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Mapping Of Subtrate Categories With The OBIA Method Using SPOT-7 Imagery On Fringing Reef At Tanjung Pemancingan, Kotabaru Regency

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Abstract:
Background*: Tanjung Pemancingan has a fringing coral reef ecosystem close to mangrove ecosystems and river mouths. Coral reefs in this region are subject to both anthropogenic and anthropogenic factors. These factors affect the condition of the coral reef substrate.*
Materials and Methods*: This study aims to map the categories of coral reef substrates using the OBIA method and the SVM algorithm.*
Results*: The results showed that for the classification of the ten categories of substrates, the OA (overall accuracy) was 65.35%. The results of the classification categories of 10 substrate categories show that the biotic HC (hard coral) category has an area of about 9 ha, the coral category mixed with other substrates (HC Mix) is around 0.55 Ha, the SP (sponge) the substrate category is around 0.17 Ha and SC (soft coral) about 0.10 Ha. Furthermore, DCA mixed or dead coral covered by algae and mixed with other substrates with other substrate categories around 4.65 Ha, followed by DCA around 3.51 Ha and DC (dead coral) around 0.1 Ha. While abiotic elements such as sand (S) are around 5.41 Ha, then HG (hard ground), which is dead reef flat, covered by sediment, and exposed at the lowest tide, has an area of around 50 ha. Another abiotic category, RCK-S, covering an area of 7.06 Ha, is a category of andesite rock and sand outcrop substrates near coral reefs and beaches.*
Key Word*: Coral Reef Mapping, SPOT-7 Imagery, Substrate Classification, OBIA, SVM, Tanjung Pemancingan*

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I. Introduction

An exotic landscape characterizes Tanjung Pemancingan Kotabaru, and its coastal area has mangrove ecosystems and fringing-type coral reefs. These marginal coral reefs are inseparable from the supply of coral larvae originating from the Makassar Strait, especially the Sunda barrier reef region distributed by the current southward in a stepped manner stone from island to island or through connectivity between coral reefs.

The distribution of coral reefs on the west side of Tanjung Pemancingan is adjacent to mangrove vegetation. This condition is possible due to the change in the mass of water from the Makassar Strait, which brings more transparency and more salinity water during high tide. Currents and those that carry more transparent water allow the cleaning of sediment on the coral surface and carry natural food in the form of plankton.

Coral reefs in the Tanjung Pemancingan area play a significant role in maintaining coastal stability from abrasion. The fringing coral reefs around the coast play a role in dampening wave energy. This ecosystem provides a diverse source of germplasm, alternative food and pharmaceutical sources, and potential environmental services that can be utilized in the future.

On the other hand, climate change marked by La Nina and El Nino phenomena also affects coral reef ecosystems. When floods are triggered by high to extreme rainfall, causing pools of freshwater flood coastal areas. At the same time, low-salinity and turbid water also spread in coral reef waters.

El Nino events are characterized by an anomaly in seawater temperature where an increase in temperature above the normal average also causes coral bleaching, resulting in death. This event also occurred in 2010, mid-2015 to early 2016. Likewise, at the end of 2019 and early 2020 at Tanjung Pemancingan, there was partial bleaching of the fringing coral reefs and coral reefs in the breakwater. In addition to natural events, other challenges include damage due to anthropogenic factors, both directly and indirectly.

In addition to natural events, other challenges include damage due to anthropogenic factors, both directly and indirectly. Increased sedimentation in coastal areas results from forest conversion in the upper region, which has increased runoff during the rainy season. This sedimentation is always followed by an increase in nutrients in coral reef waters, which impacts increasing benthic algae and sponges replacing coral formations. Likewise, organic and plastic waste increase negatively impacts the coral reef ecosystem.

According to Burke et al. (2012), South Kalimantan, especially the coral reefs in the Kotabaru Regency area, are classified as moderate to high based on the combined level of local threats. The combined local threat level includes coastal development, watershed-derived pollution, pollution and damage stemming from marine use patterns such as overfishing and destruction.

