Separability of Mangrove Landcover by Using RapidEye Satellite Imagery

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ABSTRACT

RapidEye satellite imagery was used to classify two schemes of coastal landcover in Liong River, Bengkalis Island. Transformed divergence were used due to separability analysis and accuracy of convergence matrices was used kappa's test. Two landcover classification schemes were used. The first scheme consist of 8 classes and 26 band combination of RapidEye classification result were not promised, especially when mangrove class paired with the forest and rubber plantation classes. The other scheme shownthe better solution since it has three classes (mangrove, waters body and others).

Keywords: mangrove, RapidEye, separability, transformed divergence

INTRODUCTION

RapidEye is a constellation of five satellites, launched on August 29, 2008 and run by Germany. It has a wide application prospect due to its advantages of wide coverage, short repetition cycle, high resolution and abundant multi-spectral bands. Due to powerful data acquisition capabilities and unique spectral characteristics, RapidEye satellites are being recognized and used by various international organizations sensing applications remotely. RapidEye images have high spatial resolution and spectral information abound. Nadir spatial resolution is 6.5 meters and when orthorectified spatial resolution increased to 5 m. There are five spectral bands, namely, green, red, blue and near infrared edge. RapidEye satellite is the first commercial satellite to include the red edge of the band, which is sensitive to changes in chlorophyll content. Red edge band has great potential in monitoring the health of vegetation, increasing the separation of species and assist in measuring protein and nitrogen content in biomass. RapidEye satellite constellation main specifications are listed in Table 1. (Zeng *et al*. 2011). The information products that RapidEye offering on several market segments uses: agricultural insurance, agricultural producers, international institutions, cartography (Tyc *et al. 2005*).

Table 1. RapidEye satellite spesification

Satellite Number	5
Orbital altitude	630 km
Sensor Type	Pushbroom
Spectral Range	Blue (440 - 510 nm) - Band1 Green (520 - 590 nm) - Band2 Red (639 - 685 nm) - Band3 RedEdge (690 - 730 nm) - Band4 Near Infrared (760 - 850 nm)
Spatial Resolution	6.5 m when orthorectified 5 m
Dynamic Range	12 bit

...ectral characteristics that can be distinguished ...s occurred in the narrow wavelength range.

Although RapidEye has discrete spectral range, the interval started at 40 nm to 90 nm, these will be difficult to be usedon objects classification which have narrow spectral range. But for the objects that have width spectral range such as land uses/covers, the separability of RapidEye imagery importanceto be examined. Several other satellites that have been operating before RapidEye such as SPOT and ALOS AVNIR-2 have been evaluated to map land uses/covers (Huang and Siegert, 2006; Muramatsu et al. 2010).

The purpose of this study was to determine the ability of RapidEye satellite imagery in identifying and separating mangrove class landcover.

MATERIALS AND METHODS

Study Area

The research was conducted in the River Liong, one of “riverine” mangrove ecosystem in Bengkalis Island, Bengkalis, Riau Province and started in September-October 2013 (Figure 2).

Figure 1. Study area, dots color symbolized Area of Interest (AoI) of landcover classes

Data

Two tile-ID Level 3A of RapidEye were used, both recorded at the time, 19th January, 2011. BSQ is interleaved data and saved as GeoTiff format. Radiometric contained 16bit, spatial resolution 5 m, since Level 3A orthorectified. Each file consist of 5 spectral band. Projection system WGS84 and North Universal Transverse Mercator (UTM), zone 48.

was used, ERDAS IMAGINE and supported ...op.

METHODS

Pre-processing data

Two steps performed during pre-processing data, i.e: color balancing and mosaicking and atmospheric correction.

Color balancing and mosaicking

The color balancing attempts to remove the brightness variations in images before they are mosaicked by assuming the variations can be modeled as a surface. The surface methods used was linear. Meanwhile, the mosaic process offers the capability to stitch images together so one large. Color balancing and mosaicking performed by using one specific and automated module on ERDAS IMAGINE called MosaicPro.

