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DEVELOPMENT OF A SIMPLE METHOD FOR DETECTING MANGROVE USING FREE OPEN SOURCE SOFTWARE

PENGEMBANGAN METODE SEDERHANA UNTUK DETEKSI MANGROVE MENGGUNAKAN SOFTWARE BERBASIS FREE OPEN SOURCE

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ABSTRACT

Mangrove forests are becoming attractive natural charms and make everyone to take advantage of the existence of these coastal ecosystems both directly and indirectly. However, the condition of mangrove forests is threatened by their presence due to environmental factors around them. Sustainable mangrove monitoring efforts must always be increased to support the preservation of the mangrove ecosystem. The purpose of this study is to develop a fast and easy mangrove forest identification method based on remote sensing satellite imagery data. The research location chosen was the mangrove area in Segara Anakan, Cilacap. The data image used is Landsat 8 image acquisition on December 3, 2017 with path/row 121/065 obtained from the LAPAN Pustekdata Landsat catalog. The methods used include the Optimum Index Factor (OIF) method for selecting the best channels and the supervised classification method using the Semi-Automatic Classification Plugin (SCP) contained in open source software and provides three algorithm choices for the classification process including Minimum Distance, Maximum Likelihood and Spectral Angle Mapping. The results show the combination of RGB 564 (NIR+SWIR+RED) was the best in the identification of mangrove forests and the Maximum Likelihood classification algorithm was the most optimal in distinguishing mangrove and mangrove classes from both Macro Class and Class levels. The results of the calculation of the area show the mangrove area of 7,037.16 ha. The developed method can produce information on the distribution of mangroves at research sites more quickly, easily, effectively, and efficiently.

Keywords: Mangrove, OIF, Semi-Automatic Classification Plugin (SCP), Landsat 8.

ABSTRAK

Hutan mangrove menjadi pesona alam yang semakin menarik dan membuat semua orang memanfaatkan keberadaan dari ekosistem pesisir tersebut baik secara langsung maupun tidak langsung. Namun kondisi di lapangan sering ditemukan kondisi hutan mangrove yang mulai terancam keberadaannya akibat tekanan dari aktifitas manusia dan perubahan faktor-faktor lingkungan di sekitarnya. Usaha monitoring mangrove yang berkelanjutan harus selalu ditingkatkan untuk mendukung pelestarian dari ekosistem mangrove. Tujuan penelitian ini adalah untuk mengembangkan sebuah metode identifikasi hutan mangrove yang cepat dan mudah berdasarkan data citra satelit penginderaan jauh. Lokasi penelitian yang dipilih adalah kawasan mangrove di Segara Anakan, Cilacap. Data citra yang digunakan adalah citra Landsat 8 akuisisi tanggal 3 Desember 2017 dengan path/row 121/065 yang diperoleh dari katalog landsat Pustekdata LAPAN. Metode yang digunakan adalah metode Optimum Index Factor (OIF) untuk pemilihan kanal terbaik dan metode klasifikasi supervised menggunakan Semi-Automatic Classification Plugin (SCP) yang terdapat pada software open source dan menyediakan 3 pilihan algoritma untuk proses klasifikasi diantaranya Minimum Distance, Maximum Likelihood dan Spectral Angle Mapping. Hasil penelitian menunjukkan kombinasi RGB 564 (NIR+SWIR+RED) merupakan kombinasi terbaik dalam identifikasi hutan mangrove dan algoritma klasifikasi Maximum Likelihood adalah yang paling optimal dalam membedakan kelas mangrove dan mangrove baik dari level Macro Class dan Class. Hasil perhitungan luasan menunjukkan luasan mangrove sebesar 7.037,16 ha. Metode yang dikembangkan mampu menghasilkan informasi sebaran mangrove pada lokasi penelitian secara lebih cepat, mudah, efektif, dan efisien.

Kata kunci: Mangrove, OIF, Semi-Automatic Classification Plugin (SCP), Landsat 8.

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INTRODUCTION

Indonesia is an archipelagic country that has a very high biodiversity potential. Mangrove forests become one of the many natural potentials. Based on data of the National Mangrove Map in 2017 that stated the total area of Indonesian mangroves is 3,361,216 Ha. The total area makes Indonesia one of the countries is value of having the largest area of mangrove forests in the world. With such a vast natural resource wealth, so it is needed some concrete steps to preserve mangrove forests. According to data from the Ministry of Forestry (2006), it is clear that almost 70% of mangrove ecosystems in Indonesia are damaged both moderately and severely damaged. Many ways can be used to monitor the condition of mangrove ecosystems, one of which uses remote sensing technology.

The use of remote sensing technology can facilitate the monitoring of mangrove forest conditions. Danoedoro (2009) explains the detection of mangroves using remote sensing technology based on the approach of the appearance of canopy texture and location elements. Alatorre *et al*. (2011) have distinguished mangrove and non-mangrove objects using the Receiver Operating Characteristic (ROC) method in the Gulf of California in northwestern Mexico. Mangrove information can be easily identified using visible and near-infrared channels from Landsat ETM satellite imagery (Suwargana, 2008). Identification of mangroves using radar satellite imagery (ALOS Palsar) has also been carried out by Bunting *et al*. (2018) using Machine Learning techniques. Subardjo *et al*. (2012) used a semi-digital visual interpretation method of Landsat imagery to analyze changes in the extent of mangrove vegetation on the Coast of Mimika Regency, Papua. Purwanto *et al*. (2018) have also identified true mangroves using the OBIA method.