Post-mine closure of coal mines, including coal ports and terminals, will be implemented in the next two decades. PT Arutmin Indonesia NPLCT plans that the Tanjung Pemancingan area will be used as a micro-tropical forest area, including mangroves and coral reefs as an ecotourism and environmental education, developing a Silvio fishery and turning coral reef waters into a tourism and educational area. All of this aligns to achieve the SDGs, namely a maintained environment and poverty alleviation through community development.

In order to make a plan for managing the reef ecosystem in the Tanjung Pemancingan area, it is necessary to prepare a database which begins with mapping activities with object-based analysis of satellite imagery. The mapping and analysis aim to see in detail the substrate's distribution, characteristics, and extent of coral reefs.

II. Materials And Methods

Data collection activities were carried out during September and November 2021. This activity is located around the port operation area and coal terminal of PT Arutmin Indonesia NPLCT. The research area covers the fringing reef area along the east side to the north of the Kotabaru Tanjung Pemancingan. Starting from the flat fringing reef around Bangko Sarang Tiung bay to the north of the NPLCT loading jetty and its west side. A map of data collection locations can be seen in Figure 1.

The tools and materials used in this study include diving equipment, slates and pencils, underwater cameras, GPS (Global Positioning System, roll meters, 1.5 x 1.5 m plots, laptops, Microsoft Office 2019, ArcGIS Desktop 10.8, ENVI 5.3, ER Mapper 2015, eCognition Developer 64 bit version 9.1 and Surfer 1, SPOT-7 2020 Imagery.

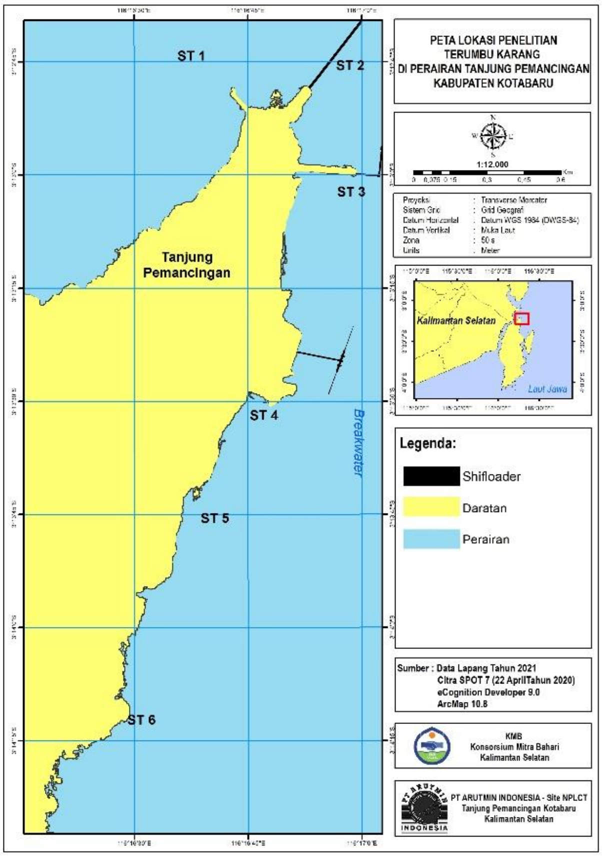

Figure 1. Data Collection Locations

Data Acquisition

Sampling Location Determination

Coral reef data collection locations were carried out using purposive sampling, taking as many as six stations for squares or plots on the reef flat to the edge on the east and north sides of Tanjung Pemancingan.

Observation and Measurement of Water Floor Objects

Field data collection is needed to complete image analysis using a systematic random sampling method. The distance between sampling points is around 5 – 20m depending on homogeneity and heterogeneity. The observation locations were determined when planning the field survey, starting with the visual interpretation of Spot 7 imagery recorded in early 2020. Data collection considered shallow water benthic cover diversity and the spatial resolution of the satellite images used in the classification. The field observation process uses a 1.5 m2 (plot) to assess substrate cover and Hand GPS to record coordinate data. The use of underwater cameras for plot documentation facilitates post-processing and categorizing data sets.

In this study, the quadratic (plot) method was used to verify the results of image analysis with a focus on assessing the percentage cover of the substrate category in the plot of the observation area. Observation of this bottom substrate using snorkelling and diving techniques in one plot 1.5 x 1.5m. The area of the plot is adjusted to the spatial resolution of the satellite image used in the classification to assess the benthic category.

