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The Use of Small Format Air Photos for Mapping Land Cover Changes in *Gumuk Pasir Parangtritis* Core-Zone, 2015-2019

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Abstract

Gumuk Pasir Parangtritis (sand dunes of Parangtritis) is one of the potentials of the coastal area of *Parangtritis* village in Yogyakarta, with several important roles for the coastal ecosystem and its surroundings, such as ecology, disaster, tourism, economy, and aquifer reserves. However, behind this important role, the existence of sandbanks is increasingly threatened from year to year because the area of sand cover continues to decline, especially in the core zone. Therefore, regular and effective mapping and monitoring efforts are needed. This study aims to a) conduct land cover mapping using the Geographic Object Based Image Analysis (GEOBIA) method in the 2015-2019 timeframe; b) analyze changes in land cover in the core zone of sandbanks during 2015-2019; and c) evaluate the results of restoration of sand dune core zone in terms of land cover changes that have occurred until 2019. Small format aerial photographs (FUFK) are the data used in this study while the mapping method used is rule-based classification. The land cover of the sand dune core zone in 2015 included buildings, vegetation, sand, roads and ponds, while in 2019 it was in the form of buildings, vegetation, sand, and roads. Based on the classification results in the two years, it can be seen that there are changes in land cover (including area) through the cross-section of the two classification results. Some of the factors include the number of land use changes, the amount of vegetation, and sand mining. Furthermore, this change can be used as a basis for evaluating the success of the restoration efforts of the *Gumuk Pasir Parangtritis* core zone to date. The results of the evaluation show that the restoration carried out so far has not had much impact so it can be said that it has not been successful, because the area of sand cover has actually decreased a lot (from 528,680 m2 to 344,347 m2), while the land cover in the form of vegetation and buildings has increased in size (from 869,341 m2 to 1,037,879 m2 for vegetation cover and an area of 4,674 m2 to 22,953 m2 for buildings).

1. Introduction

Gumuk Pasir Parangtritis is one of the natural potentials possessed by the coastal area of *Parangtritis* village of Yogyakarta, with various roles. These roles include as a habitat for flora and fauna in coastal ecosystems and a tsunami barrier (Khotimah, 2006). Fakhrudin, et al., (2010) also called this area uniquely natural. This is due to the presence of a barchan sand dune type in the Gumuk Pasir Parangtritis which should have been formed in an arid/dry climate area.

The process of forming in *Gumuk Pasir Parangtritis* has long been classified as active and ongoing. However, over time, with the emergence of various activities in the *Gumuk Pasir Parangtritis* area, the condition has become increasingly concerned, as indicated by the decline in the area of sand dunes from year to year. based on literature on aerial photography data in 1972, 1992, 2002, 2006, and 2015 (Fakhruddin, et al., 2010); (Maulana & Wulan, 2015).

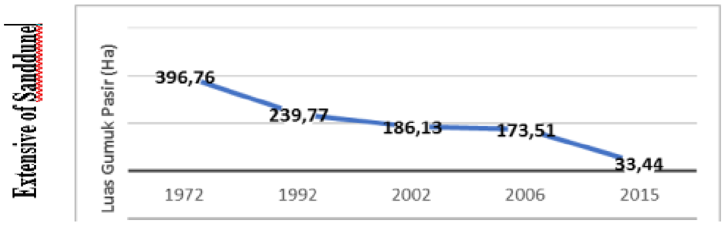

Figure 1. The Area of Sand Dunes

The area of the sand dune in 1992 decreased from the initial area of 396.76 Ha (in 1972) to 239.77 Ha. This decline continued until 2015 with the remaining area of 33.44 hectares. There are several factors that have led to a decrease in the area of sand dunes, namely a change in land use which was originally transformed into residential land, sand farming and recreation areas. The condition of the sand dunes has become increasingly alarming with the existence of a coastal greening program carried out by the Agriculture and Forestry Office of Bantul Regency in the 1980s (Khatimah, et al., 2017). This makes the sand dune formation process hampered because it disturbs the wind tunnel area (Sunarto, 2014).

