funding and time (Schultz and Engman 2012). Remote sensing of passive systems for shallow water research utilizes many visible waves (400-750 nm) divided into blue, green, and red channels. The ability to penetrate electromagnetic waves in the water column is strongly influenced by the characteristics of these waters. Setyawan et al. (2014) add that the more turbid seawater then the penetrating power of both spectra (green and blue bands) will decrease.

With remote sensing commonly known as benthic habitat mapping more complex can be studied which not only can result in the division of any benthic habitat cover that is a shallow ecosystem of view and also parameter parameters such as depth, base shape, and geomorphology of coral reef zonation. The area along the coastline is dominated by the sand and mud substrate from the land. The further away from the shoreline, the base material can be hard material that is a growing medium for coral reefs (Cinner et al. 2012). Based on the different environmental and spatial characteristics of each benthic habitat class, the image mapping can be more easily done by adding the coral reefs coronary zonation element because each zonation class has depth information and the distance of each zone to the shoreline.

The utilization of these images can not only produce benthic habitat coverage information but also physiographic information of shallow waters such as the basic shapes of waters or morphology and depth of waters (Hedley et al. 2012; Kobryn et al. 2013). Further depth information can be used to create coral reef geomorphology zoning (Leon et al., 2012) that serves as environmental parameters that become constrained in the mapping of benthic habitats. Environmental parameter information can facilitate mapping of benthic habitats to recognize aquatic base objects. Remote sensing is currently the recommended technology to be a member of coral reef ecosystems and shallow habitats with prior research done by space for research (Selgrath e al. 2016; Lucas and Goodman 2014). In a previous study, mapping of benthic habitats using Lyzenga was an excellent formulation for correcting water columns using satellite imagery using Landsat-8 (Wahidin et al. 2015). The habitat of shallow water is the main factor of fish presence on the reef. Abundance, diversity, and distribution of fish are highly dependent on the complexity of their habitats (Feary et al. 2014; MacNeil et al. 2015).

The advantages of remote sensing images obtained from satellites will produce an object image, and symptoms on the surface of the earth as the original object (Lubis, et al. 2017). Characteristics of the objects are that it does not appear in the form of images so that it is possible to recognize the object using remote sensing method (Sutanto 1992). Identification of benthic habitat consists of sand, sea, and coral reefs. A coral reef is a form of the submarine land of shallow sea waters that are often found on the beaches in the tropics. This form of land was built by coral organisms and lime-producing algae (Nurdin et al. 2015; Miller et al. 2012). Information on basin habitats is generally obtained through direct observation (field survey) and also with remote sensing technology in the form of satellite images (Phinn et al. 2012). Meanwhile, studies related to the detection of shallow water habitats in Indonesia using satellite imagery and combining it with field observations are still insufficient to date. In the recent years, very many sensory satellite sensors can detect objects in shallow water ecosystems such as coral community (Knudby et al. 2014), live coral cover (Goodman et al. 2013, Roelfsema and Phinn 2010), even benthic species and coral health. Distribution of shallow waters and the identification of benthic habitats can be done by utilizing remote sensing technology (Lyzenga 1978). In the remote sensing method having 6 basic components is a uniform energy source, the atmosphere, the unique interaction between powers with objects on earth, has a perfect sensor, the existence of efficient data processing system (Volpe et al. 2011; Giardino et al. 2010). The purpose of this study was to obtain information on the distribution and extent of benthic habitat (sand, coral reef, and deep sea), using remote sensing method in Batam Island in Sekupang waters, Indonesia.

MATERIALS AND METHODS

Study area

This research is done by utilizing Landsat-7 image in Batam Island area, Sekupang waters. Landsat-7 recording image data was downloaded in December 16, 2016. In this study Landsat-7 image data to highlight more objects in shallow water, Zhu and Woodcock (2012) suggest that by combining the natural logarithms of three visible light channels (Band (Band 2: 30 m, green, 0.525-0.605 µm) and (Band 1: Band 1 (30 m, Blue, 0.450-0.515 µm), it gets the picture which will reveal the results of informative image processing in benthic habitats in shallow water

Procedure

The processing of satellite imagery to obtain a shallow baseline habitat map was undertaken with the following steps: masking the study area, geometric correction, atmospheric correction, and correction of the water column. Channels used for this correction are the blue channel (Band 2) and green channel (Band 3). Furthermore, the image is classified as supervised based on field observation data with maximum likelihood algorithm. The classification of satellite imagery in this way has been widely used to produce a basic shallow waters habitat map (Lyzenga 1978). In this study, we mapped the shallow basal habitats with classification schemes: marine, coral reefs, and sand. The Landsat-7 image combined by using several bands or channels, i.e., 421 band composites (Band 4 near-infrared (NIR) channel, Band 2 green channel, and Band 1 blue channel). Satellite imagery used in advance is pre-processing consisting of radiometric correction, sunlight correction, and geometric correction. □

