GEOBIA for Land Use Mapping Using Worldview-2 Image in Bengkak Village Coastal, Banyuwangi Regency, East Java

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Abstract. The east coast of Banyuwangi regency has a diverse variety of land use such as ponds, mangroves, agricultural fields and settlements. WorldView-2 is a multispectral image with high spatial resolution that can display detailed information of land use. Geographic Object Based Image Analysis (GEOBIA) classification technique uses object segments as the smallest unit of analysis. The segmentation and classification process is not only based on spectral value of the image but also considering other elements of the image interpretation. This gives GEOBIA an opportunities and challenges in the mapping and monitoring of land use. This research aims to assess the GEOBIA classification method for generating the classification of land use in coastal areas of Banyuwangi. The result of this study is land use classification map produced by GEOBIA classification. We verified the accuracy of the resulted land use map by comparing the map with result from visual interpretation of the image that have been validated through field surveys. Variation of land use in most of the east coast of Banyuwangi regency is dominated by mangrove, agricultural fields, mixed farms, settlements and ponds.

Keywords: GEOBIA, Land use, coastal, WorldView-2

1. Introduction
Since the last fifteen years, the use of object-based approach for classifying remotely-sensed images are getting more attention from researchers. Unlike the pixel-based approach which heavily relies on the spectral value of the individual pixels, the object-based approach uses segments as the smallest mapping unit and incorporates some visual interpretation keys in the classification. This includes colour, shape, pattern, size, association, etc. [2]. Thus, object-based classification are able to define the object classes based on spectral and spatial aspects of the image at once [2]

Object-based approach for semi-automated LULC mapping have been a major focus area of remote sensing and image processing research since the past decade [11]. The object-based classification works in the same way as a pixel-based classification. However, the difference is that it does not classify each pixel
individually, but classifying the image based on the segment or group of pixels that compose an object. The training areas for the classification of the objects are derived from the existing database in order to avoid a time-consuming manual acquisition [10]. GEOBIA provides an opportunity to improve the extraction of land cover and use information from remote sensing image data.

Land is a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface including those of the near-surface climate the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), the near-surface sedimentary layers and associated groundwater reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc. [4]. Land use is characterized by the arrangements, activities and inputs by people to produce, change or maintain a certain land cover [3] while land cover refers more to “the vegetational and artificial constructions covering the land surface [6]. Construction is entirely visible directly from remote sensing imagery.

This research aims are to apply the GEOBIA classification method for generating the classification of land use in coastal areas, and assess the accuracy of the map result. The result of this research is land use classification maps using GEOBIA.

2. Methodology and Materials

2.1 Study Area

The study area in this research is Bengkak Village, in the coastal area of Wongsorejo District, Banyuwangi Regency, East Java with sample area extent of about 289,796.20 m² (Figure 1). In this area we found high variation of land uses including sea water, fishpond, built-up area, river, mangrove area, open field, etc. This high land uses variation in this study area gives us an ideal location to test the land use classification using GEOBIA approach.

**Figure 1.** Localization of area study (Source: Adapted from WorldView-2 image dated July 2015. (DIGITALGLOBE, 2016)
2.2 Materials
This study is conducted using WorldView 2 image data. This data launched October 2009 with 11 bit per pixel and repeat time 1.1 days. WorldView 2 provide 8 multispectral bands (4 new band and 4 standard bands) and 1 panchromatic. The multispectral bands are coastal (400 - 450nm), red (630 -690 nm), blue (450 - 510 nm), red edge (705 - 745 nm), green (510 - 580 nm), near-IR1 (770 - 895 nm), yellow (585 - 625 nm), near-IR2 (860 - 1040 nm). Every bands has a different specific applied one to each other. Multispectral bands has spatial resolution 1.85 m GSD at nadir, 2.07 m GSD at 20° off-nadir.