Along with the increasing need for information on condition and distribution of mangrove forests in Indonesia, therefore it is needed an easy and fast method for identifying mangrove using remote sensing satellite imagery data. Some constraints include the large number of image bands which increasingly confuse operators in determining the right combination of bands to identify mangrove forests. In addition, the number of bands from several images is also very diverse and each of these bands also has own characteristics. This requires a carefulness of operators in determining the right image bands to distinguish mangrove forests from surrounding objects.

The Optimum Index Factor (OIF) method is a simple method that is often used in determining the combination of 3 (three) bands in an image that has the most optimal and informative color display by applying statistical calculations (Chavez *et al*., 1982). The higher OIF value of the selected band combination then the information is more diverse and can be used for further analysis. Patel *et al*. (2011) explanned that the selection of the right bands using the OIF method can improve the accuracy of the image classification results. Identification of mangroves using the OIF method was done by Marini *et al*. (2015) where the combination of RGB 573 was the best in identifying the distribution of mangroves on Subi Kecil Island. Other research conducted by Manoppo *et al*. (2015) where the combination of RGB 564 is the best combination to identify the distribution of mangroves in Lingayan Island. Also Susanto *et al*. (2011) used the OIF technique to identify mangrove forests on Janda Berhias Island, Batam.

The development of free open source software for processing satellite image data is increasing rapidly. One of the free open-source software that available is Quantum GIS (QGis) whose version is developing until now. In QGis software there is a plugin that can be used to support the process of classification of satellite imagery known as the Semi-Automatic Classification Plugin (SCP). This SCP plugin provides several tools from downloading free imagery data, preprocessing, postprocessing and raster calculation (Congedo, 2014). Sutanto *et al*. (2016) used the Semi-Automatic Classification Plugin of QGIS Software to perform radiometric correction of Landsat imagery data. Mukhtar *et al*. (2018) have also conducted a land cover analysis in the Trenggalek district using the Semi-automatic Classification Plugin (SCP). The classification method in this plugin uses three types of algorithms including Minimum Distance, Maximum Likelihood and Spectral Angle Mapping (SAM).

This study aims to develop an early detection method for mangrove forests and separate mangrove forest objects from surrounding objects. Mangrove ecosystem in Segara Anakan, Cilacap was chosen as the research location. The increasing disturbance and threats from both natural and human factors indicate the condition of mangroves in Segara Anakan, Cilacap is not in good condition. Conversion of mangrove forest areas into paddy fields, shrimp ponds, settlements, and utilization of mangrove tree wood causes damage to mangrove ecosystems. In addition, the sedimentation rate is very high, reaching 1 million cubic meters per year, which if it is not controlled will further accelerate the Segara Anakan lagoon to land (RRI, 2016). The method developed is expected to help and support the national mangrove rehabilitation program, especially in providing information about mangrove ecosystems condition easily, quickly and up to date. Easy means using free open source software, whereas fast is using a very simple method and up to date uses satellite imagery data that has adequate spatial coverage and

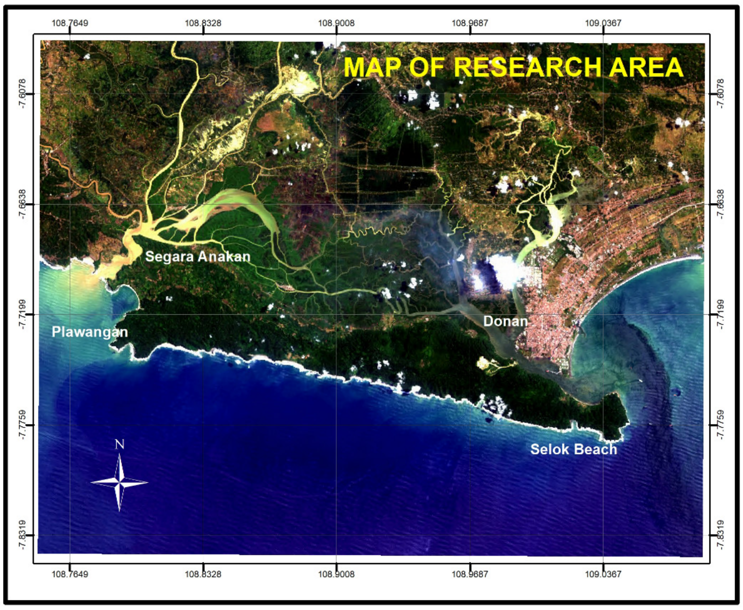

Figure 1. Map of the research area.

is supported by excellent temporal capabilities.

METHODOLOGY

Data Analysis

Landsat 8 image data ware obtained by downloading from the Pustekdata Landsat catalog of LAPAN (http://landsat-catalog.lapan.go.id/). Image band downloaded is only band 1 until band 7 accompanied by its metadata file (.MTL format). The downloaded image data have been corrected geometrically.