The occurrence of sunlight and water waves is a common problem in high-resolution satellite imagery. Sunlight effect phenomenon occurs due to the reflection of sunlight that concerns the object (usually waters) in the direction of the satellite sensor recording angle. The removal of the sunlight effect is done by using a near infrared channel following an already developed algorithm. Removal of sunlight effect disturbance, at the same time, was able to eliminate water wave disruption. In the satellite image view, it will look like a glass reflection so that it interferes with the processing and analysis. Separation of land and sea is done to remove objects that are not the subject area of study (in this case mainland) by masking on satellite imagery. Furthermore, the analysis is done by composite satellite images with 8 channels, adapted to the object of study. In composite, the original color display (true color) is done by combining red, green, and blue channels. Classification based on shallow water habitat is done by the unsupervised method, and further validation is done with field results and re-classing. The results are tested to determine the accuracy of the level of accuracy of classification stages or flow diagrams in this study are started with literature study and ended in the distribution of benthic habitat in Sekupang waters (Figure 2).□

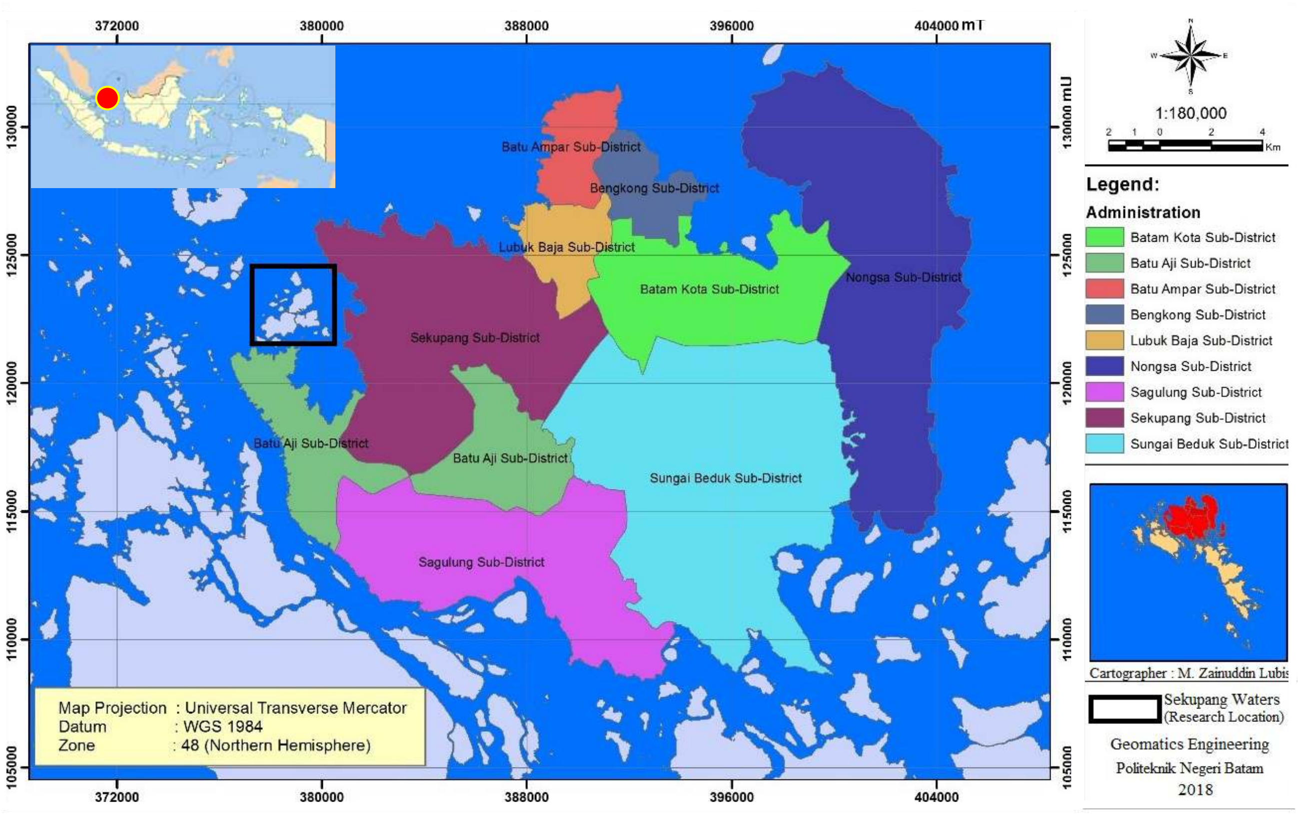

Figure 1. Research location in shallow waters of Sekupang, Batam Island, Riau Islands Province, Indonesia (black color square)