The importance of sand dunes conservation, which is currently increasingly concerning, was realized after several studies related to sand dunes were carried out. These studies include the important role of sand dunes. As a result, Tt was decided to divide the sand dunes into three areas, namely the support zone, the core zone and the restricted zone. The core zone is the main part that needs to be considered in efforts to conserve sand dunes, one of which is by carrying out restoration, starting in 2016. Restoration efforts carried out in the core zone can be identified through the assessment and mapping of land cover conditions of sand dunes. Based on this, it is necessary to carry out further research related to land cover in sandbanks. This study aims to; a) conduct land cover mapping using the Geographic Object Based Image Analysis (GEOBIA) method, within the 2015-2019 timeframe; b) analyze changes in land cover in the core zone of sandbanks within the same timeframe; and c) evaluating the results of restoration of the sand dune core zone in terms of land cover changes that have occurred until 2019.

Remote sensing data in the form of small format aerial photographs (FUFK) is employed in this study because of its advantages that can be analyzed temporally. The mapping method used in this determination is Geographic of Object Based Image Analyst (GEOBIA). The use of this method aims to optimize the classification results by avoiding the salt and pepper effect of high-resolution image processing that usually appears in multispectral classifications (Yu, et al., 2006).

2. Research Method

Mapping with the GEOBIA method (in e-Cognition Developer 9.1) is the method chosen in this study for the reason of optimizing the results of land cover classification in the study area.

There are two main stages carried out in the process of processing FUFK data using GEOBIA, namely segmentation and classification.

2.1 Segmentation

The segmentation method used is multiresolution segmentation with five main parameters, namely scale, shape, compactness, subtlety, and color.

The segmentation stage was carried out on the two data, FUFK 2015 and 2019, on a trial and error basis from a scale of 10-60 (other parameter values are default). The optimal scale is determined based on visual analysis. The input channel weight used is 1, meaning that each channel (Red, Green, Blue) is considered the same sensitivity. Weighting the shape parameters will automatically assign weights to the color parameters. This also applies to the weighting of compactness which will simultaneously give the weight of the fineness parameter. The weight for shape and compactness parameters in this study refers to previous research conducted by Kulkarni (2012) whereas trials are in the range 0.1-0.3 and 0.4-0.6 for shape and compactness parameters respectively.

2.2 Classification

The classification stage is carried out after the segmentation process is complete. As with the segmentation process, the classification process is carried out on a trial-and-error basis. GEOBIA's rule-based classification is a classification method used in this study. There are two stages of classification carried out, namely the first stage and the second stage. The first stage is carried out to separate the vegetation classes (shrubs, trees, moor) from non-vegetation while the second stage is to divide the non-vegetation classes into sand, roads, ponds and buildings. These two stages were carried out on both FUFK data.

The correctness of the classification results was tested using the *confusion matrix* method, between the results of the GEOBIA classification in FUFK 2019 and conditions in the field. Sampling was carried out by stratified random sampling. To find out the changes that have occurred, it can be done by overlaying the two land cover classification results, 2015 and 2019. In relation to the analysis, the results of the mapping of the two data can be done qualitatively and quantitatively.

3. Results and Discussion

3.1 *Gumuk Pasir Parangtritis* Cover Result of the 2015 and 2019 GEOBIA Classification

The land cover change mapping process was carried out on FUFK data for 2015 (before restoration) and FUFK in 2019 (after restoration).

3.2 Segmentation

Based on the results of the trial-and-error process at the segmentation stage carried out at FUFK in 2015 and 2019, the optimal value was obtained on a scale of 40, 0.3 for shape parameters, and 0.6 for compactness parameters. These weights produce segments with less under-segmentation and over-segmentation rates than other weights. The condition of the study area, in this case the variation of the object, is important in the process of determining the weight of the color and shape parameters. The relatively high color weight is good for application in the study area with various object color variations (spectral) conditions (Azahra, 2019a). This is in accordance with the conditions in the study area so that a higher weight is given to the color parameter than the weight of the shape parameter, considering that there are many objects in the study area that have the same feature value. Figure 2 is the result of segmentation in FUFK in 2015 and 2019. In relation to the weight of the compactness parameter, high weight is given to the study area with objects that are compact.