In other hand, panchromatic band (450 - 800 nm) has 0.46 m GSD at nadir, 0.52 m GSD at 20° off-nadir spatial resolution. WorldView 2 with system orbit sun-synchronous has an average revisit time of 1.1 days. This image data of WorldView 2 is impressed on July 15th 2015 with 0% cloud cover (Handbook WorldView 2)

![WorldView 2 Spectral Bands](Source: DigitalGlobe Proprietor)

**Figure 2.** WorldView 2 Spectral Bands (Source: DigitalGlobe Proprietor)

2.3 Methodology
The method used in this study include:

2.3.1 Pre-processing. This process is started with geometric correction or generally known as georeferenced. Geometrically corrected imagery can be used to extract accurate distance, polygon area, and direction (bearing) information [5].

2.3.2 Processing. In this step we use two step classification:

2.3.2.1 Visual classification
In this classification we interpret the remote sensing image using a visual method image remote sensing with the visual method. The result of this process is map reference to validation.
2.3.2.2 GEOBIA classification

In this step, we begin with segmentation image and then classification. This second step produces a tentative map of land use. Image segmentation algorithm is a crucial step in image processing and analysis. The goal of segmentation is to separate an image into some regions of feature and to pick up the interesting objects [7]. The use GEOBIA (Geographic Object Based Image Analysis) in the process of remote sensing image classification complements previous techniques. GEOBIA have a better ability for not only consider the pixel values in the classification process, but also other elements of interpretation, especially for images with high resolution [1]. One software that is able to perform GEOBIA process is eCognition issued by Trimble. GEOBIA starts with the segmentation process using multiresolution segmentation method with a parameter of value scale, compactness, smoothness, shape and color [2]. Multi resolution segmentation is an optimization procedure which, for a given number of image objects, minimizes the average heterogeneity and maximizes their respective homogeneity [9]. Furthermore, the classification is done through two phases: the first is to select a sample object which is then classified using the nearest neighbor method. The second stage is incorporate elements of other interpretations that are specific to each object such as the size and associations.

After we have map reference and tentative map of land use, we can start to accuracy assessment. We can overlay both of two data to know the differences. Percent error accuracy assessment means value of overshoot and undershoot between them. To accuracy assessment we use sampling area with purposive random sampling.

3. Result and Discussion
3.1 Segmentation Process

Segmentation algorithms are used to subdivide entire images at a pixel level, or specific image objects from other domains into smaller image objects. In the segmentation process for determining the scale is quite an important aspect, because of this will affect the next process in the classification. The determination of scale will affect the segmentation on the image. (In this research the segmentation process of worldview-2 images by inserting 10 in the settings on scale value with a weight on the bands of costal, blue, green, and yellow are 1 and Near infra-red 1, Near infra-red 2, Red, and Red Edge are 3. Meanwhile, the shape value is 0.1 and the compactness is 0.5. The result of this process is obtained from the segmentation of each segments that have a proximity of homogeneity such as figure 4.
Figure 3. Flow Chart
Figure 4. Flow diagram of Multiresolution segmentation (Source: reference book of ecognition developer [9])

Figure 5. (a) WV-2 image composite 762; (b) images segmentation scale 10; (c) WV-2 image RGB
The use of value as a segmentation base is to consider spatial resolution that affects the value scale. Value of shape and color that is inversely proportional that has shape value higher than colour value makes colour value become lower. While the value of compactness is inversely proportional to the value of subtlety. The compactness value higher than value of its subtlety become lower [2].

3.2 Classification Process

The classification process using the nearest neighbor algorithm (NN) taking into account the value of the channel spectral Near infra-red 1 (NIR1), Near infra-red 2 (NIR2), Red and using The normalized difference vegetation index (NDVI) values, brightness and maximal difference. NDVI is a simple graphical indicator that can be used to analyze remote sensing measurements, typically but not necessarily from a space platform, and assess whether the target being observed contains live green vegetation or not. The selection of a sample of the object segmentation produces some variations including: Sea, settlements, swamps, mixed crops, river, shrubs, ponds, moor, open land and mangrove. Samples were selected based on class training and on the terms of a visual interpretation of the value of the object in the image histogram. This technique considers the aspect of sample classes with some of the features extracted into information that can be able to apply it to the image, resulting in a classification of land use in the image.

A simple NN classification was performed using all potential training sites as input data. The second classification procedure uses the estimated class thresholds to set up an object-based classification rule. Determination of classes using the estimated threshold class is used to obtain the best classification of several objects which are mixed with other objects and errors in the determination of class by NN classification.