The assessment of the substrate category on coral reefs refers to the Global Coral Reef Monitoring Network (GCRMN) assessment guide and English et al. (1994), which focused on ten categories of 31 categories of substrates, namely Biotic (hard coral, soft coral, sponge, other fauna, benthic algae), Abiotic (sand and rubble) and dead Scleractinia (dead coral and dead coral with algae).

Data Analysis

Initial Processing of Satellite Imagery

The initial processing stage of satellite imagery (image preprocessing) is carried out to improve the original image data (raw data) into satellite images ready for interpretation. The work carried out includes correcting errors due to the scattering of particles in the atmosphere recorded by satellite imagery (radiometric correction), repairing errors in the position of satellite image recording against earth references (geometric correction), masking and cropping, image composites and object sharpening in images through spectral value stretching. Image. Furthermore, water column correction is carried out to improve image quality by reducing interference in the water column.

There are two ways of correcting the water column, especially in finding the value (ki/kj), representing the attenuation coefficient ratio. First, through the gradient values on the linear lines formed by a pair of visible spectrum bands. Second, it can also be obtained based on the Lyzenga formula (1981) as follows:

$$Y = (\text{In } band\ 1) + \left(\frac{ki}{kj} \times \text{In } band\ 2\right)$$

$$\frac{ki}{kj} = \alpha + \sqrt{a^2 + 1}$$

$$\alpha = \frac{(Varian\ band\ 1 - Varian\ band\ 2)}{(2 \times covariant\ band\ 1\ dan\ band\ 2)}$$

Ki/kj = Ratio of the blue and green channel coefficients.

Object-Based Image Analysis (OBIA)

The object-based classification was done to recognize objects based on groups of pixels, not just on individual pixels. This technique is known as Object-Based Image Analysis (OBIA). This classification uses an algorithm to classify pixel values for proximity to pixels in a specific class based on a sample of pixels. The image resulting from the guided classification algorithm is considered an intricate classification image. After that intricate image, The results are smoothed based on the polygon boundaries or areas formed by the previous image segmentation process.

Support Vector Machine (SVM)

Additional field information in the form of benthic habitat cover for classification using the Support Vector Machine (SVM) algorithm. The SVM concept tries to find the best separating function among the unlimited number of functions. Six best separator functions can be found by measuring the separator limits and looking for the maximum value. Wahidin et al. (2015) in Manan (2019) stated that the SVM algorithm could produce better accuracy in OBIA-based methods. Mathematically, the following equation can use the basic concept of SVM based on (Vapnik, 1982 in Manan, 2019)

$$K = \exp\left(-\frac{\|x-x'\|^2}{2\sigma^2}\right) \quad \ldots(1)$$

Where: X represents the vector of each data, represents the number of degrees of the polynomial function.

Validation/Accuracy Test

The accuracy test carried out in this study was to compare the classification results of benthic distribution maps with field data. The method used in this accuracy test is a confusion matrix based on the following equation (Congalton and Green, 2008 in Manan, 2019):

Overall Accuracy (OA) : .... (2)

$$OA = \frac{\sum_{i=1}^{k} n_{ii}}{N}$$

Producer Accuracy (PA) : .... (3)

$$PA = \frac{n_{ii}}{n_{i+}}$$

User Accuracy (UA) : .... (4)

$$UA = \frac{n_{ii}}{n_{+i}}$$

Description:
N : the number of objects contained in the classification and reference results
n_{i+} : the total number of objects in the i-th row
n_{+i} : the total number of objects in the ith column
n_{ii} : the diagonal value of the matrix of the i-th row and i-column

The acceptable accuracy limit for shallow water bottom habitat maps based on SNI 7716:2011 concerning Mapping shallow sea bottom habitat is 60%.