Determination of the most optimal combination of composite bands using the OIF method. Before calculating OIF, it is necessary to calculate the number of combinations of existing bands using the factorial equation below:

$$\binom{N}{3} = \frac{N!}{(3! * (N-3)!)} \quad \text{.. (1)}$$

where,
N = total number of bands in the map list

After the number of combinations is determined then OIF calculation is performed using the equation shown in Equation 2.

$$OIF = \sum_{i=1}^{3} SDi / \sum_{j=1}^{3} ABS(CCj) \quad \text{..............(2)}$$

where,
SDi = Standard deviation of band i
ABS = Absolute value of 3-band correlation coefficient

The initial image processing including radiometric and atmospheric correction and cropping using Quantum GIS 3.6.0 software. Atmospheric correction method used in Quantum GIS is Dark of Substraction (DOS) where the reflectance value of the sensor is converted to the surface reflectance value (Fibriawati, 2016). In this study the training area was taken for the deep sea area where the object is assumed to have a reflection value closed to 0 (dark object). The pixel value of the dark object will correct the pixel value for other objects. The RGB composite process uses a combination of result bands that have the highest OIF value. RGB composites were carried out to identify the distribution of mangroves and non-mangroves visually. The classification of mangrove and non-mangrove objects uses a supervised classification technique using the Semi-Automatic Classification (SCP) tool. Classification was done based on Macro Class and Class level as well as using 3 (three) existing algorithms including Minimum Distance, Maximum Likelihood and Spectral Angle Mapping (SAM). The complete research flow diagram can be seen in Figure 2.

RESULTS AND DISCUSSION

A simple method in mangrove identification consists of preliminary detection of mangrove forest using the most optimal combination of bands and the separation of mangrove and non-mangrove objects using the supervised classification of free open-source software. The calculation of OIF values using existing equations is very easy and not too complicated. After obtaining the OIF value from all existing band combinations, it is necessary to rank from the highest OIF value to the lowest OIF value. Technically, free

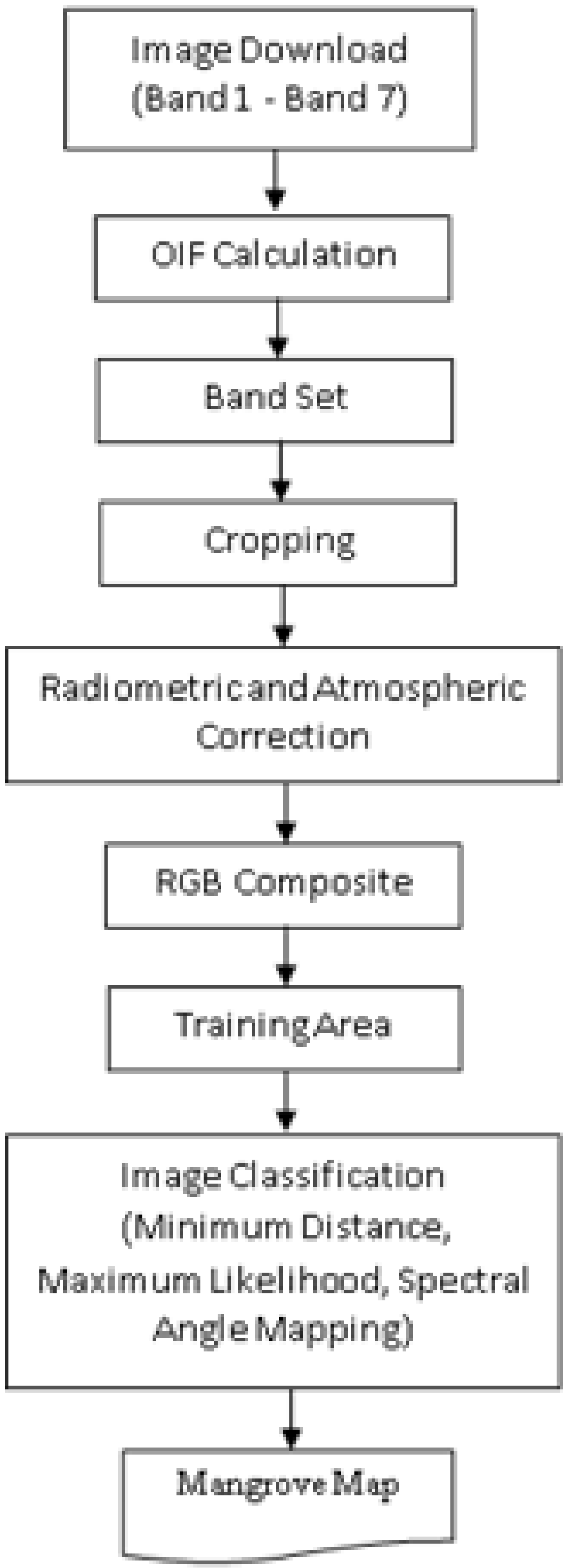

Figure 2. Research Flow Diagram.

open-source software is very easy to obtain and use for spatial analysis, especially for identifying mangrove forests. The use of free open-source software can support image processing starting from the pre-processing until the final classification process.