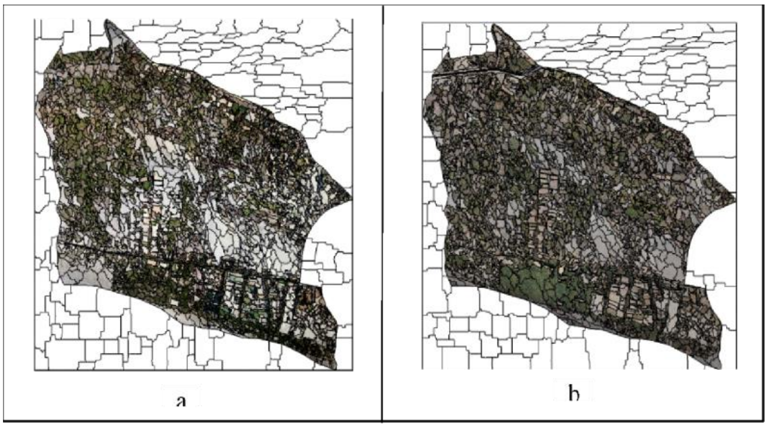

Figure 2. Segmentation results in FUFK

3.3 Classification

The classification method used is rule based classification by combining elements of visual interpretation and feature space in the software e-Cognition Developer 9.1. The first stage classification is carried out to separate vegetation classes from non-vegetation classes, the second stage classification is carried out to detail non-vegetation classes into building, sand, road and pond classes (FUFK 2015) and building, sand, road classes (FUFK 2019). The purpose of detailing the non-vegetation class is to obtain the area of sand cover because the sand cover is related to sand dunes. The vegetation class was not carried out in more detail because the specification of vegetation types in this study was not the main focus. In addition, detailing the vegetation class will require more and more complicated rules and more complex data specifications are required.

a. 2015

The land cover classified by the GEOBIA method on the 2015 FUFK data is that there are five types of land cover, namely roads, sand, buildings, ponds, and vegetation (Figure 3). These five land covers are classified with additional rules and exceptions.

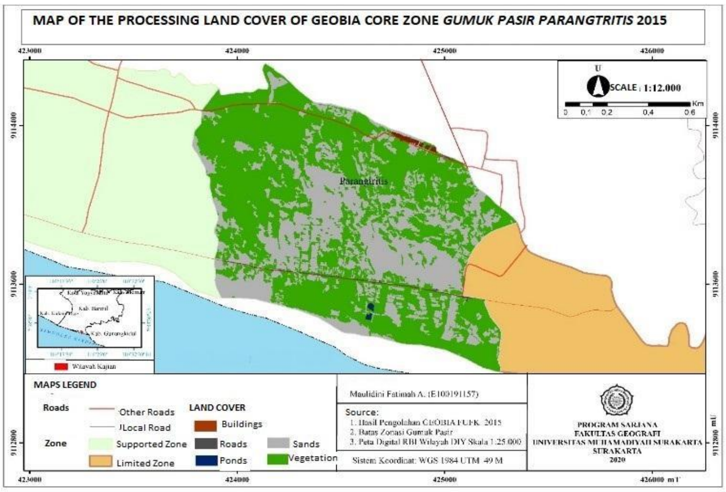

Figure 3. Land cover map 2015

From a qualitative point of view, the land cover mapping result of the *Gumuk Pasir Parangtritis* zone is that the vegetation land cover in the study area is more dominant than other land cover. One of the reasons for the large amount of vegetation cover in the core zone of the sand dune is the success of the tree planting (afforestation) movement on critical land by the government (Sunarto, 2014). Of course, this can hamper and even stop the process of forming sandbanks, the existing wind tunnel is becoming increasingly closed. Kidd (2001, in Nuraini, 2016) also explains that land cover in the form of vegetation is a dominant factor in changing the shape of sand dunes. There are lots of building land cover in the northern part of *Gumuk Pasir Parangtritis,* associated with the village settlements around *Gumuk Pasir Parangtritis* and roads. Land cover in the form of sand is predominantly found in the eastern part of the sandbank area. It should be noted that in this area, sand dunes are still actively forming, but the process is not optimal. One of which is the large amount of vegetation growing and building in the core zone of the sand dune, especially in the wind tunnel zone. Land cover in the form of ponds is still found because restoration has not been carried out. Table 1 below illustrates the area of land cover as a result of the FUFK classification in 2015.