Grading errors occurred in the NN when entering class of mixed crops, because only considering the value of any spectral objects that should be in the classification of mangrove as mangrove itself is generally identified as mixed crops class. To get the correct grade of classification threshold is using estimate distance by sea class, which means that the class mangrove is in a certain distance to the sea class. So class mixed crops near the sea is then converted into mangrove class using estimation and classification threshold distance by sea class.
Obtaining the classification results based on the sample is carried out in detail using grade separation element which is a measure of other interpretations and associations. For example the sea has great segmentation size because it has a high homogeneity in order that the sea will be easier to identify. Similarly, mangrove object has an association that is very close to the sea so, although having a spectral reflectance curve is almost the same as other vegetation objects, elements of this interpretation will be able to separate the mangrove class of its own. This process is performed to separate the elements of interpretation which can be entered each object class.

3.3 Accuracy Assessment

Accuracy assessment of GEOBIA is another hot issue [10]. Some studies use point data to assess GEOBIA results, while others use polygons (i.e., objects) as reference data [10]. Unlike the pixel-based image analysis methods, accuracy assessment for OBIA method involves some aspects of geometry that consists of shape, location, and symmetry between extracted objects and reference objects [8]. In this research we use polygons to be a reference data from visual interpretation. We asses the accuracy of every object by using stratified random sampling.

Figure 6. Iterative process of (knowledge-based) image segmentation and classification
In this research we have 9 classes of landuse in coastal area in Bengkak Village. They are open land, sea, mangrove, settlement, river, fishpond. Accuracy assessment is done for every class of landuse (Table 1). We have a new information about true or false classification in m² and in % for every class and overall landuse.

| Landuse     | True (m²)  | False (m²) | True (%) | False (%) |
|-------------|------------|------------|----------|-----------|
| Open land   | 11157.56   | 10303.62   | 51.99    | 48.01     |
| Sea         | 47668.43   | 69.67      | 99.85    | 0.15      |
| Mangrove    | 26530.55   | 1476.67    | 94.73    | 5.27      |
| Settlement  | 9391.80    | 16665.01   | 36.04    | 63.96     |
| River       | 398.98     | 37.11      | 91.49    | 8.51      |
| Swamp       | 6519.32    | 484.50     | 93.08    | 6.92      |
| Shrubs      | 5521.31    | 1283.40    | 81.14    | 18.86     |
| Fishpond    | 79946.56   | 1371.79    | 98.31    | 1.69      |
| Crop land   | 49028.05   | 6837.39    | 87.76    | 12.24     |
| Mixed Farm  | 11968.27   | 3136.20    | 79.24    | 20.76     |
| Surface Area| 248130.83  | 41665.37   | 85.62%   | 14.38%    |

**OVERALL** 289796.20

From Table 1 above, we know that overall accuracy landuse of GEOBIA classification is 85.62%. Although this accuracy value is quite high, a closer observation of the accuracy of each object shows that the gaps are very significant. For all samples areas, it was found that the highest accuracy was obtained for the sea with 99.85%. Mangrove, swamp, river and fishpond are all have higher than 90%. On the other hand, the lowest accuracy was obtained for open land and settlement.
Although spectral element is not the only basis for classification, but it is still considered in the classification process GEOBIA. It affects the accuracy values between settlement and open land is relatively low. As it is known, the roof of the settlements in Indonesia, including in Banyuwangi is constructed with tiles made from raw material red soil. Wavelengths in the WorldView-2 imagery only to NIR-2 so as NDBI spectral transformation can not be applied (Figure 8).

**Figure 8.** Spectral Curve (Source: Lillesand & Kiefer, 1984)

4. **Conclusions**

GEOBIA techniques combined with high-resolution images such as WorldView 2 can be used for land use classification including in the coastal area. This classification technique does have several advantages when compared with the classification of visual and multispectral classification. Some of these advantages include the ability of automation as well as elements outside the spectral interpretation that can be taken into account in this classification. In this study, image interpretation based solely on the elements of color, size, and spectral association alone but to some particular object requires another interpretation elements such as shape, texture, and pattern of the site in object recognition. The accuracy of the use of the element will greatly affect the accuracy of classification.

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