

Comparative Analysis of Object-Based and Pixel-Based Classification of High-Resolution Remote Sensing Images for Mapping Coral Reef Geomorphic Zones

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ABSTRACT

Coral reefs ecosystem has great value in terms of economy, culture, and biology for the global society and is the most productive and diverse biological ecosystem in the world. Earth observation from space so called remote sensing technology by using high-resolution Satellite, offers powerful capabilities for understanding, forecasting, managing, monitoring and decision making about coral reefs ecosystem. This study focuses on the comparison analysis between Object Base and Pixel Base image classifications of remote sensing imagery for Mapping Coral Reef Geomorphic Zones in the Karimunjawa National Park. The accuracy of each method was assessed using reference data sets derived from high-resolution satellite images, aerial photograph and field investigation. The accuracy of geomorphology zone mapping used Object Base Classification technique indicates that the overall accuracy (OA) was 88,62%. while the pixel-based classification produces the low overall accuracy was 73%. This research suggest that the object-based technique could be a promise approach for mapping coral reef geomorphic zones, where the information obtained from this research was more accurate. In paper, we observed that the object-based technique shows higher accuracy in classification process than the pixel-based technique because pixel based can't satisfy the high-resolution satellite data properties and it produced data redundancy.

Keywords: *image processing, image, remote sensing*

1. INTRODUCTION

Coral reefs ecosystem has great value in terms of economy, culture, and biology for the global society and is the most productive and diverse biological ecosystem in the world [1]. Ocean and land observation from space so called remote sensing technology by using high-resolution satellite, provides powerful capabilities for decision making because satellite captures some data for understanding, forecasting, managing, monitoring and about coral reefs ecosystem.

Accurate, reliable and up-to-date coral reef mapping has significant role for economic issues, food policy and environmental implementation. Since climate changes, human activities and water quality changes need to be monitoring. Compared to conventional methods of surveying, there are many advantages in using remote sensing technology for coral reef mapping. Remote sensing technology is considered as a powerful and useful tool that enables feasible and practical data acquisition to determine either the extent or the geographical distribution of coral reef. Typically, the classification is one of the widely used approaches for the extraction of coral reef geomorphic zones information from remotely sensed data.

IKONOS, Worldview and Quick bird are commercial satellites imagery which are the widespread public availability from space, it was very important development remote sensing technology in the 2000s. The spectral resolution of IKONOS, Worldview and Quick bird was

roughly equivalent to Landsat but the spatial resolution was much improved. Many research by remote sensing scientists into the utility of these spatial data for mapping reef communities produced mixed results [2],[3],[4]. Some studies of coral reef geomorphology are based on data fusion by integrating field and remote sensed datasets [5]. High-resolution satellite imagery can be interpreted in some methods. Field observation is common for photographs Visual inspection, while manipulations of digital data and image processing make use of computers. Classification is the most common image analysis step which can enhance the image to improve its visual interpretability and perform the image through a computer image processing system. The reef scientist can get digital image data from classification process and use it as input for further relevant analyses.

Pixel based unsupervised and supervised classification approaches are traditional analyzed methods which are limited in the image properties which they assess data from remote sensing [6]. Object Base Image Analysis (OBIA) is a new popular method in the field of image processing. Papers by [6],[7],[8], [9] all of them use OBIA methods. The reliability of spatial products is very much determined by the level of error in the digital map product. Therefore, understanding, finding and measuring the source of errors related to and contained in digital maps is very important. Validation processes, resulting accuracy measures and their relative remote sensing image products need to understand

the commonly used as a result for scientists, technicians, and managers [2],[10],[11]. However, the validation process is measuring the difference between the results of image processing in the form of image pixel values and visual references values in the field with the same location and time. This study examines the application of methods with a pixel-based and object-based approach for mapping the geomorphological classification of coral reefs in Karimunjawa by assessing the accuracy of the classification for each method approach through an error matrix.

2. METHODS

2.1. Research Methodology

The research methodology used is an experimental method with an empirical approach. Field data is used as part of the input in the initial processing and as comparative data between the results of image interpretation with actual field conditions called validation

2.2. Research Stages

Image Processing. The study was conducted in the Karimunjawa Marine National Park, Jepara, Central Java and was conducted in March-April 2018. World View-2 imagery was acquired in August 2017 (standard level 2A 16 bit) with the UTM Zone 48S-WGS84 coordinate projection system.