Tabel 3.1 Land Cover and its Area (2015)

No	**Land Cover**	**Width (m^2)**
1	**Buildings**	**4.674**
2	**Vegetation**	**869.341**
3	**Sand**	**528.680**
4	**Ponds**	**1.689**
5	**Roads**	**6.621**

Source: Analyzed by author, 2020

Based on the table, it can be seen that the land cover of the core zone of sand dunes from GEOBIA processing (FUFK 2015) in the form of buildings has an area of 4,674 m2, vegetation land cover has an area of 869,341 m2, sand land cover has an area of 528,680 m2, pond land cover has an area of 1,689 m2, and land cover has an area of 6,621 m2. Thus, it can also be seen that the largest land cover is vegetation and the narrowest is ponds.

b. 2019

The results of the 2019 FUFK classification show that in the study area there are four classes of land cover, namely buildings, roads, sand, and vegetation. From a qualitative point of view, the dominant land cover is vegetation (Figure 4). The land cover for buildings in the study area has a clustering and spreading pattern. Overall, the land cover classified by the GEOBIA method in FUFK is in accordance with the study area, but there are some discrepancies. One of them is water which is classified as a building. The similarity of features between two or more different objects is the main cause of the mismatch (Azahra, 2019 b).

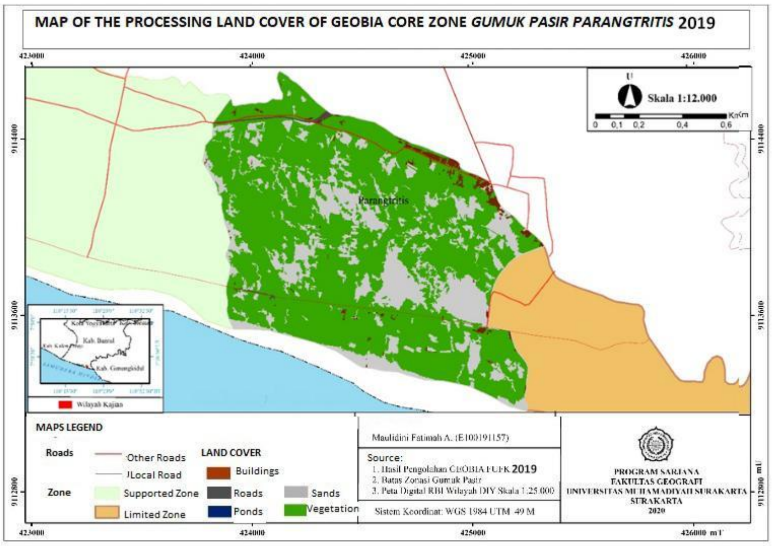

Figure 4. Land cover map 2019

In terms of quantitative land cover in 2019, the largest land cover was dominated by vegetation, namely 1,037,879 m2, followed by sand cover covering 344,347 m2, building cover 22,953 m2, and road cover with an area of 5,802 m2 (Table 2). The dominating vegetation land cover indicates that the vegetation in the core zone of the sand dune can grow well, although this condition is not ideal and tends to hamper the process of sand dune formation. In fact, the area ratio between vegetation land cover and sand cover in the core zone area obtained is 3: 1.

Table 2. Land cover and its area (2019).

No	Land Cover	Width (m^2)
1	Buildings	22953
2	Vegetation	1037879
3	Sand	344347
4	Roads	5802

Source: Data Analysis, 2020

Based on the table, it can be seen that the land cover of the core zone of sand dunes from GEOBIA processing (FUFK 2015) in the form of buildings has an area of 4,674 m2, vegetation land cover has an area of 869,341 m2, sand land cover has an area of 528,680 m2, pond land cover has an area of 1,689 m2, and land cover has an area of 6,621 m2. Thus, it can also be seen that the largest land cover is vegetation and the narrowest is ponds.

3.4 Accuracy Test

The accuracy test was carried out using a confusion matrix with the sampling method obtained an accuracy value of 93%. The obtained value is based on the calculation of field checking data which can be seen in Table 3. The inaccuracy of some of the classification results is due to several things including the similarity of features on different objects and the existence of land use change.

