A STUDY ON THE POTENTIAL OF APPLYING MODERATE RESOLUTION IMAGING SPECTRORADIOMETER (MODIS) FOR DETECTING LAND COVER CHANGE IN THE MEKONG DELTA

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ABSTRACT

The change of land cover can be a result of certain natural or human-made disaster such as flood, drought, forest fires, etc. In turn, information about the current status and trends of change of land cover and land use is needed for the managers and decision makers to establish the appropriate and optimal policies in planning, development, disaster mitigation, and other social-economic activities. Remotely sensed data has proven to be an effective mean for this purpose. Previous studies using medium resolution imageries of Landsat, SPOT and others have shown some limits, such as the acquiring cycle is long (Landsat: 16 days, SPOT: 26 days) and the coverage is not adequate for large area study. The MODIS data, which can be acquired daily, with 36 spectral bands in three different spatial resolutions, 250m, 500m and 1000m, are ideal for monitoring land cover change in wide regions in association with natural events. This study focus on using the two bands Red and Near Infrared of MODIS 250m for monitoring vegetation cover change, applied to the Mekong delta in South Vietnam. Data acquired in time series hence can be use to monitor the vegetation cover of this region and more useful information can be derived from it.

1. INTRODUCTION

Mekong delta is a large area in South Vietnam (Figure 1) including 13 provinces. This area produces the highest quantity of rice crop, vegetable and fruit. Therefore it is very sensitive to the change of environment caused by nature events (burning, flooding…) and human activities (deforestation, urbanization). To detect that changes, in the past the satellite data like Landsat, Spot etc. were used with some limitation mainly in the acquiring cycles and the size of scenes. In 2001, the launch of EOS AM-1 platform with the cost-effective Moderate Resolution Spectroradiometer (Modis) data has overcome those difficulties. With the time series data, the land cover change product could help the environmental manager in making timely

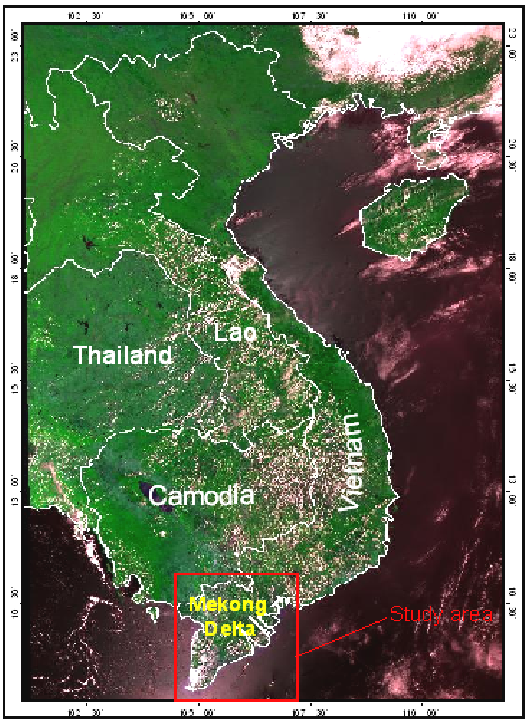


Figure 1. The study area

decision. The main purpose of this study is to exploit the potential of Modis data in this aspect.

Within 36 spectral bands of Modis, our study focuses in two bands: band 1 (Red 620-670nm) and band 2 (Near-Infrared 841-876 nm), which is very suitable to detect land cover in large area.

The method of analyzing change vector of (X. Zhan et al. 2000) is applied. It was used successfully in many countries in the world. This report will also show the some early results in this direction.

2. DATA SOURCE

Two dates of Modis satellite images were collected and used in this study. They are acquired in 24/12/2001 and 01/02/2002 (Figure 2)

Modis data are received from the Modis instrument onboard NASA'TERRA satellite via its scanning radiometer system with 36 spectral bands extending from the visible to the thermal infrared wavelengths (*Running et al. 1994*) with resolutions 250m (band 1,2); 500m (band 3 to 7); 1000m (band 8 to36). However, two bands (Red and Near-Infrared) – 250m resolution are used because they are the most suitable for detect land cover especially the vegetation.