III. Result

Water Column Correction

The water column correction is used by calculating DII (Deep Invariant Index) from the Lyzenga formula which uses information from the Ratio of the attenuation coefficient for each pair of visible light bands. The results of the calculation of the attenuation coefficient ratio of the visible light band pair of SPOT 7 images are presented in the following table:

Table 1. The Ratio of the attenuation coefficient of the visible light band pairs of the SPOT 7 image

Band Combination	Attenuation Coefficient (ki/KJ)
DII 2/3 (blue - green)	0.010752253
DII 2/4 (blue-red)	0.001771271
DII 3/4 (green - red)	0.003958538

Creating a Classification Scheme

The naming and description of the ten substrate category components are based on the dominant coverage of the substrate category at each observation point, composed of one or more substrate category components. The naming, description and code for each class of substrate category are presented in Table 2.

Table 2. Name and Code of Substrate Category

Substrate category class	Class Code	Description
Hard Corals	HC	*Hard corals* predominate
Hard Coral Mix	HC Mix	Mixed *hard corals*
Dead Coral with Algae	DCA	Dominant *Dead Coral with Algae*
Dead Coral with Algae Mix	DCA Mix	*Dead Coral with Algae* mixed
Dead Coral	DC	Dominant *Dead Coral*
Sand	S	*Sand* dominant
Sponges	SP	*Sponge* dominant
Hard Ground	HG	*Hard Ground* dominant
Soft Corals	SC	Dominant *Soft Coral*
Rock – Sand	RCK S	*Rock* mix *Sand*

The naming of the class of substrate categories in this study was adjusted to the composition of the dominant substrate category observed in the field because the classification scheme for the classification of substrate categories does not have standard provisions or standardization in terms of mapping.

The classification scheme produced in this study consists of 2 levels of classification schemes (Figure 2). The reef level classification scheme (level 1) consists of 3 classes, namely the land/cloud class, shallow marine waters, and deep sea waters. In comparison, the substrate category classification scheme (level 2) consists of 10 substrate category classes (Table 3). The classification scheme developed in this study may be different from the classification scheme for shallow water substrate categories in other places, considering that the complexity of the substrate categories varies from region to region and this is strongly influenced by many factors.

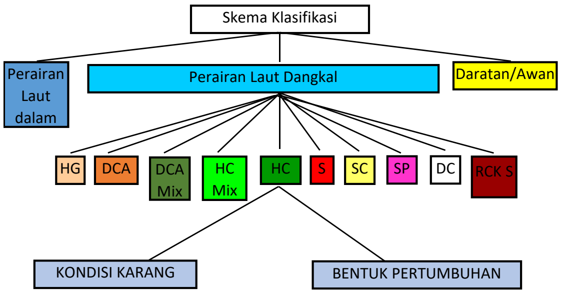

Figure 3. The results of the 2-level classification scheme

The classification scheme for shallow sea water substrate categories resulting from 250 observation points will then be divided into two, namely, 185 observation points will be used as RoI (region of interest) data in the image classification process. Then the remaining 65 observation points will be used as data for testing the accuracy of the image classification results. Classification schemes for the ten resulting shallow water substrate categories will all be used in the SPOT 7 image classification process.

Image Classification

The image classification used in this study is object-based classification (OBIA), and the image used is SPOT 7 imagery. Segmentation is the basis of the object-based classification process to produce segments or objects which will then be assigned to a specific class in the classification process.

Segmentation Scale Optimization

The segmentation process in this study uses the multiresolution segmentation (MRS) algorithm. Segmentation by applying several different scales (multiscale) can produce objects with different numbers and shapes based on the complexity of an object. At level 1, the segmentation scale used is 100 to produce 9,765 objects. Based on the segmentation process of scales 2, 3, 5, and 10 in the SPOT 7 imagery, the number of objects was 691,746, 350,701, 133,538, and 33,711, respectively. Wahiddin (2015) has proven that the effect of segmentation scale can affect the shape, size, and number of objects produced.