OIF Calculation of Landsat 8

Based on the existing needs related to the identification of mangroves and non-mangroves, the number of Landsat 8 image bands used in this study is only seven bands, starting from band 1 until band 7. OIF value indicates a measure of the amount of information contained in a composite image (Jaya, 2010). The results of calculations using first equation produced the number of combinations of bands formed by 35 combinations. The results of OIF calculations are shown in Table 1, while the correlation values between bands are shown in Table 2.

The results of OIF calculation show the combination of band 4, band 5 and band 6 has the highest OIF value of 2497.486, while the combination of band 1, band 2, band 4 has the lowest OIF value of 173.797. Although the combination of bands 4, 5 and 6 does not have the highest standard deviation but the correlation coefficient values between band 4, band 5 and band 6 are relatively lower. This is different from the combination of bands 5, 6, and 7 which have the highest total number of standard deviations but the total correlation coefficient of band 5, band 6 and band 7 is relatively high so that the OIF value of this combination (band 5, 6 and 7) is not too high. The results of the formation of RGB composites from a combination of band 4, band 5 and band 6 are shown in Figure 3. Based on the combination of bands 4, 5 and 6 then the RGB composites were formed as many as 6 pieces including a combination of RGB 456, RGB 465, RGB 546, RGB 564, RGB 645 and RGB 654. This band combination is a combination of band 4 (Red), band 5 (NIR) and band 6 (SWIR 1).

The results of the visual appearance of RGB composites in Figure 3 show that RGB 564 composite is the best and most informative in showing the distribution of mangrove forests in the research location. Mangrove objects are shown with a reddish-brown whereas other RGB combinations are not clear in distinguishing mangrove objects from their surroundings. Therefore the composite of RGB 564 was chosen in the identification of mangrove forests in this study.

Classification Results Using the Semi-Automatic Classification (SCP) Tool

The development of the Quantum GIS software version is getting faster. The image classification process in this study uses the Semi-Automatic Classification (SCP) tool. The tool is not installed by

Table 1. OIF values of Landsat 8

Band combinations	Sum of standard deviations	Sum of correlation coefficient of bands	OIF	Rank
456	5327.138	2.133	2497.486	1
156	5278.740	2.300	2292.120	2
256	5298.245	2.315	2288.658	3
356	5439.820	2.535	2145.886	4
567	5691.656	2.674	2128.517	5
457	4409.257	2.113	2086.728	6
157	4360.860	2.260	1926.180	7
257	4380.364	2.276	1924.588	8
345	4157.421	2.246	1851.033	9
357	4521.939	2.453	1843.432	10
145	3996.343	2.181	1832.344	11
245	4015.846	2.204	1822.072	12
135	4109.025	2.360	1741.112	13
235	4128.528	2.388	1728.864	14
125	3967.450	2.343	1693.321	15
246	1835.503	1.665	1102.404	16
467	2228.914	2.432	916.494	17
367	2341.596	2.604	899.230	18
267	2200.021	2.541	865.809	19
167	2180.520	2.530	863.570	20
346	1977.078	2.356	839.167	21
136	1928.682	2.412	799.619	22
236	1948.185	2.444	797.129	23
146	1816.000	2.400	756.350	24
126	1787.107	2.509	712.279	25
347	1059.197	2.382	444.667	26
237	1030.304	2.451	420.361	27
137	1010.801	2.419	417.859	28
247	917.622	2.497	367.489	29
147	898.120	2.470	363.610	30
127	869.226	2.559	339.674	31
234	665.786	2.672	249.171	32
134	646.283	2.629	245.828	33
123	617.390	2.697	228.917	34
124	504.708	2.904	173.797	35

Table 2. Correlations between Landsat 8 bands

Band	Band 1	Band 2	Band 3	Band 4	Band 5	Band 6	Band 7
Band 1	1						
Band 2	0.991	1					
Band 3	0.841	0.865	1				
Band 4	0.947	0.966	0.841	1			
Band 5	0.674	0.678	0.845	0.560	1		
Band 6	0.755	0.763	0.816	0.699	0.874	1	
Band 7	0.780	0.788	0.798	0.743	0.810	0.990	1