Atmospheric correction

Atmospheric correction executed by using ATCOR2, the ATCOR module which performs the atmospheric correction of satellite imagery over flat terrain. The method was developed mainly for optical satellite sensors with a small swath angle, where the scan angle dependence of the radiance and transmittance functions is negligible. The algorithm works with a database of atmospheric correction functions stored in look-up tables. The database consists of a broad range of atmospheric conditions: different altitude profiles of pressure, air temperature, and humidity; several aerosol types; ground elevations from 0 to 2.5 km above sea level; solar zenith angles ranging from 0° to 70°. The database covers visibilities (surface meteorological range) from 5 km to 120 km, values can be extrapolated down to 4 km and up to 180 km (GEOSYSTEM, 2013).

Classification scheme development

Two classification schemes were used in this study. The first scheme consists of 9 classes of waters body, bareland, local farm (consist of mix crops), mangroves, man-made, shrub, peat forests and rubber plantations. The second scheme consists of three classes, namely non-mangrove (a combinationof first scheme landcover classes excluding mangroves and waters body), watersbody and mangroves.

Intensive field observations conducted throughout the month of September-October 2013 to measure mangrove vegetation. A total of 104 plots spread on mangrove transect Liong River. Field observations of landcover (besides mangrove) carried all the way to transect location.

Spectral reflectance signature

Spectral signatures are the specific combination of reflected electromagnetic radiation (EM) at varying wavelengths which can uniquely identify an object. Those signature developed using mean values of landcover AoI dan plotted on two dimensional graphic.

Separability analysis

Signature separability is a statistical measure of distance between two signatures. To determine whether a particular type of landcover can be identified or discriminated statistically and to find a good combination band then separability analysis was examined. Separabilityapproach used is Transformed Divergent (TD) which expressed by the equation (1) and (2):

$$TD_{ij} = 2000\left(1 - exp\left(\frac{-D_{ij}}{8}\right)\right) \quad (1)$$

$$D_{ij} = \frac{1}{2}tr\left((C_i - C_j)(C_i^{-1} - C_j^{-1})\right) + \frac{1}{2}tr\left((C_i^{-1} - C_j^{-1})(\mu_i - \mu_j)(\mu_i - \mu_j)^T\right) \quad (2)$$

Where:

D_{ij} = Divergence

i and j = two signatures (classes) being compared

Ci = covariance matrix of signature i

μi = mean vector of signature i

tr = trace function

T = transposition function

Separabilities criteria used in this study refers to Jensen (1996),

Separability Value	Description
>1900	Excellent
>17000 - <=1900	Good
<=1700	Inseparable

Contingency Matrix

This evaluation classifies all of the pixels in the selected AOIs and compares the results to the pixels of a training sample. In this evaluation, a quick classification of the sample pixels is performed using the Maximum Likelihooddecision rule. Then, a contingency matrix is presented, which contains the number and percentages of pixels that are classified as expected (ERDAS FIELD, 2012)

Kappa

The Kappa analysis is a discrete multivariate technique used in accuracy assessment to statistically determine if one error matrix is significantly different from another. Kappa analysis has become a standard component of most every accuracy assessment and is considered a required component of most image analysis software packages that include accuracy assessment procedures (Congalton and Green, 2009). Kappa can be calculate by using equation (3).

$$\hat{K} = \frac{n\sum_{i=1}^{k} n_{ii} - \sum_{i=1}^{k} n_{i+}n_{i+}}{n^2 - \sum_{i=1}^{k} n_{i+}n_{i+}} \quad (3)$$

RESULT AND DISCUSSION

Spectra reflectance signatures

Jensen (2007) categorized 4 surface reflectances, vegetation, water, urban and landscape. Based on the categorized peat forest, local farm, mangrove, rubber tree and shrub are in vegetation category; any waters body such as sea waters, rivers waters, shrimp pond waters that are found classed in waters category; any kind of construction and build by the human being such as roads, houses, bridges or any building are classed in urban and landscape category, bareland arranged to soil category. Spectral reflectance signature of each class can be plotted on Figure 1.

