GEOBIA for mangrove mapping using UAV-modified NIR 1 camera sensor

N Khakhim\textsuperscript{1}, M A Marfai\textsuperscript{1}, R F Putri\textsuperscript{1}, A Wicaksono\textsuperscript{1}, W Lazuardi\textsuperscript{1}, Z Isnaen\textsuperscript{1}, T Walinono\textsuperscript{1}

\textsuperscript{1}Faculty of Geography, Universitas Gadjah Mada, Sekip Utara Jalan Kaliurang, Bulaksumur, Yogyakarta, 55281
e-mail: nurulk@ugm.ac.id

Abstract. Mangrove ecosystem is a natural resource that can be beneficial for coastal community. One of its benefits is it can be utilized as an ecotourism spot such as Baros Mangrove Conservation Area in Kretek, Bantul. Hence, mangrove ecosystem must be conserved or expanded if possible. The first step to conserving mangrove ecosystem is to map its existing condition. UAV can be used to acquire a high-resolution imagery quickly. With modified near-infrared (NIR) sensor from a pocket camera can produce three band i.e. NIR, green, and blue that can be used to calculate several vegetation indices such as Simple Ration (SR), Normalized Difference Vegetation Index (NDVI), and Enhanced Difference Vegetation Index (ENDVI). Those bands and vegetation indices then used to map mangrove using Geographic Object-Based Image Analysis approach. The result indicated that high-resolution imagery from modified NIR camera sensor can be used to detect mangrove and distinguish it from other object using supervised classification. The digitally classified imagery then compared to manually digitized mangrove map to calculate the total error of the map.

1. Introduction
Mangrove ecosystem are usually found along coastal areas in tropical and subtropical regions on river banks near estuaries and lagoons [1]. Mangrove has a unique adaptation system that make it be able to live and thrive in tidal areas [2-6], states that mangrove ecosystems are the most productive ecosystem because there are various types of typical vegetation and fauna that breed in this ecosystem. Moreover, mangrove have ecosystem services which can support human life, i.e. produce of various food, building materials, and medicines materials [7, 8], as a natural barrier in coastal areas to prevent coastal erosion and seawater intrusion, stabilize sediments, reduce carbon dioxide levels in the atmosphere, and reduce the impact of tsunami waves [9-12]. Those benefits make mangrove must be conserved or extended if possible. One of the way to achieve that is using ecotourism approach[13, 14]. Ecotourism is a way to managed mangrove ecosystem in a sustainable manner and utilized its potential for education and tourism and be beneficial for the welfare of the community.

One of the first step to conserving mangrove ecosystem is to map its existing condition. It is crucial to know the existing condition of mangrove to determine the plan in how to conserve it. Unmanned Aerial Vehicle (UAV) can be used to acquire a high-resolution imagery quickly and relatively cheap [15, 16]. UAV is a new approach in mapping, monitoring, and assessing environmental conditions [17]. But in detailed region such as mangrove ecosystem an ordinary camera sensor with its visible band will not be a much help because mangrove and other vegetation have the same appearance. Modified sensor that derive near-infrared (NIR) band will be advantageous because vegetation is more responsive toward NIR than other band [18]. The modified camera use cyan filter to block red spectrum allow near-infrared spectrum to enter the sensor, therefore it will produce three band i.e. NIR, green, and blue [19]. Those band can be used to generate several vegetation indices such as Simple Ration (SR) [20, 21], Normalized
Difference Vegetation Index (NDVI) [18, 22], and Enhanced Difference Vegetation Index (ENDVI) [23] Those bands and vegetation indices then used to map mangrove using Geographic Object-Based Image Analysis approach.

2. Study Site
Mangrove ecosystems in Yogyakarta’s is a unique phenomenon because usually these ecosystem only able to live in muddy coastal areas, whereas in Yogyakarta the coast is generally dominated by sand material. One of the place where mangrove is thriving is in Baros Mangrove Conservation Area, Kretkek, Bantul. These area is selected because it is one of the most developed mangrove ecotourism spot in Yogyakarta. These ecosystem were wellmaintained and there are many vegetation other than mangrove. It is ideal to conduct an experiment to distinguish mangrove from other object, especially other vegetation with the modified NIR camera sensor.