Image Characteristics Citra World View-2 consists of 8 multispectral channels (coastal, blue, green, yellow, red, red edge, NIR-1, NIR-2) with spatial resolution of 2 meters and panchromatic with a spatial resolution of 0.5 meters [12]. In this study, supervised classification and object-based image analysis (OBIA) methods were conducted to high-resolution multispectral World View imagery to extract information about coral reef geomorphic zones in selected region. Pixel based classification method is a classic method where the classification of remote sensing images is done by pixel per pixel and based on the spectral value of each pixel in the image so that one pixel only belongs to one class. Geomorphological zone classifications are determined from spectral patterns through training samples. In this paper, mapping of coral reefs is based on the geomorphology of coral reefs according to Maxwell [13]. Recognition Software classifies pixels into detailed class hierarchies with membership values for each class and pixels are not only assigned to one class. Fuzzy classification concept classifies an image object has memberships in more than one class. The best classification results are taken from the classification with the highest assignment value

Table 1 The Rule Set of OBIA Process

Rule Set	Band	Algorithm	Classification
Rule Set 1	NIR, GREEN	NIR/GREEN	land : 1-10, water <1
Rule Set 2	Coastal Blue, Green.	Coastal Blue/ Green	Shallow water <1
Rule Set 3	Blue, Green, Red		Geomorphic Zones

Table 2 Coral Reef Geomorphic Zones Segmentation

Object	Band	Algorithm	Classification
lagoon	Blue, Red	Blue/Red ≥ 2.7	Relation Border to lagoon >0.9 become lagoon; Lagoon with area < 1000 px become unclassified.
reef crest	Blue, Red	Blue/Red $\geq 1,6$	Border to Reef slope >0
reef flat	Blue, Red		Unclassified at Geomorphic: Reef Flat
reef slope	Blue, Green, Red	Red*Blue/Green < 300	Relations to neighbor object are Border to Deep water and Border to Reef slope

Accuracy Assessment, Accuracy comparisons between pixel-based classifications result and object-based classifications result of World View II images are performed using 250 random reference points. producer accuracy, user accuracy, and kappa statistics are used to compile an error matrix derived from index values

3. RESULTS AND DISCUSSION

Classifying remote sensing imagery from World View II has been used as a material for pixel and object-based image analysis approaches. Error matrices using the same test area and the same time as reference data have been used in assessing the accuracy of the classification using pixel based and object-based approaches. The results of the accuracy assessment indicate that the object-based analysis

approach has a higher producer accuracy for most coral reef geomorphological zone classifications.

Pixel based classification results: Geomorphic zone classification is assessed by comparing the pixel value of images numerically through training samples. The supervised classification process of World View II involves 3 basic stages: the training stage, the classification stage and the accuracy assessment stage.

The accuracy of the classification results is very important, so the accuracy assessment is very essential. Accuracy assessment is done by comparing the results of classification with real objects in the field which are then used to compile the error matrix. Table 1 and Table 2 shows an accuracy assessment result. As we see in Table 3 the overall accuracy for pixel base image classification is 73 %. Information classes of “reef crest” has high producer’s and user’s accuracy, but the information classes of “reef slope”

has a low producer's and user's accuracy. There is a similarity spectral reflectance between the reef slope, reef

crest and reef flat cause low accuracy, this could be due to the miss-classification between these five classes.

Table 3 Accuracy assessment results of Pixel base Classification

Image\Survey	Reef Flat	Reef Crest	Reef Slope	Lagoon	Total	UA
Reef Flat	18	2	2	3	25	72,00%
Reef Crest	2	19	3	1	25	76,00%
Reef Slope	3	2	18	2	25	72,00%
Lagoon	2	1	4	18	25	72,00%
Total	25	24	27	24	100	
PA	72,00%	79,17%	66,67%	75,00%	OA	73,00%

Table 3 shows the error matrix based on the test area where the best pixel base classification value for the geomorphological zone class is quite high. This shows that the average grade and standard deviation for most objects are classified with high membership values. As we can see from Table 3, the overall accuracy of the pixel base analysis approach is 73%, based on the accuracy of the producers and users of individual classes. Producer's accuracy for "reef flat" class information is 72%, this shows that 72 percent of the reef average was correctly identified, while user accuracy is also 72%, this also shows that 72% of the area classified as "reef flats" falls into this category. Producer's accuracy for the "reef crest" class information was 79,17 %, this shows that 79,17 % of the "reef crest" was correctly identified while user accuracy was 76%, this result showed that 76% of the area classified as "reef crest" was correct right in this category. Producer's accuracy for "reef slope" class information is 66.7 %, this shows that 66.7 % of the reef average was correctly identified, while user accuracy is 72%, this shows that 72% of the area classified as "reef slope" falls into this category.