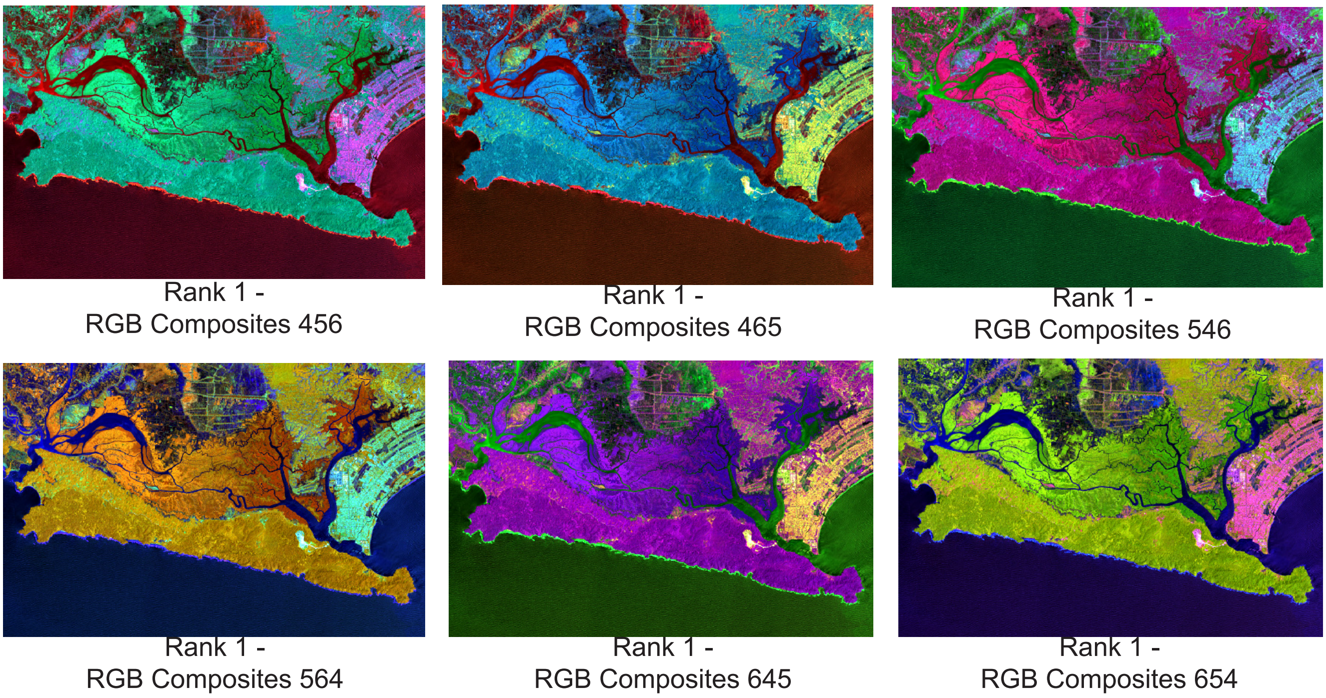

Figure 3. Composite results for Bands 4, 5 and 6 with the highest OIF values.

default in the main software, so firstly the user must perform the installation process using the facilities provided. The initial step before carrying out the classification process is making some training areas for mangrove and non-mangrove classes as shown in Figure 4. The training area was created based on observations and information on the type of land cover in the field. The more training areas that are created, the results of the classification is better. The training area (ROI) is polygons in relatively homogeneous pixels on mangrove and non-mangrove land cover objects (settlements, water, rice fields, forests, open land, etc.). It is necessary to make RGB composite using the results of previous OIF calculations (Composite RGB 564) to identify mangrove forests more easily.

The classification process using the SCP tool is different from the classification process using other processing software. In the classification process using the SCP tool requires two types of class level inputs, namely the Macro Class (MC) and Class (C) levels. The Macro Class level contains more general types of classes, while the Class level contains more specific class information. For example, the Macro Class level is Vegetation so the Class level consists of trees, grass, and others. In this study only focus on mapping mangrove forests so that the class information needed is only two classes, namely mangroves and non-mangroves. There are ten training areas for mangrove and non mangrove objects. The Macro Class level of the mangrove class is symbolized by the letter m, while for the Class level symbolized by the letters m1, m2, m3 and so on according to the number of training areas created. For the Macro Class level, the non mangrove class is symbolized by the letter nm, while for the Class level symbolized by the letters n1, n2, n3 and so on

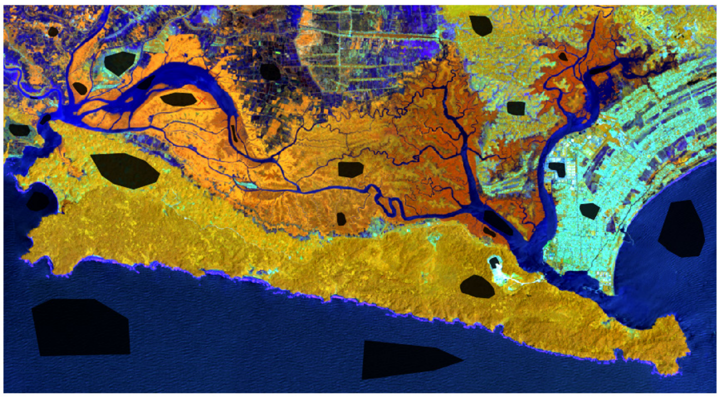

Figure 4. Distribution of training area of mangrove and non mangrove.