![Figure 1](image_url). Study site of this research in Baros Mangrove Conservation Area. Left is in true color and right is in standard false-color derived from the modified NIR camera sensor. Vegetation is red and built-up area is blue.

3. Material and Methods

3.1. Data
The main data used is high-resolution standard false-color imagery derived from the modified NIR camera sensor. Those imagery were acquired on September 5th 2018 and the corrected using digital camera imagery correction procedures by [24]. The correction purpose is to transform digital number in each pixel into reflectance value of the object.

3.2. Data
3.2.1. Geographic Object-Based Image Analysis. GEOBIA is a classification method that turn pixels into segments that represent geographical objects based on their spectral and spatial patterns [25]. This allows the classification to have object as mapping unit, not a pixel anymore. Hence, it will be beneficial when applied to high-resolution imagery such as aerial photograph. This approach has been use to map mangrove by [26] and [27].
3.2. Geographic Object-Based Image Analysis. Segmentation accuracy test introduced by [28] as used in [29] and [30] is applied to test the accuracy of the map. This test process compares area of the results of segmentation with reference polygon that are considered correct. Reference polygon is created using a manual digitization and will be considered correct. The segmentation-result polygon and reference polygon are then overlaid to calculate five parameters of segmentation accuracy, namely over segmentation (os), under segmentation (us), closeness to an ideal segmentation result (D), area fit index (AFI), and quality rate (qr). The following is the formula used to search for these five parameters.

\[
os = 1 - \frac{\text{segment} \div \text{reference}}{\text{segment}}
\]  

(1)

\[
us = 1 - \frac{\text{segment} \div \text{reference}}{\text{reference}}
\]  

(2)

\[
D = \sqrt{\frac{os^2 + us^2}{2}}
\]  

(3)

\[
AFI = \frac{\text{segment} \div \text{reference}}{\text{segment}}
\]  

(4)

\[
qr = \frac{\text{segment} \div \text{reference}}{\text{segment} \div \text{reference}}
\]  

(5)

4. Result and Discussion

The result of the classification indicates that GEOBIA can detect mangroves well. When compared with manual classification, the result is not so different. Accuracy test stated that the GEOBIA classification has a great result. There are five parameters that have been used. The value of over segmentation (os) is 0.0878; under segmentation (us) is 0.1483; closeness to an ideal segmentation result (D) is 0.1219; area fit index (AFI) is -0.0709, and quality rate (qr) is 0.7870. The more the value of os, us, and D close to zero the more it indicates a perfect match with the referenced map. AFI and qr value indicate that the classification is undersegmented, but it can be tolerated. Built-up area classification is not well-detected. But it does not matter because the goal of this research is to detect mangroves. Mangroves can be well-detected because four vegetation indices were used, e.g. SR, NDVI, and ENDVI. Every vegetation index has a different spectral signature for mangroves as shown in Table 1.
Figure 2. The result of the object based classification (right) and manual classification (left)

Table 1. Mangroves Spectral Signatures for Every Bands and Vegetation Indices

| Variabel   | Average Digital Number |
|------------|------------------------|
| 1. Near-infrared | 11,6059                |
| 2. Green    | 6,1176                 |
| 3. Blue     | 6,2055                 |
| 4. SRVI1    | 1,9564                 |
| 5. SRVI2    | 0,9862                 |
| 6. NDVI     | 0,3176                 |
| 7. ENDVI    | 0,1881                 |

Source: Data processing

5. Conclusion
Modified near-infrared (NIR) camera can produce tNIR, green, and blue band that can be used to calculate four vegetation indices. They were Simple Ration (SR), Normalized Difference Vegetation Index (NDVI), and Enhanced Difference Vegetation Index (ENDVI). Those vegetation indices proved can be used to detect mangrove using Geographic ObjectBased Image Analysis approach (GEOBIA). Accuracy test were done and the result were over segmentation (os) is 0,0878; under segmentation (us) is 0,1483; closeness to an ideal segmentation result (D) is 0,1219; area fit index (AFI) is -0,0709, and quality rate (qr) is 0,7870.

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