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TROPICAL BIODIVERSITY MAPPING FROM HYPERION IMAGE IN BOGOR INDONESIA

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ABSTRACT:

Hyperspectral remote sensing is increasingly used for many applications, and one of them is biodiversity mapping. common used data are MODIS and other low resolution satellite images, which have been freely accessed and obtained, while the use of medium resolution hyperspectral images was rare, until mid 2009 when EO-1 Hyperion was declared free. This has motivated some studies to make first step,of ambitious project: tropical biodiversity mapping. As tropical country with rich biota, biodiversity mapping is very important in Indonesia. a terrestrial spectrometry completed the data for deeper analysis. A biodiversity map will be derived from EO-1 Hyperion data over Bogor Botanical Garden. The area covers about one kilometer square. The study shows that there is a need for building better tropical spectral library.

1. INTRODUCTION

Biodiversity map is an important issue for todays global earth condition. It is not just an interest for biologists and environmentalists,but now it deals with the global issue of climate change, where biodiversity richness in every part of the earth is under threat for extinction. Biodiversity (richness) occurs at many scales and includes genetic diversity, species diversity (species richness), functional diversity, and ecosystem diversity (Gamon, 2008). Tropical ecosystems are among the world's hotspots of species richness and endemism. Many of the forested ecosystems are disappearing or being degraded at rapid rates. In the past, remote assessment of biodiversity has been largely indirect because satellite sensors have generally lacked the spectral and spatial resolution needed to capture patterns of species richness directly. Additionally, optical remote sensing of biodiversity is generally limited to what can be detected from above and is heavily weighted by the signal returning from top surface layer – for example, the upper canopy layers of a forest.

With the advent of new imaging spectrometers, we now have several more direct pathways for linking remote sensing to some measure of biodiversity. Some of these alternate measures of diversity may be more accessible from remote sensing than species richness. When combined with spatial detail (small pixel sizes) and temporal resolution (multitemporal imagery), hyperspectral sensors provide a rich array of tools for direct assessment of vegetation functional and structural diversity from remote sensing.

The use of remote sensing to detect biodiversity depends on the biodiversity level being measured and this relates to either spatial or spectral resolution. If there is high correlation between remote sensing and biodiversity then there will be a strong correlation between the optical diversity with the surface canopy or other measures of biodiversity detectable.

Hyperspectral data are narrow band information of the reflectance of objects on the earth surface. The data are usually acquired from satellite, aircraft, or from a spectroreadiometer. This kind of technology provides advantages in analising the spectral object information in detail. One of the spectral data that are still under research stage is the Hyperion, carried by the EO-1 satellite (Nemani *et a,l* 2003). Hyperion data contain 242 spectral band that can be classified into AVNIR spectral range (bands1-70) to SWIR spectral range (bands 71-242). There are 220 unique spectral bands or channels in Hyperion images, with a complete spectrum covering from 357 to 2567 nm. From the 242 bands contained in Hyperion data only 198 bands were calibrated, and the uncalibrated channels were due to the detectors' low responsivity. These are the level 1 Radiometric product. There is an overlap between the VNIR and SWIR so that only 196 bands are unique. The calibrated channels are band 8 to 57 for the VNIR and 77-224 for the SWIR (University of Cincinnati, 2003).

In general, the capability of hyperspectral sensor to detect many narrow spectral bands can be applied to detect chemical and anatomic characteristics from many plant reproductivity. Some studies have shown the advantages of using narrow bands (hyperspectral data) using certain spectrum in comparison to wide spectral band (multipectral data) for example, to obtain quantitative and qualitative information of the most sensitive part in vegetation or crop plants (Elvidge, 1990; Adams *et al*, 1995; Gao, 1996, Ceccato *et al*, 2001).

Because of different spectral width used by hyperspectral data, this requires different approaches in its processing procedures. For mapping purposes, the commonly applied project is the

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land cover classification. The capability of narrow bands in the hyperion data will be assessed to map the land cover in general and the biodiversity of tropical plants in particular.