Reef Level Classification (Level 1)

Reef level classification is the basis for the classification process for shallow water substrate categories (level 1). Image classification at level 1 uses the contextual editing method. Classification level 1 in this study resulted in 3 classes: cloud/land (land), shallow sea waters (Area of Interest) and deep sea waters.
Classification results of level 1 are processed from objects that are formed on the results of segmentation, namely, forming 9,765 objects. From the total area of the research location of 9,776 ha, the area of each class was obtained based on the classification results, namely on the image obtained land class of 1,062.66 Ha, shallow sea water class of 323.93 Ha and deepsea class of 1,133.22 Ha, obtained area of each class and maps based on the classification results as follows:

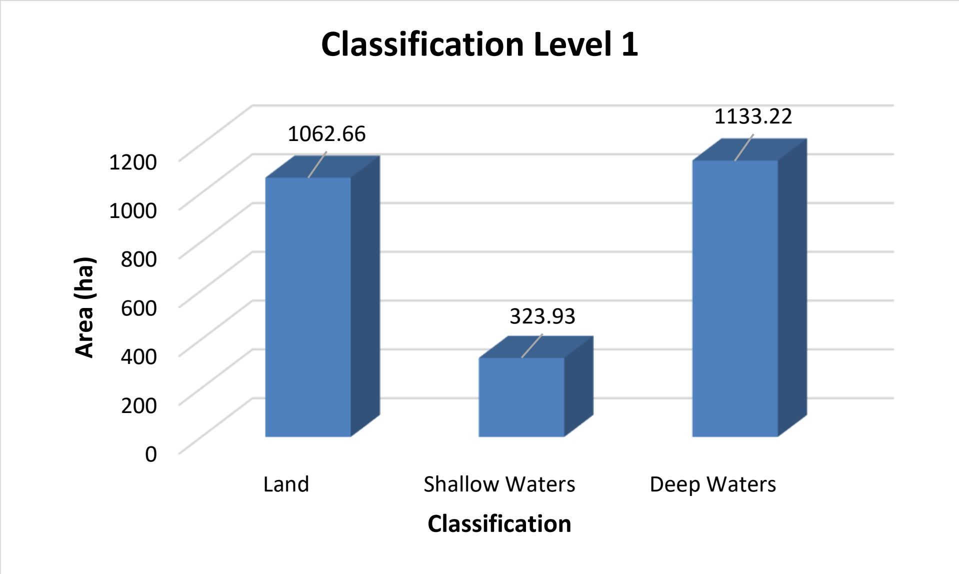

Figure 4. Class area of level 1 Classification Results

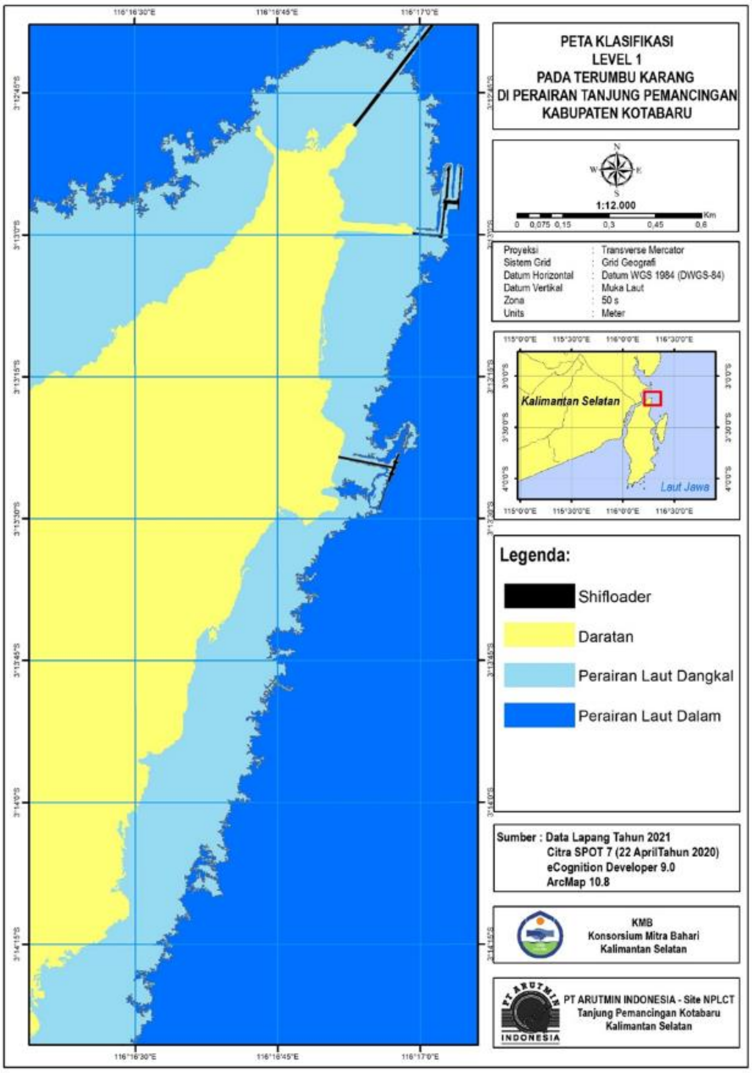

Figure 5. Class Area of level 1 Classification Results

Substrate Category Classification (Level 2)

The results of level 1 classification, especially in the shallow sea waters class, are used as area boundaries in classifying substrate categories for level 2 classification. The shallow sea waters class at level 1 is then re-segmented at level 2 by applying optimization of segmentation scales 2, 3, 5, and 10.

The resulting objects or segments are then classified by guided classification using a machine learning algorithm, namely SVM, using data from the classification scheme for shallow water substrate categories (Table 3) as input thematic layers that have been made previously based on direct observations in the field. From a total of 250 field observation points, 185 observation points are used as input data (input thematic layer) in the classification process, and the remaining 65 observation points are used as data to test accuracy with the confusion matrix. The feature input in the level 2 classification process with SPOT 7 images uses the feature input, namely the layer values (mean and standard deviation) of all visible light bands and the results of the three DII band pair compositions.