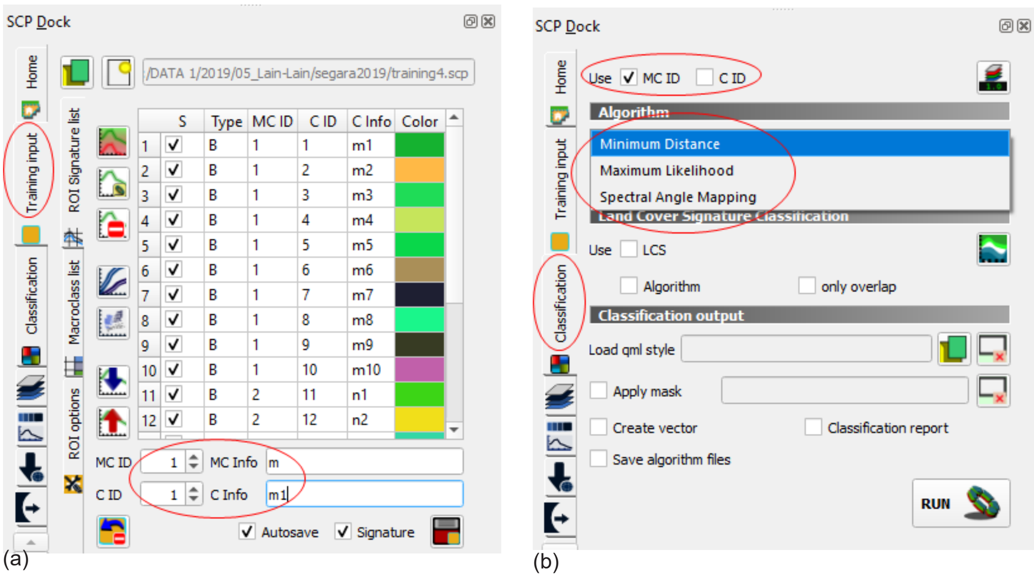

Figure 5. (a) Labelling Process of Training Area (ROI), (b) Classification Process.

according to the number of training areas as shown in Figure 5a.

After training area (ROI) is completed then the next step is the classification process using 3 (three) Algorithm provided, namely Minimum Distance, Maximum Likelihood and Spectral Angle Mapping (SAM) as shown in Figure 5b. The working principle of the Minimum Distance method is to classify an object into a particular pattern class based on Euclidean distance calculations. The object will be classified into classes with the smallest distance between the prototype of each class and the object to be classified. The disadvantages of this method do not consider class variability. The Maximum Likelihood Algorithm method is the most frequently used for the object classification process because it uses the basis of probability calculations. The working principle of the Maximum Likelihood algorithm is the pixels are grouped based on the probability of ownership of a class with an average value and covariance is modeled in the form of a normal (parametric) distribution in a multispectral feature space (Sisodia *et al*., 2014 in Jhonnerie, 2015). While the SAM algorithm determines the angle (radians angle) and spectral library in situ measurement results. The spectral angle which has the optimal accuracy

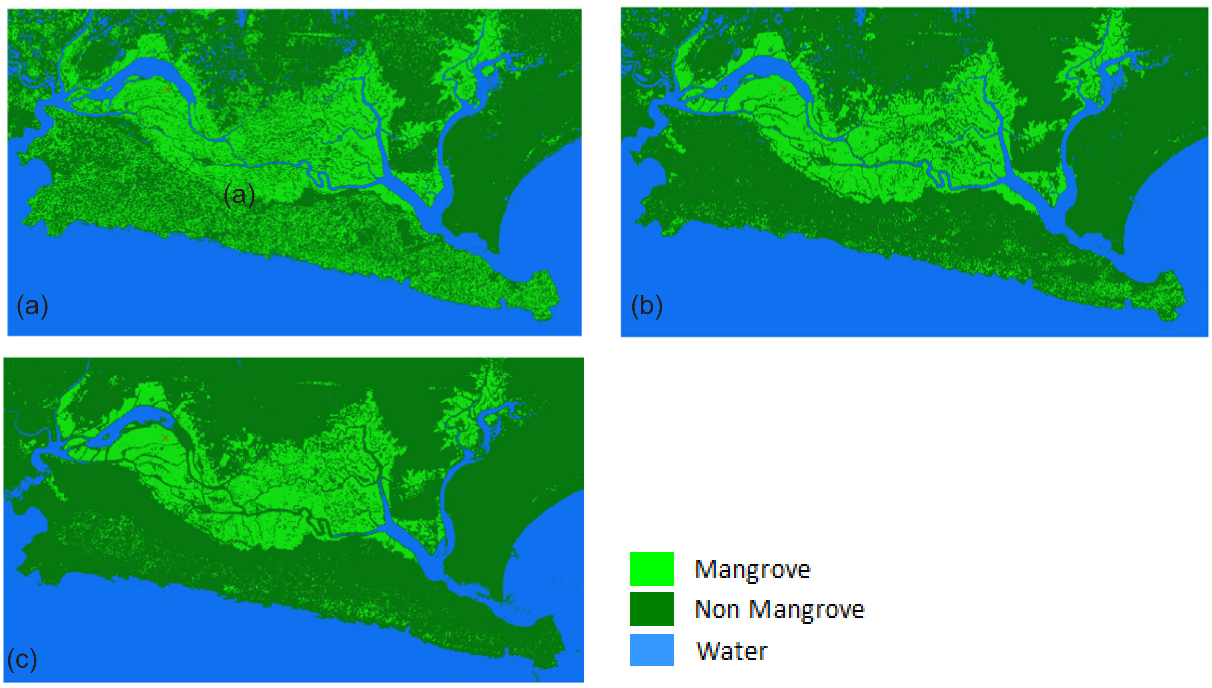

Figure 6. (a) Labelling Process of Training Area (ROI), (b) Classification Process.

value is determined based on the calculation of the angle with the equation.