2. MATERIALS

2.1 Study Area

The study area for this research is in Bogor Botanical Garden area and surrounding, Indonesia (Figure 1). Bogor Bitanical Garden is managed by the Ministry of Forestry in Indonesia and contains more than one thousand plant species. The area covers about 1.2 X 1.2 kilometer squares, and this is equivalent to about 1600 pixels in the Hyperion image. From Figure 1 it can be seen that the only homogenous type of vegetation covering at least one pixel in Hyoerion is the grass. Therefore, in this exercise biodiversity will focus on extracting limited vegetation cover, but will be extended to cover more land cover such as manmade (asphalt), residential/roof, water (freshwater), etc.
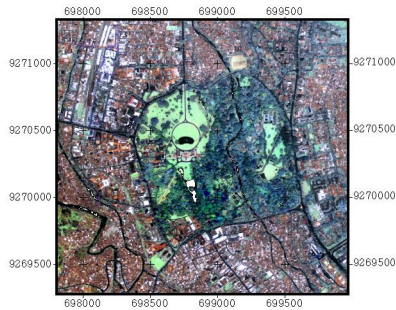

Figure 1. Bogor Botanical Garden, viewed from IKONOS image, West Java, Indonesia (UTM Zone 48S).
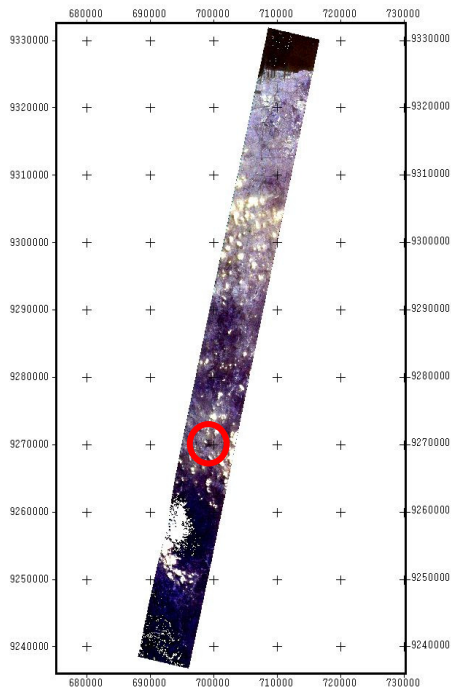

Figure 2. Whole scene of Hyperion Image of Bogor, Jakarta and surrounding areas using RGB combination of bands 24, 12 and 8 (Botanical Garden in red circle) Image was obtained from **http://eo1.usgs.gov**.

2.2 Hyperion Data

The hyperion data were acquired on 13 September 2002 with less than 10% of cloud cover. Unfortunately, some cloud covers some little parts of the botanical garden. The image can be seen in Figure 2. The zoomed image display in RGB for VNIR and SWIR bands can be seen in Figure 3 and 4.

Figure 3. Zoomed Hyperion Image of Bogor Botanical Garden and surrounding areas using RGB bands 29, 23 and 16 (VNIR).
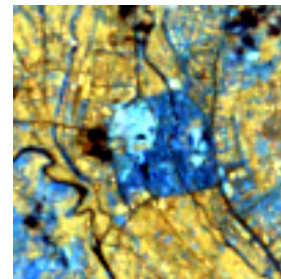

Figure 4. Zoomed Hyperion Image of Bogor Botanical Garden and surrounding areas using RGB bands 204, 150 and 93 (SWIR).

3. METHODS

The general procedures for classifying the Hyperion data can be seen in Figure 5. The procedures mainly consist of data preprocessing that include conversion of data into absolute radiance, atmospheric correction to get reflectance value and classification using the spectral angle mapper method.
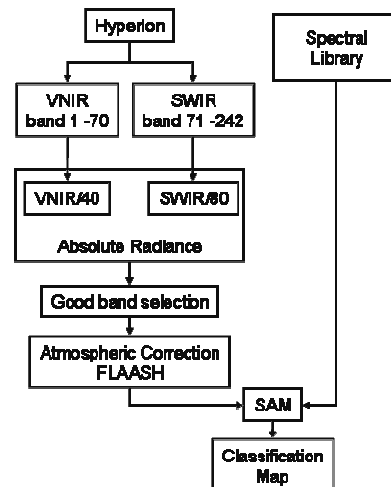

Figure 5. Classification procedures using spectral angle mapper from Hyperion satellite data.