Object Based Classification: Processing and addressing of a certain scale is the task of each object-based classification. Image information is represented by the difference in scale h based on the average size of the object image and the same imagery can be segmented into smaller or larger objects [14]. Object-based classification does not depend on the value of individual pixels, but the value of pixels that have a degree of similarity in groups and neighbors. The next process is the segmentation process where groups of pixels that have the same characteristics are identified. The process of segmentation depends on the threshold of similarity and spectral similarity which then results in the number of variables and the size of the object [15]. In addition, the objects are described by shape, size, tone, texture, compactness, and other characteristics describing the spatial features of the object [16]. Geomorphological zones formed by the classification assignment process of the differences of all these variables. In object-based classification, the term inheritance is known where the

characteristics of sub-objects inherit the characteristics of super objects in the upper hierarchy [11].

As a result of classification, seven geomorphology zones were distinguished including land, deep sea, reef crest, reef slope, reef flat and lagoon (Figure 2). The output of the image is a thematic map that accurately results in the classification process without errors or bias [11]. There are a number of equations that can show the level of error statistically, such as producer accuracy, user accuracy, overall accuracy and Kappa which can be calculated using the confusion matrix [17].



Figure 1 Research Site map

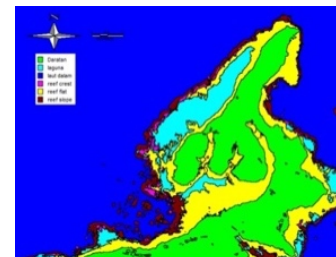


Figure 2 Object Base Classification Result

Standard confusion matrices are used to assess accuracy based on field data and are then classified into five geomorphological zones. As we can see in table 4, the producer accuracy, user accuracy, and overall accuracy for three classification methods.

Table 4 Accuracy assessment results Object Base Classification

Image\Survey	Reef Flat	Reef Crest	Reef Slope	Lagoon	Total	UA
Reef Flat	28	1	2	1	32	87.50%
Reef Crest		28	2		30	93.33%
Reef Slope	1	2	27	2	32	84.38%
Lagoon	2		1	26	29	89.66%
Total	31	31	32	29	123	
PA	90.32%	90.32%	84.38%	89.66%	OA	88.62%

As we can compare in table 1 and table 2, the overall accuracy of object-based classification is 88.62% while the overall accuracy of pixel-based classification is 73%. The results of this study are consistent with Gao and Mas research's in 2008 that object-based image analysis approaches produce higher accuracy than pixel-based image analysis approaches. According to the results of this study, the object-based analysis approach is more potential as an alternative technique than pixel base analysis approach for mapping coral reef geomorphology zones in Karimunjawa. comparison of object-based and pixel-based classifications such as comparing salt and pepper in cooking, so it needs to be validated how much influence salt and pepper. visual interpretation and validation points (pixels in the pixel-based classification and certain points in the object) are needed for the validation process. Misclassification caused by blurred or false pixel values causes a lack of accuracy in the pixel-based analysis approach, whereas the object-based analysis approach tends to be more accurate because it uses classes. In addition, misclassification can be caused by an error in validating field data into pixel coordinate values appropriately, therefore in the pixel-based analysis approach some post-classification editing needs to be done such as filtering and erasing manually [18].

4. CONCLUSION

This research uses World View II imagery with a spatial resolution of 0.5 m with object-based image classification approach and pixel-based image classification approach. The results of the accuracy assessment for the Mapping of Geomorphic Zones of Coral Reef using an object-based image classification approach is 88.15 higher than the pixel-based image classification approach is 73%. This shows that object-based image classification has the advantage that it has higher potential as an alternative method compared to pixel-based classification for high spatial resolution images.

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