The accuracy test results using the SVM algorithm on the segmentation scale 3 obtained PA (Producer Accuracy) and UA (User Accuracy) values ranging from 28.57% - 100%. The complexity of the substrate categories strongly influences the low accuracy value in several classes of substrate categories at the research location and the number of observation points in each class of substrate categories. In addition, the classification algorithm cannot avoid the spectral similarity between the substrate classes, especially for classes composed of two components of the substrate category. According to Anggoro et al. (2017), the factors that affect low accuracy are due to the high complexity of the substrate categories in the study area and the equivalence between GPS accuracy and the spatial resolution of the images used. Green et al. (2000) stated that the accuracy of the substrate category mapping can be used if the substrate category classification map produces an overall accuracy (OA) of > 60%, meaning that the accuracy of the substrate category map produces an OA (Overall Accuracy) value below the number it cannot be used for analysis or other purposes and in this study the accuracy test for primary substrates refers to SNI 7716: 2011, which is an accuracy rate of 60% (BIG, 2014). Based on this, in this study, the results of the classification of shallow water substrate categories can be used considering the accuracy test results yield an overall accuracy value above 60%, namely an OA of 65.35% using the SVM algorithm on a segmentation scale of 3.

In the calculation of the accuracy test for the classification results, the amount of field data used to test accuracy with the amount of data displayed in the confusion matrix table is different from the amount of data because the accuracy test calculation table is the result of recognition software calculations where the amount of data increases due to the process of segmentation/grouping data. The following, are the results of the accuracy test of the level 2 classification:

Table 3. Producer Accuracy, User Accuracy and Overall Accuracy for Ten Benthic Categories

Field / Image	HG	HC	DCA mix	SP	SC	DCA	S	HC Mix	DC	Sum	User Accuracy
HG	**6**	0	0	0	0	0	4	0	0	10	60
HC	0	**31**	2	4	3	3	2	1	0	46	67,39
DCA mix	1	0	**4**	0	0	1	0	0	0	6	66,67
SP	0	0	0	**2**	0	0	0	0	0	2	100
SC	0	0	0	0	**10**	0	0	0	0	10	100
DCA	0	2	0	0	0	**5**	3	0	0	10	50
S	1	1	1	0	0	1	**4**	2	1	11	36,36
HC mix	0	1	0	0	0	0	1	**3**	0	5	60
DC	0	0	0	0	0	0	0	0	**1**	1	100
Sum	8	35	7	6	13	10	14	6	2	**101**	
Producer Accuracy	75	88.57	57,14	33,33	76,92	50	28.57	50	50	OA	**65,35**