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3.1 Hyperion Data Preprocessing

The first step of the preprocessing of Hyperion data is the geometric correction. It aimed at validating the coordinate system to the local coordinate system so that it can be compared to the existing local map and the GPS data. The second step of the preprocessing is the atmospheric correction following the extraction of the absolute radiance.

Atmospheric correction is one of the key step to obtain the surface reflectance of remote sensing optical satellite data operating in visible and near infra-red spectrum. In this preprocessing, spectral (excluding uncalibrated and overlapping bands) and spatial subsets were generated within the scene. The image was masked to exclude water bodies and to minimize under- or over-correction in subsequent processing steps. Calibrated radiance data were converted to surface reflectance using Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH). For the FLAASH input data, the Hyperon data were scaled down by the factor of 400 for the AVNIR and 800 for the SWIR. For this exercise, only AVNIR data were used for the classification.

3.2 Classification of Hyperion Data

The classification applied for vegetation mapping here uses the Spectral Angle Mapper method. The Spectral Angle Mapper matches the hyperspectral pixels to the known or reference spectra. The algorithm determine the spectra similarity by calculating the angle between the spectra, where the smaller angle represents better correlation than the wider angle. In the spectral angle mapper technique for identifying pixel spectra only the angular information is used (Richards and Jia, 2006).

The classification of hyperspectral using spectral end members derived from the spectral library is aimed at producing a map of surface composition where the interpreter does not have any prior knowledge to the surface condition. Here, there is no ground truth data is used for the supervised classification. The available spectral libraries are mainly written using reflectance information as a function wavelength.

4. RESULTS AND DISCUSSION

4.1 Spectral Library

Some of the spectral references for certain objects are available in ENVI (Figure 6). From Figure 4 it can be said that for the classification process, the image must be converted to reflectance, instead of just the radiance.

4.2 Absolute Radiance Images

The absolute radiance images displayed in Figure 7 are the results following the down scaling of the digital number by 40 and 80 for the VNIR and SWIR images, respectively. The unit for the image is $\mu W/cm^2.nm.sr$. Following the FLAASH computation, the profile of the reflectance of the point sampled in Figure 7 can be seen in Figure 8. The graph produced is slightly different fromm the reflectance of the distilled water from the spectral libraries (Figure 6). This may be due to the material contained by the river water.

4.3 Selecting Good Bands

Not all of the spectral band in the Hyperion data ae used.

Several good bands include bands 9-52, 77-120, 130-167, and 180-222.
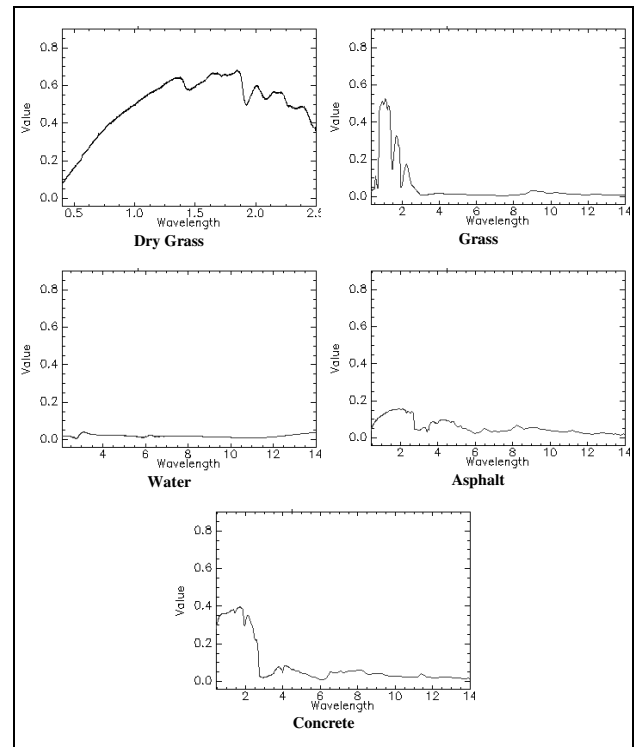