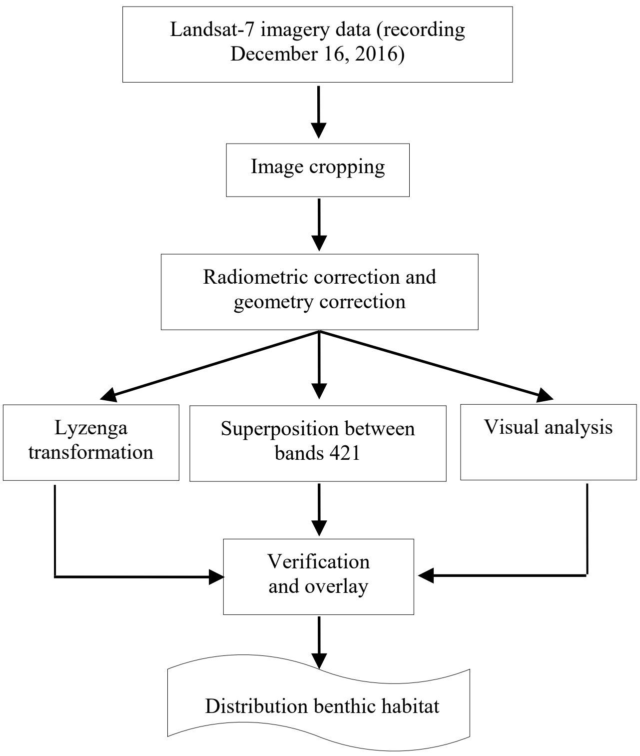

Figure 2. Research flow diagram of distribution benthic habitat

Pre-processing performed on Landsat-7 satellite images. In this study consists of two stages: correction of radiometry and geometry correction. Radiometric correction aims to improve the visual quality of images and simultaneously correct unsuitable pixel values. Geometry correction aims to position the object in the image according to the actual position in the field, and the accuracy study refers to the method of Hamel and Andréfouët (2010). In this study, we used the Lyzenga method algorithm for the classification of benthic habitats in shallow waters of Sekupang waters, particularly to see coral distribution, sand, and sea (Lyzenga 1978). As the equation by developing an algorithm approach to formulas as in Equation 1, this formula can be applied to image processing program using Landsat-7 imagery.

$$Y= [\ln(TM1)] +[(ki/kj)(\ln (TM2))] \quad (1)$$

Where:

Y : The results of the classification of the Lyzenga algorithm

TM1 : Landsat image channel;

TM2 : Channel 2 Landsat image

Measure In-situ by applying an exponential reduction model

Calculate ki/kj

The algorithm of equation 2 transformed from the negative sign (-) becomes positive (+) which is useful to get an introduction to the variation of benthic and shallow water habitat, which becomes:

$$Y = [\ln(TM1)] + [(ki/kj)(\ln(TM2))] \quad (2)$$

RESULTS AND DISCUSSION

Distribution of habitat benthic

The spectral characteristics of coral reef habitat objects can be obtained from the average bands in the imagery for each class observed. At the visible wavelength range, which consists of blue light (0.45-0.5 μm), green (0.5-0.55 μm), and red (0.65-0.7 μm), each class has a reflectance value (indicated by the value of digital number/DN) (especially in blue light), as shown in (Table 1). Decreased reflectance occurs at the visible border of light toward the NIR (Near-Infrared) and SWIR (Short Wave Infra-Red). Digital analysis performs the access process, which consists of spectral value analysis of each data of Landsat image that is with 421 band composite done several times according to the result that in accordance with requirement and process of the algorithm of Lyzenga result ratio existing in the area is shallow Sekupang, Batam. As the results of the variant versions, covariance, and water column attenuation ratios of the variance value can be seen in Table 2, while the value on the processing yield is seen in Table 1.