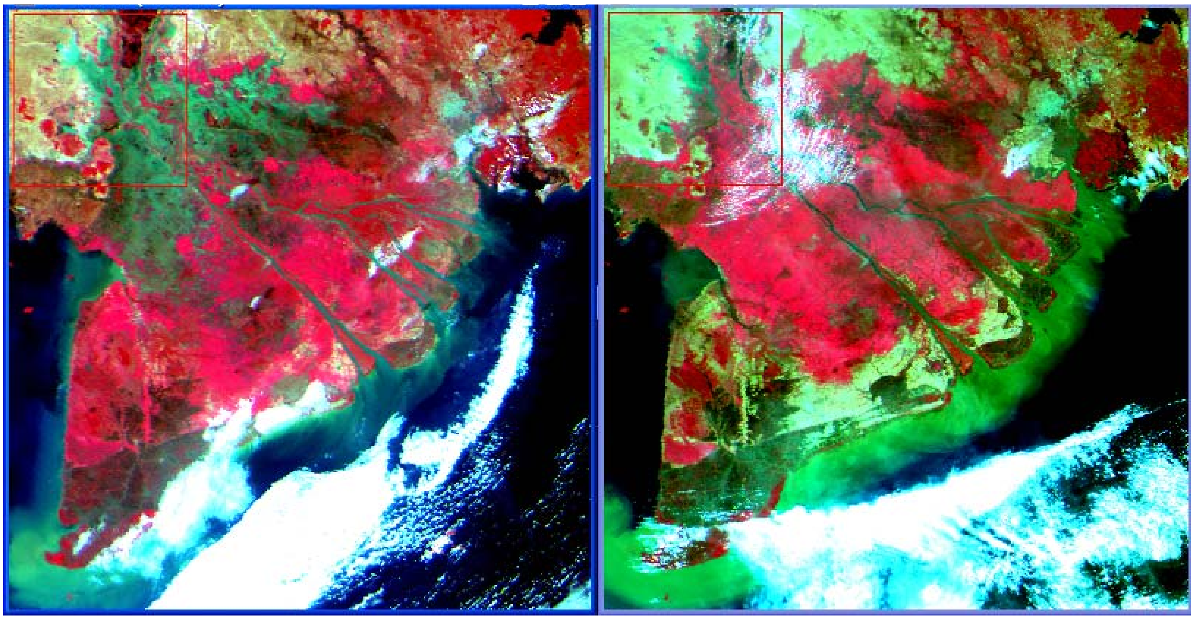


Figure 2 a. Modis -324-24/12/2001 **b. Modis-324-01/02/2002**

3. SOME EARLIER RESULTS

There are several methods to study vegetation cover. They mostly use two bands: red and near-infrared.

3.1 NDVI (Normalized Difference Vegetation Index)

The most popular formula to compute NDVI involves the ratio of the NIR (Near-Infrared) and Red band:

$$NDVI = \frac{NIR - RED}{NIR + RED} \tag{1}$$

3.2 TVI (Transform Vegetation Index):

It is the NDVI enhanced formula to remove the negative value in NDVI

$$TVI = (NDVI + 0.5) * \sqrt{\left|\frac{NDVI + 0.5}{NDVI + 0.5}\right|} \tag{2}$$

NDVI, TVI are good in measuring vegetation. Through this value, people can know the "healthiness" and age of the vegetation. Besides, they are also used to reduce the affect of cloud and atmospheric attenuation.

3.3 EVI (Enhanced Vegetation Index, *Heute 1999*)

This formula can correct the Raleigh scattering and ozone absorption:

$$EVI = G * \frac{NIR - RED}{NIR + C1 * RED - C2 * BLUE + L} \tag{3}$$

where for Modis data the parameters are

BLUE, RED, NIR: blue, red, nir reflectance
C1= 6 : Atmosphere resistance red correction coefficient
C2 = 7.5 : Atmosphere resistance blue correction coefficient
L = 1 : Canopy background brightness correction factor
G= 2.5 : Gain factor

4. METHODOLOGY

Modis satellite images have large viewing swath width (2300km) so that cloud influence is often high. In experience, the cloud can be reduced by removing pixels having reflectance band1 (Red) > 20% (Figure 3)