Figure 6. Selection of spectral references for land cover and biodiversity mapping. The y axis indicates the values of object reflectance.
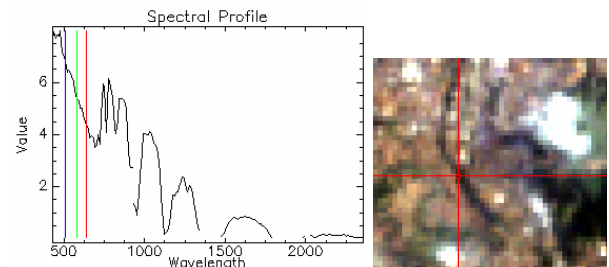

Figure 7. The profile of the radiance Image of Figure 5 (River water).
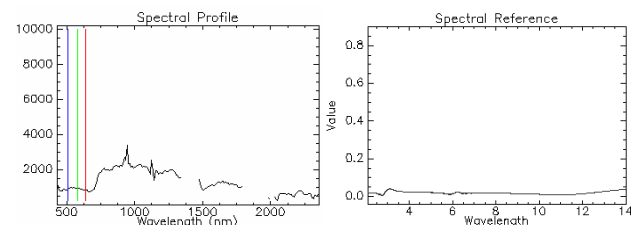

Figure 8. The profile of the reflectance Image (left) of the point in Figure 7 (River water) compared to distilled water from the spectral library (right).

4.4 Classification Results

The classification scheme used maximum angle of 0.1 radians with good VNIR bands only (bands 9-52). The results of the classification can be seen in Figure 9 and Table 10.
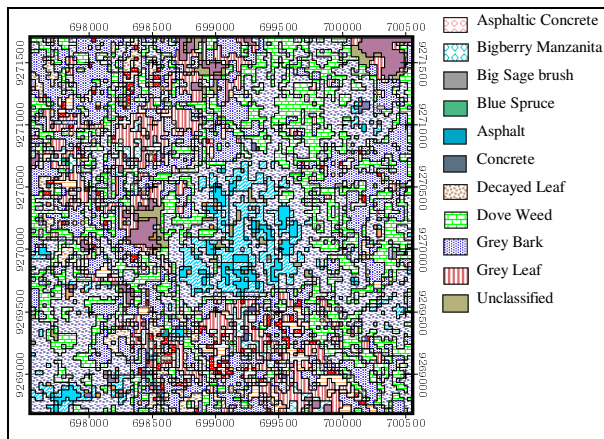
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Figure 9. Classification results using SAM with maximum angle of 0.1 applied to all good VNIR bands.

Class	Points	%	Area (m²)
Asphaltic Concrete	2	0.020%	1,800
Bigberry Manzanita	549	5.490%	494,100
Big Sage brush	2,192	21.920%	1,972,800
Blue Spruce	4	0.040%	3,600
Asphalt	17	0.170%	11,700
Concrete	13	0.130%	2,700
Decayed Leaf	265	2.650%	238,500
Dove Weed	2,300	23.000%	2,070,000
Grey Bark	2,317	23.170%	2,085,300
Grey Leaf	982	9.820%	876,600
Unclassified	151	1.510%	135,900

Table 10. Class Statistics.

5. CONCLUSION

From the results above it can be concluded that the spectral data of VNIR bands work better than the SWIR, at least for mapping land cover of the study area. This means that bands selection is very important for matching different objects. Secondly, the spectral libraries obtained from the ENVI match with some objects in the study area, therefore, there is a need for building own spectral library of tropical features. The spectral angle can then be tightened for more confident results.

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