In Table 1 can be seen, for each region is calculated the value of variance. Where the minimum value and maximum value for shallow waters band-1 is 116.417, 126.286) and band-2 is 82.625, 104.524. So the value ki/kj of the formula $\frac{ki}{kj} = a + \sqrt{a^2 + 1}$ the result is 0.404515. From these results can be classified directly by the colors, which is the absolute value obtained from the formula. Table 2 shows the results of calculations using the Lyzenga algorithm by searching for variant values or variations of Band 1 and Band 2, they can find the covariance value of the band 1 and band 2 variants. To determine the value of a can also get from the formula (VarB1-VarB2)/(2 * CovB1B2).

Distribution of benthic habitat in shallow waters, Sekupang waters, Batam resulted from the extraction process of Landsat image 7, on 16 December 2016, with the process of extraction of the image is done to get benthic habitat, the image is then classified using unsupervised to distinguish shallow water habitat is sand, coral reefs, and cloudy sea. The result of the area in each classification is done by using calculate geometry. The results of this study indicate that the method is a good method because classification using the Lyzenga method based on the object of Landsat 7 image significantly improves the accuracy for benthic habitat mapping classification, as compared to pixel-based classification techniques with Landsat, and affects the accuracy value on the map. Figure 3 shows the existence of color difference, with 3 classes of object division conducted in this study. The result of classification of benthic habitat in the form of area data is still planimetric in 2 dimensions. Figure 3 shows the green color is a coral reef, the yellow color shows the sand and blue color is a turbid sea. result of classification in the shallow coastal waters of the Batam island, with the area: sand with 3.443 ha, cloudy sea with an area of 3.854 ha, and coral reefs with an area of 5.161 ha, this shows the classification process with class division of 3 classes, then the highest area is on coral reef area (Figure 3).

From this classification result (Figure 3) there is a close association between geo-morphological zones with the existence of certain benthic habitat, so this research applies multiscale classification (reef level, geomorphic zone, and benthic habitat). The results obtained show the geomorphology and ecology of the coral reef area which is divided into three levels: reef level, geomorphic zones, benthic community zones, but the results are identified only to outline which can be seen in (Figure 3). Mapping of benthic habitat in Batam island cluster (Sekupang shallow waters) has been done with the different method of classification and result of accuracy. The most common classification used so far is the pixel-based classification method, while object-based classification methods have never been done in this region. Classification results indicate that the dominant abiotic is scattered throughout the coastal areas, but most are on the southern part of the cape. The boundary between land and sea is still dominant abiotic (sand).

Table 1. Band classification value 1-7

Class/ region	Band 1	Band 2	Band 4	Band 5	Band 6	Band 7
1	123.484	96.435	49.903	43.048	152.226	23.903
2	126.286	104.524	63.429	67.619	155.119	36.81
3	119.358	93.321	43.566	36.113	152.66	21.283
4	120.462	95.462	44.846	50.462	152.923	29.154
5	116.417	82.625	30.992	22.458	136.408	14.733
6	116.564	85.141	40.641	31.436	136.846	19.756
7	120.768	88.244	26.341	19.378	146.646	14.085
All	126.291	91.875	44.402	51.408	147.795	34.655

Table 1. Variation value on channel B1 and B2

Varian	**12.65313**
Covariance B1 and B2 value	21.19523
a	-1.03379
ki/kj	0.404515