Table 3. The accuracy test of processing results of GEOBIA 2019.

Land Cover of GEOBIA Processing Results in 2019		Field Appearance				Total
		Buildings	Roads	Sand	Vegetation	
GEOBIA Classification	Buildings	**3**	0	0	0	**3**
	Roads	0	1	0	0	1
	Sand	0	0	18	2	20
	Vegetation	0	0	4	**57**	61
	Total	**3**	1	22	**59**	79

Source: The results of the land cover classification of Gumuk Pasir Parangtritis by using the GEOBIA method 2019 and field survey

$$overall\ accuracy = \frac{The\ Correct\ number\ of\ samples}{The\ total\ number\ of\ samples}\ x\ 100\%$$

$$overall\ accuracy = \frac{79}{85}\ x\ 100\% = 9\mathbf{3}\%$$

3.5 Land Cover Change Result from the 2015 and 2019 GEOBIA Classification in *Gumuk Pasir Parangtritis*

Qualitative changes in land cover in the *Gumuk Pasir Parangtritis* core zone can be identified by visual observation or by overlaying the results of the land cover classification for the two years. The results of the researchers' observations indicate that many changes occur in the class of sand into vegetation. A striking change in land cover also occurs in the land cover in the form of ponds, in 2019 the land cover for the ponds has turned to sand (due to restoration efforts). The land cover change in details can be seen in Figure 5.

In terms of area, the changes in land cover in 2015 and 2019 can also be seen (Table 4). The biggest change occurred in the type of land cover from sand to vegetation covering an area of 272,217 m2 and for vegetation land cover, an area increased by 168,538 m2. This condition shows the rapid growth of vegetation from 2015 to 2019. In addition to vegetation cover, building land cover also has an additional area of 18,279 m2. It is necessary to note that this land cover change is related to the additional road cover of the southern causeway (JJLS). This was proven after the construction of the JJLS megaproject increased the number of buildings around the *Gumuk Pasir Parangtritis* area. One of the reasons is the increasingly affordable accessibility and income opportunities from the tourism sector.

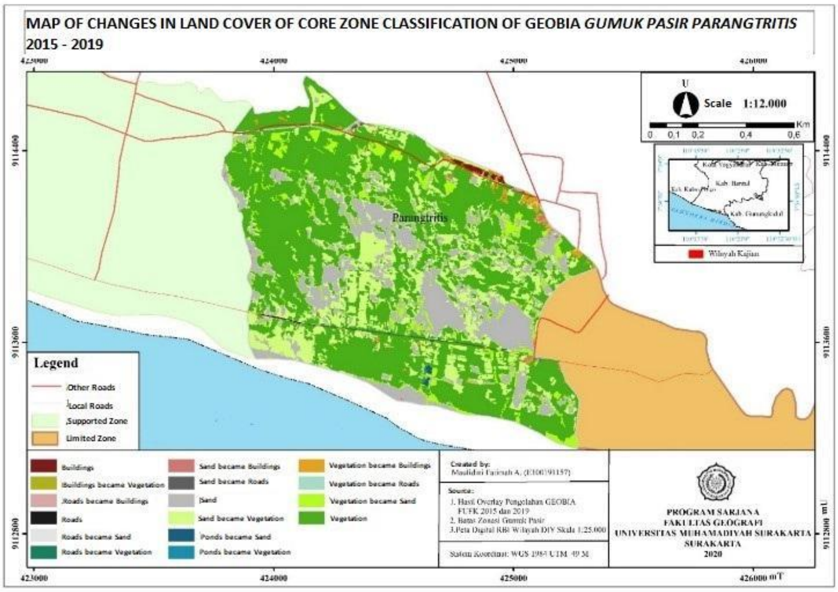

Figure 5. Map of changes in Land Cover of core zone of *Gumuk Pasir Parangtritis* 2015-2019.