The results of the classification of substrate categories (level 2) using the SVM algorithm are presented in Figure 6 for the application of the ten classes of substrate categories and Figure 7 for the percentage diagram of the area covered by the substrate categories in the ten classes of substrate categories, presented as follows:

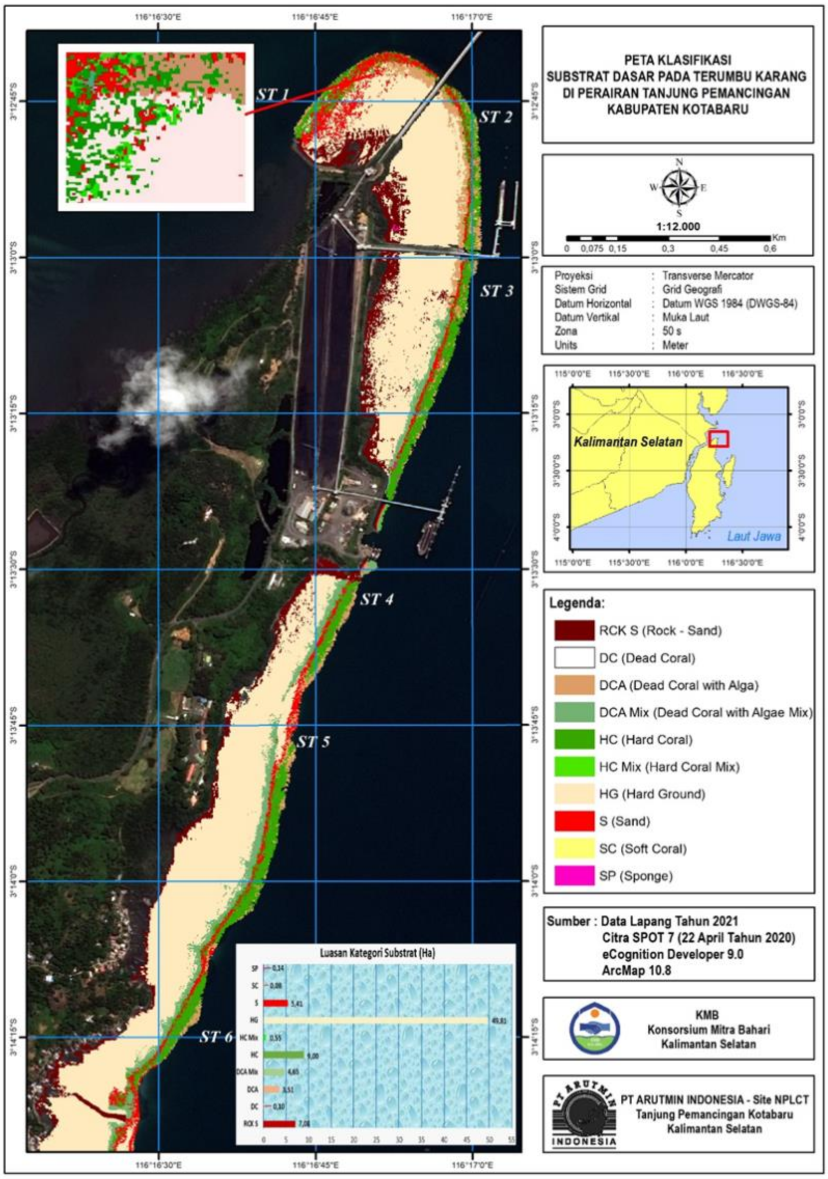

Figure 5. Classification Map of 10 Classes of Substrate Categories on Fringing Reefs at Tanjung Pemancingan Using a Scale of 3 on SPOT 7 Imagery

Based on the results of the bottom water substrate classification map (Figure 6), it is clear that the substrate categories are distributed in shallow water areas. Visually, it can be seen that there are differences in the distribution of benthic habitat classes (10 classes). This difference is due to the difference in the number of classes formed, which will affect the classification process and will undoubtedly have an impact on the results of the accuracy of the water bottom substrate classification process.