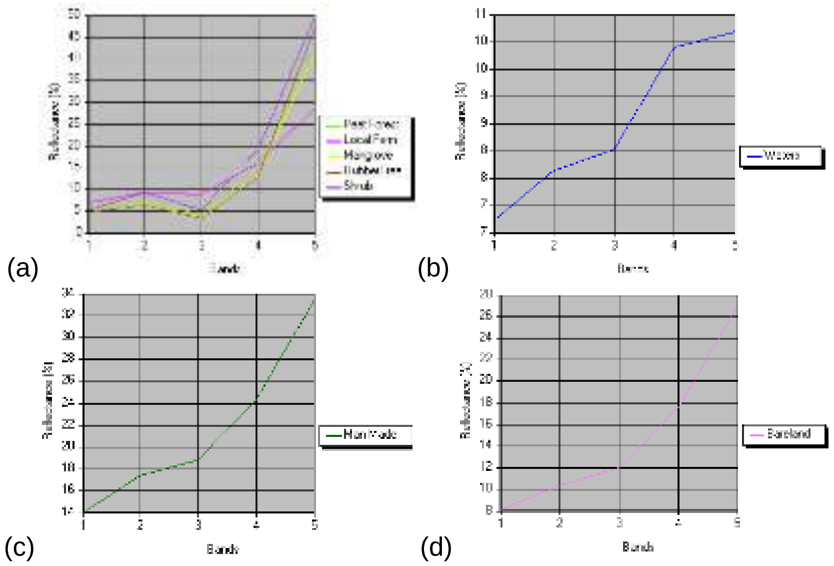

Figure 2. Four type of surface reflectances, (a) vegetations, (b) waters (c) urband and lanscape (d) soil

Signature curvesstartedat blue band and then rise towards the green band then go down slightly to the red band, thenarise again when reflected by the red-edge band and rising sharply at near infrared band, for each type of class vegetation. Large variation reflectance occurredat near infrared band followed by the red-edge, green, red and blue, respectively. Reflectance of visible bands range from 5% to 20%, while for the near-infrared band, providing a high reflectance values ...ear infrared band had a very important role in ...t the elevations or intensities of reflectances of

Water is a good absorber of electromagnetic energy, Figure 2 shows that most of the energy is absorbed and reflected back only a small fraction (between 6 -11%) and the near infrared band has a good response, indicating that the band is very sensitive to separate objects containing water and non-water. Categories of urban or landscape and soil reflectance have similar trend spectral signature. However, the value of urban objects has a higher reflectance value than the soil one (soil around coastal areas are always affected by tidal phenomena).

Furthermore, this research found a similarity of reflectance on three classes vegetation landcover: peat forest, mangroves and gum trees (Figure 3). It is hard to distinguish these three classesfrom one another, but at near infrared band there are significant differences between the three. While mangrove and peat forests have similar reflectance value at near infrared band and difference at visible band.

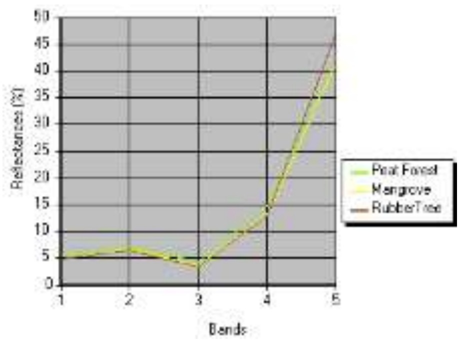

Figure 3. Mangrove among the similiar landcover surface reflectance, peat forest and rubber tree

Similarity is due to be affected by the influence of neighbor objects which are located around the classes such as soil and water and mixed with existing vegetation on it and this accumulation contribute on reflectance values are almost similar to the presence of mangroves. The first landcover classification scheme was found similarities between the spectral reflectance of landcover categories even between classes in one category. These problems are not found in second landcover classification scheme that consists of only three classes only, namely water, mangrove and non-mangrove (Figure 4). Significant difference was seen between the three classes so that it can be easily distinguished.