The classification results at the Macro Class level show that the Maximum Likelihood algorithm can separate the mangrove and non-mangrove classes better than other algorithms. The distribution of mangrove classes in non-mangrove areas is relatively less, especially in the Nusakambangan Island and Cilacap City areas. Classification results using the Minimum Distance and Spectral Angle Mapping algorithm show there are still many mangrove classes mixed with non-mangrove classes, especially those in the Nusakambangan Island region. The results of the classification of mangroves and non-mangroves (Macro Class level) are shown in Figure 6.

The results of classification for Class level is divided into seven classes including mangrove, forest, bare soil, settlement, oil refinery, paddy fields and water (Figure 7). Based on the three algorithms used, the algorithm of Maximum Likelihood also looks better in distinguishing mangrove classes from other classes. This can be seen with the few mangrove classes mixed with other classes compared to the classification results using the Minimum Distance and Spectral Angle Mapping algorithm. However, the Maximum Likelihood algorithm still has some weaknesses, especially in distinguishing non-mangrove classes including oil refinery, paddy field and settlement where those classes are still mixed with other non-mangrove classes. This is because the number of training areas (ROI) created for non-mangrove classes is still relatively less so that further research can be done by increasing the training area, especially in non-mangrove classes
.

Based on the results of the classification using several available algorithms and at 2 (two) different levels, the Maximum Likelihood algorithm was chosen to be the most optimal in identifying mangrove and non-mangrove objects quickly and easily. This algorithm is very good in distinguishing mangroves and non-mangroves both at the Macro Class and Class level. Figure 8 displays the results of mangrove identification using the Maximum Likelihood algorithm after doing an adjustment or editing of class. The Maximum Likelihood algorithm has also been tested and applied in pixel-based classification processes, especially for mangrove forests (Kuenzer *et al*., 2011). Marini *et al*. (2014) conducted classification using the maximum likelihood algorithm to map fishponds aquaculture in Maros Regency, South Sulawesi Province and produce an accuracy of 90.40%.

The calculation of area shows the extent of mangrove forests in Segara Anakan, Cilacap in 2017 of 7037.16 Ha. When compared with the mangrove area of Segara Anakan, Cilacap in 2016 of 7,241.77 ha (Purwanto, 2017). This shows a decrease in the mangrove area of 204.61 ha. To further clarify the results of mangrove identification, it is necessary to compare with composite images that use the best RGB composites of OIF results (Figure 9).

Figure 9 shows the distribution of mangroves forest right at image locations with a reddish-brown.

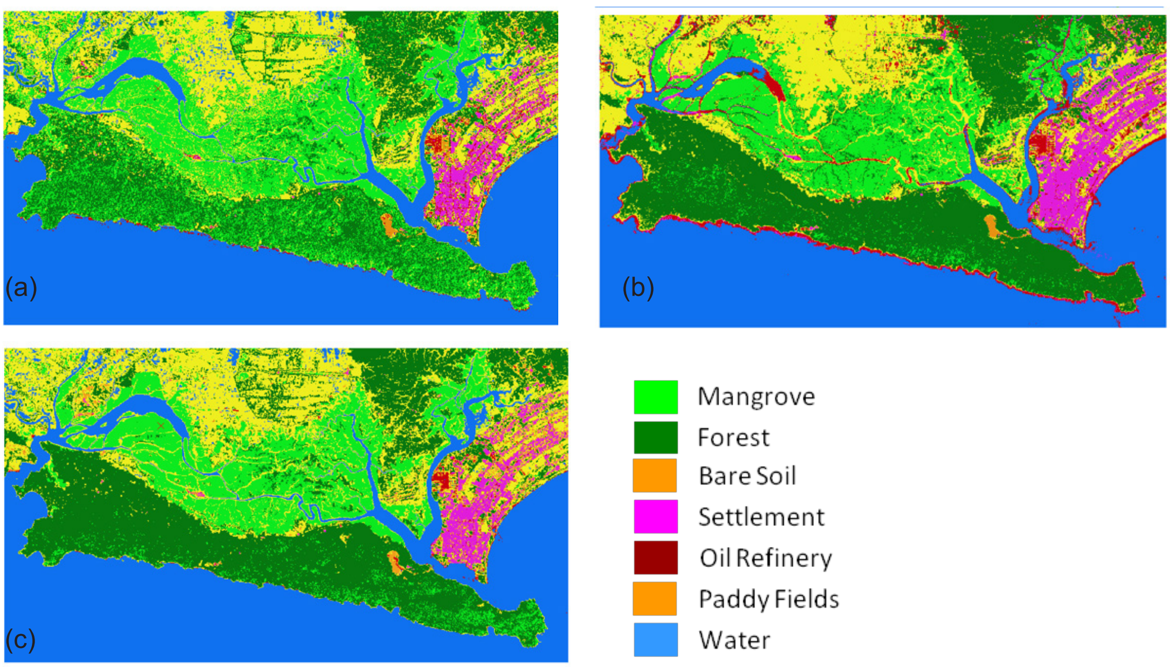

Figure 7. Mangrove and Non Mangrove Classification Results (Class Level), (a) Minimum Distance, (b) Maximum Likelihood, (c) Spectral Angle Mapping.