From the results of this classification, the area of each of the ten classes of sub-watery substrates at the research location can be obtained using the SVM algorithm with a segmentation scale of 3 in the SPOT 7 image.

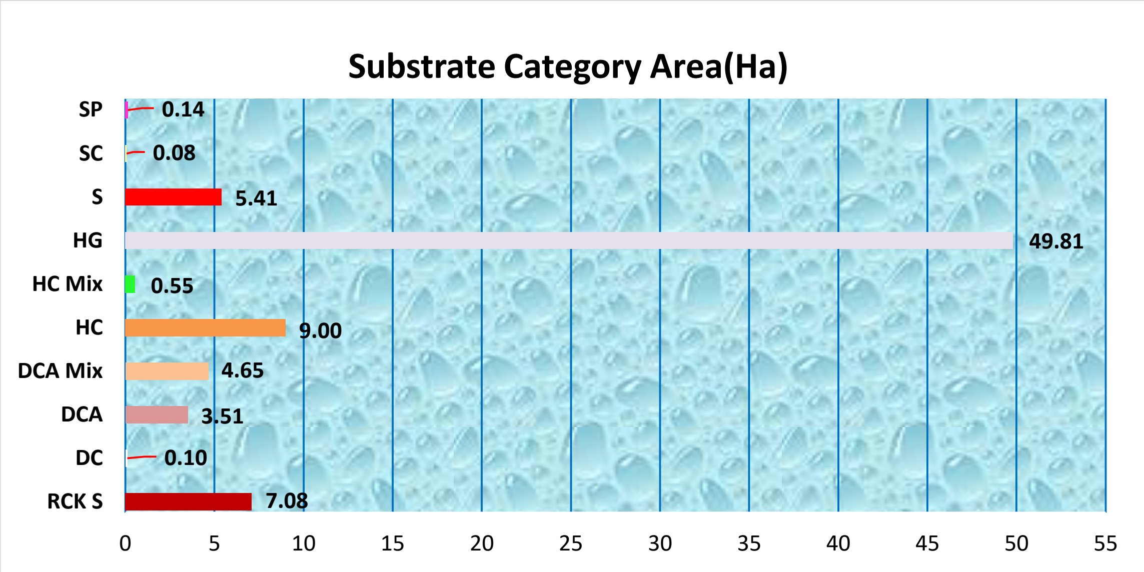

Figure 6. Distribution of the Area of 10 Classes of Substrate Categories as A Result of Classification with The SVM Algorithm on The Segmentation Scale 3 SPOT Image 7

Based on Figure 6, it can be seen that the results of the classification of substrate categories in 10 classes show that the HG (hard ground) class dominates the shallow water area at the study site, namely an area of 50 Ha. The dominant HG class shows the area behind the reef crest, which appears at low tide, directly exposed to air, heat, rainwater and accumulated runoff flows. Class HG is a hard flat limestone or rock material covered by a thin layer of sand and silt sediments. In contrast, the class of substrate category with the smallest area is obtained in the SC and DC classes of 0.08 Ha and 0.10 Ha, respectively.

IV. Conclusion

Analysis of SPOT 7 satellite imagery using the OBIA (object base image analysis) classification method with the SVM (support vector machine) algorithm shows that the classification of 10 categories of substrate classes having an OA (overall accuracy) of 65.35% already fulfils the minimum SNI accuracy test criteria of 60%. The calcification map of 10 substrate categories shows that the biotic category HC (hard coral), which is coral has an area of about 9 Ha, the category of coral mixed with other substrates (HC Mix) is around 0.55 Ha, the substrate category SP (sponge) is around 0.17 Ha and SC (soft coral) around 0.10 Ha. Furthermore, DCA mix or dead coral covered by algae and mixed with other substrates with other substrate categories around 4.65 Ha, followed by DCA around 3.51 Ha and DC around 0.1 Ha. While abiotic elements such as sand (S) are around 5.41 Ha, then hard ground (HG), the flat reef that is dead and covered with sediment, has an area of around 50 Ha. Another abiotic category, RCK-S covering an area of 7.06 Ha, is a category of andesite rock and sand substrates near coral reefs and beaches.

Acknowledgements

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