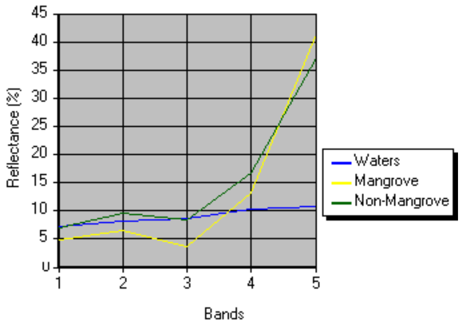

Figure 4. Surface reflectance of threelandcover classes

Spectral Separability

This study tested the combination of a number of bands started at two bands were usedto whole bands. The combination band total tested were 26 (Table 2). The first landcover scheme, RapidEye has not been able to separate all landcover classes with status Excellent (E). Most 24 class pair are separated by a combination of 2 and 3 bands: 2.5, 3.4; 1,2,5; 1,3,4 and 2,3,5. The average separability RapidEye bands on first landcover classification scheme was at Good status (1802.54), while the best accuracy is achieved by a 5 band combination: 1,2,3,4,5 although the separability tend to decreased to 17 classes.

Table 2. Combinationand numbers of band separability of landcover scheme

Band combination	Number of bands	1	2	1	2	1	2	TD average[1]	TD average[2]	Kappa[1]	Kappa[2]
1,2	2					1		1,789.16	1,922.59	0.44	0.38
1,3	2					0		1,644.47	1,987.25	0.37	0.24
1,4	2					2		1,855.95	1,995.51	0.49	0.44
1,5	2	1				4		1,448.69	1,997.08	0.48	0.38
2,3	2					3		1,833.39	1,980.67	0.48	0.35
2,4	2					9		1,764.68	1,989.82	0.48	0.45
2,5	2					**4**		1,846.46	1,999.91	0.54	0.45
3,4	2					**4**		1,867.31	1,999.98	0.5	0.48
3,5	2					1		1,798.50	1,999.91	0.51	0.45
4,5	2					6		1,664.36	1,995.35	0.56	0.49
1,2,3	3					3		1,830.20	1,973.78	0.5	0.4
1,2,4	3					3		1,826.67	1,998.44	0.52	0.45
1,2,5	3					**4**		1,860.03	**1,999.99**	0.56	0.43
1,3,4	3					**4**		1,869.70	1,999.98	0.54	0.47
1,3,5	3					1		1,793.97	1,999.61	0.54	0.44
1,4,5	3					3		1,896.13	1,998.62	0.61	0.5
2,3,4	3					2		1,810.06	1,999.56	0.55	0.47
2,3,5	3					**4**		1,870.85	1,999.56	0.57	0.43
2,4,5	3					0		1,825.37	1,999.91	0.62	0.43
3,4,5	3					3		1,882.92	1,992.20	0.59	0.49
1,2,3,5	4					2		1,845.48	1,982.66	0.58	0.47
1,2,4,5	4					2		1,853.62	1,998.73	0.63	0.45
1,3,4,5	4					3		1,896.13	1,998.36	0.63	**0.52**
2,3,4,5	4					8		1,795.17	1,989.05	0.64	0.49
1,2,3,4	4					0		1,754.68	1,955.59	0.56	0.5
1,2,3,4,5	5					7		1,742.10	1,877.78	**0.64**	0.49

Where
I = Inseparable
G = Good
E = Excellent
TD = Transformed Divergence
1, 2 = denote scheme classification

The second landcover classification schemes have dissimilarresults, RapidEye may separate the three classes of landcover. Three band combinations only which were not able to separate the pair of landcover classes: 1,2; 1,2,3,4 and 1,2,3,4,5 . The average separability value of RapidEye bands are at Excellentstatus (1.985.84). Best accuracy is obtained by band combination 1,3,4,5 are able to separate the whole class with a Kappa value of 0.52.

Training areas were used on the first classification scheme have not been able to separate the mangrove class with other classes. Every band that used a combination of at least two classes remaining inseparable particular class of peat forests and rubber plantations. Other combinations showed that mangroves could not be separated by water, agriculture, bareland, and shrubs, but their appearanceswere not found in every band combination used. The inability was caused by the [illegible], as previously described (Figure 3). While the [illegible]essfully separating mangrove with other class

CONCLUSION

RapidEye has not been able to separate the 8-class classification scheme with Excellent status, when classes reduce (3 classes) it gave promising result.

RapidEye has not been able to separate the mangrove classes with peat forests and rubber plantations classes since they have similar spectral reflectance. To increase separability, the use more spectral band is not a necessity.

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