Table 4. Land cover changes during 2015-2019

15 \ 19	**Buildings**	**Roads**	**Sand**	**Vegetation**	**Total (m^2)**
Buildings	3.765			902	**4.667**
Roads	344	463	617	5.189	**6.612**
Sand	5.921	1.090	249.158	272.217	**528.387**
Ponds			1.312	377	**1.689**
Vegetation	12.824	4.245	93.083	758.764	**868.915**
Total (m^2)	**22.854**	**5.798**	**344.170**	**1.037.449**	**1.410.271**

Source: Data Analysis, 2020

3.6 Evaluation of the Success of *Gumuk Pasir Parangtritis* Restoration

Changes in land cover that occur in the core zone of *Gumuk Pasir Parangtritis* (2015-2019) can be used as a material in the process of further studies related to the evaluation of the success of restoration efforts carried out so far. Figure 6 is a graph of changes in land cover area that occurred during 2015 (pre-restoration decision) and 2019 (post-restoration decision).

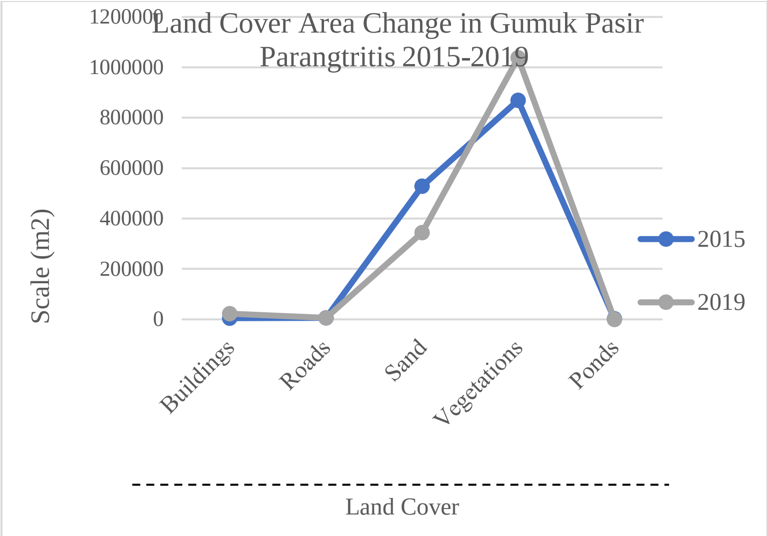

Figure 6. Land cover area change 2015-2019

Based on the graph above, it can be seen that the most significant change occurs in sand land cover which changes to vegetation land cover. The area of sand cover decreased by 184,333 m2 while the vegetation cover in the core zone had an additional area of 168,538 m2. Of course, this condition worsens restoration efforts because the vegetation will slow down the winds that carry sand (Khotimah, 2006). The existence of dense vegetation and covering the wind tunnel will also complicate the process of forming barchan-type sand dunes (BLH DIY, 2016).

The addition of building land cover area also occurred during 2015-2019 in the sand dune core zone area of 18,279 m2. Sugiarto (2016) reveals that the existence of a building on a sand dune can disrupt the process of transporting sedimented sand material. Physically, these buildings will withstand the wind, especially the presence of a permanent building, of a wall with a certain height, will inhibit or even stop the process of forming sand dunes (Khotimah, 2006). The pros and cons among the communities around *Gumuk Pasir Parangtritis* related to restoration, the absence of a special agency to manage *Gumuk Pasir Parangtritis*, and limited budget are also the factors which have contributed to the success of restoration efforts to date.

4. Conclusion

Based on the results of research conducted by researchers, it can be concluded that firstly, the results of land cover classification in the *Gumuk Pasir Parangtritis* core zone using GEOBIA in the 2015 FUFK are sand, vegetation, buildings, ponds and roads. The results of the FUFK land cover classification in 2019 are in the form of land cover for sand, vegetation, buildings and roads.

Secondly, changes in land cover from a qualitative perspective are that there have been many changes in land cover in the core zone (16 types). The majority of the changes are dominated by changes in land cover from sand to vegetation. From a quantitative perspective, the largest change in land cover also occurs in land cover from sand to vegetation with a change in area of 272,217 m2.

Finally, restoration efforts carried out to date have not had much impact on the core zone of *Gumuk Pasir Parangtritis*. One indication is the decreasing area of sand cover (from 528,680 m2 to 344,347 m2).

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