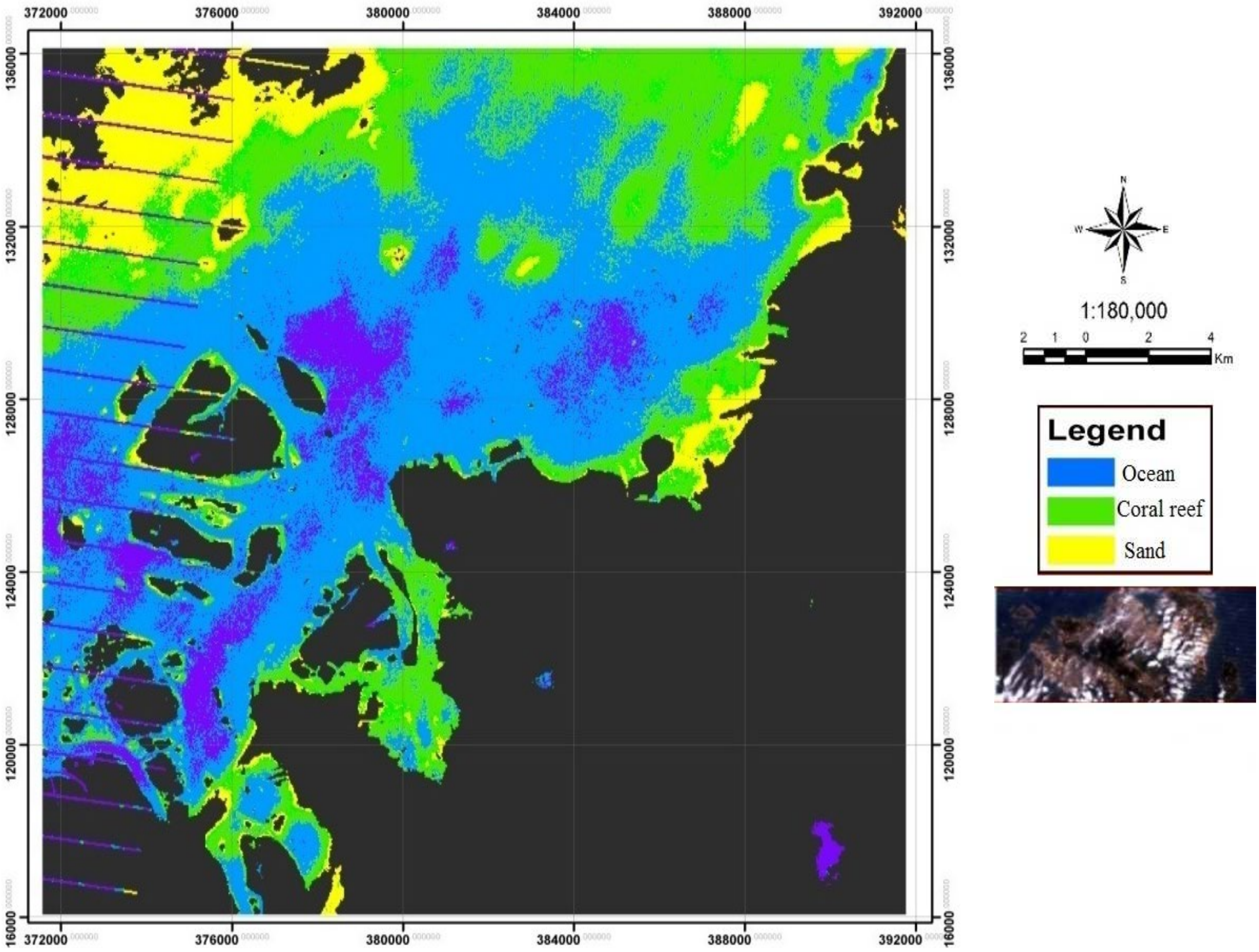

Figure 3. Map of shallow water classification of Sekupang, Batam Island, Riau Islands Province, Indonesia

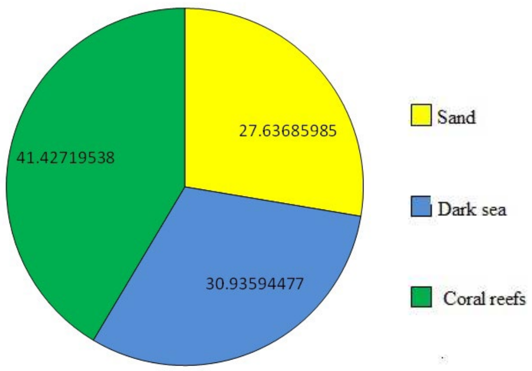

Figure 4. Percentage of benthic habitat area in the waters of Sekupang, Batam Island, Riau Islands Province, Indonesia

Percentage of habitat benthic distribution

Physical conditions in shallow waters are important for the survival of coral reef ecosystems, and especially in shallow water habitats. Examples are salinity, sea surface temperature, tidal currents, and meteorological factors will affect the condition of marine waters and coral reef ecosystems (Li et al. 2013). The area of object identification is sand with 27.64% (3.443 ha), cloudy sea with 30.94% (3854 ha), and coral reef with 41.43% (5.161 ha). The percentage of the area in which the research is described in the pie diagram, the largest area is the coral reef object with a percentage of area 41.42%, while the area with the lowest percentage is located on the sand object in the yellow colour on the diagram pie with a percentage of 27.64% (Figure 4).

Based on the results of this study it can be concluded that correction of water column can be applied to the Landsat-7 image by using channel (band) 421, which build the coefficient ratio of attenuation in image data (Ki/Kj). The application of correction results using the Lyzenga algorithm on Landsat-7 imagery affects the visual appearance of the image and the accuracy of the map. The percentage of benthic cluster classification (ocean, coral reefs, and sand) in Sekupang waters, Batam Island, has the largest extent on coral reef objects, and the smallest is in sand objects.

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