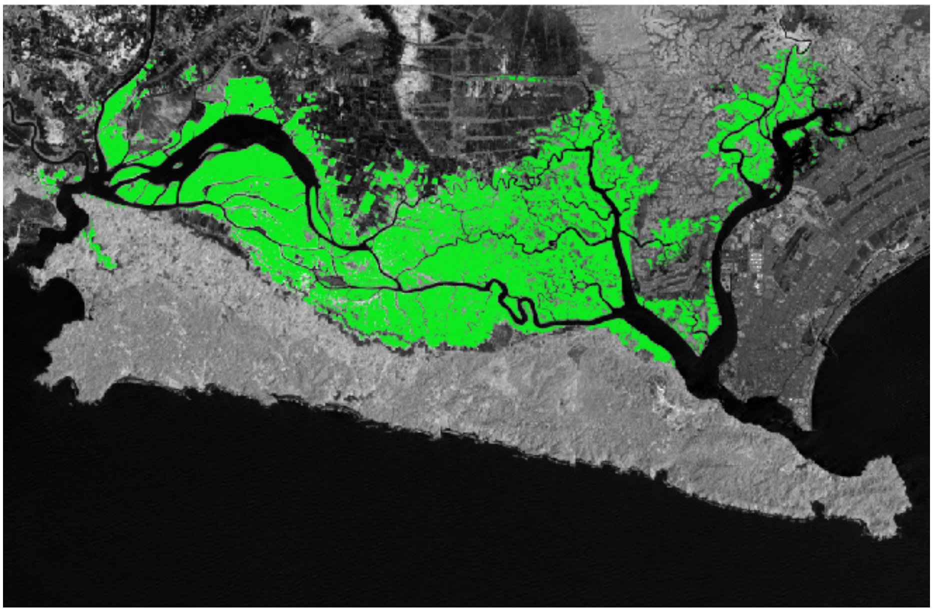

Figure 8. Classification Results of Mangrove with Maximum Likelihood (Green Color).

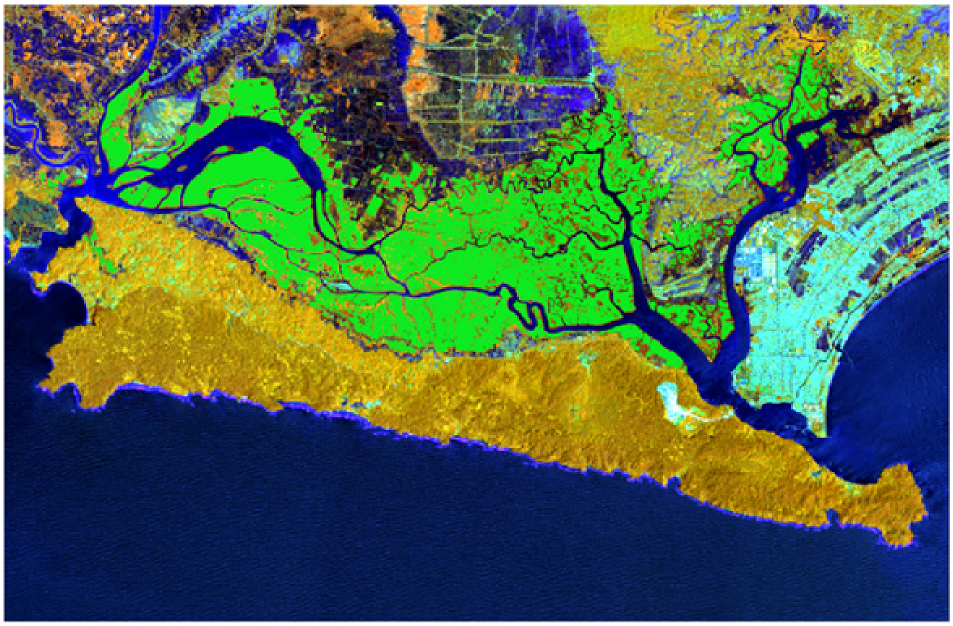

Figure 9. Overlay Between Distribution of Mangrove (Green Color) with RGB 564 Composites of Image Data.

The boundaries of mangrove with non-mangrove objects, especially forests, paddy fields and ponds are very clear. The results of the comparison can explain that choosing the right RGB composite image can help and facilitate the identification of mangrove forests so it is expected to be able to support national mangrove monitoring and rehabilitation programs where these activities require data and information of mangrove forest distribution quickly and up to date.

CONCLUSION

The RGB 564 composite (NIR+SWIR+RED) from Landsat 8 imagery is the most optimal band combination in identifying mangrove forests. The use of OIF method can simplify the selection of appropriate and optimal bands for identifying mangrove forests. Maximum Likelihood classification algorithm of Semi-Automatic Classification Plugin (SCP) can separate mangrove and non mangrove classes better for Macro Class and Class level than the Minimum Distance and Spectral Angle Mapping algorithm. The results of the calculation of the area show the mangrove area of 7037.16 ha. The use of the Optimum Index Factor (OIF) and Semi-Automatic Classification Plugin (SCP) methods is beneficial in identifying mangrove forests more quickly, easily, effectively and efficiently.

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