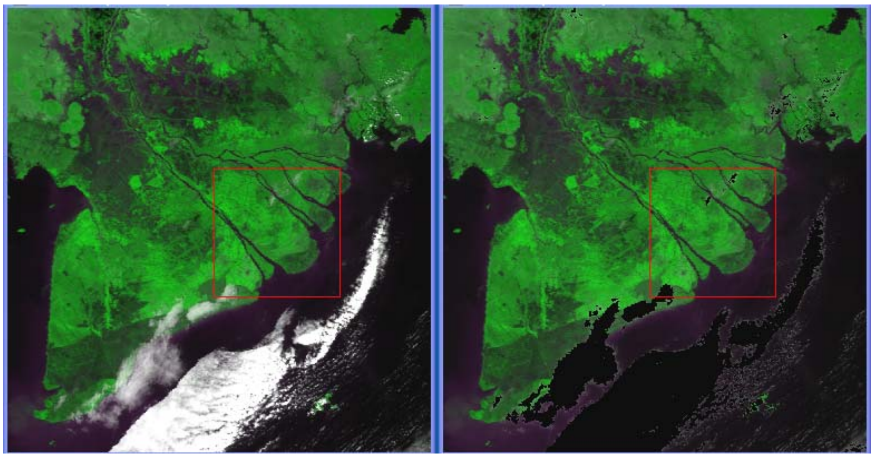


Figure 3. Modis data before and after cloud removal

The change detection method in association with the most common landcover types used in this study is showed in Table 1:

Table 1. Common land cover changes in the study area

		TIME 2			
		Forest	**Non-forest**	**Bare**	**Water**
TIME 1	**Forest**	-	Deforestation	Deforestation	Flooding
	Non-forest	Forestation	-	Urbanization	Flooding
	Bare	Forestation	Growing vegetable, paddy or bush	-	Flooding
	Water	Flood trace	Flood trace	Flood trace	-

We have used the methods of (X,Zhan et al) for detecting the land cover change. It was used successfully in change detection about flood in Cambodia, Laos and Thailand; deforestation in Brazil; fire in New Mexico (*X.Zhan 2002*).

The 4 methods will be briefly recalled here

4.1 The Red-NIR space partitioning method

First we use the red-nir space (Figure 4) to convert the Modis image into 5 types of cover: forest, bare, water, non-forest and mixture, then a Look-Up Table (Table 2) and a decision tree, classifies are used.

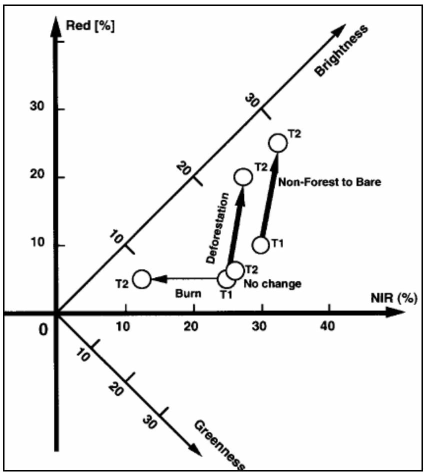


Figure 4. Red-Nir space

Table 2. LUTs to classification the land cover

Reflectance Value	**Forest**	**Non-forest**	**Water**	**Bare**
Red band (%)	7.8–9.6	10–13	6 – 13	14 - 20
Nir band (%)	29–37	35–50	0 – 20	20 - 35

4.2 The Red-NIR space change vector method

The same Red-NIR space is used for calculating the vector change from time 1 to time 2 (Figure 5)

Magnitude A and direction θ are calculated by the following equations:

$$\Delta\rho_{Red} = \rho_{Red2} - \rho_{Red1} \qquad A = \sqrt{((\Delta\rho_{Red})^2 + (\Delta\rho_{NIR})^2)} \tag{4}$$

$$\Delta\rho_{NIR} = \rho_{NIR2} - \rho_{NIR1}$$

$$\theta_0 = \arctan\left|\frac{\Delta\rho_{Red}}{\Delta\rho_{NIR}}\right| \tag{5}$$

where

$\theta =$

θ_0	if $\Delta\rho_{Red} \geq 0$ and $(\Delta\rho_{NIR}) > 0$
90^o	if $\Delta\rho_{Red} > 0$ and $(\Delta\rho_{NIR}) = 0$
$180^0 - \theta_0$	if $\Delta\rho_{Red} > 0$ and $(\Delta\rho_{NIR}) < 0$
$180^0 + \theta_0$	if $\Delta\rho_{Red} \leq 0$ and $(\Delta\rho_{NIR}) < 0$
270^o	if $\Delta\rho_{Red} < 0$ and $(\Delta\rho_{NIR}) = 0$
$360^0 - \theta_0$	if $\Delta\rho_{Red} < 0$ and $(\Delta\rho_{NIR}) > 0$

LUT values relating to A, θ, red^{T1}, nir^{T1}, red^{T2}, nir^{T2} in Table 3 are used to calculate the change of land cover and the result is showed in *Figure 6(b).*

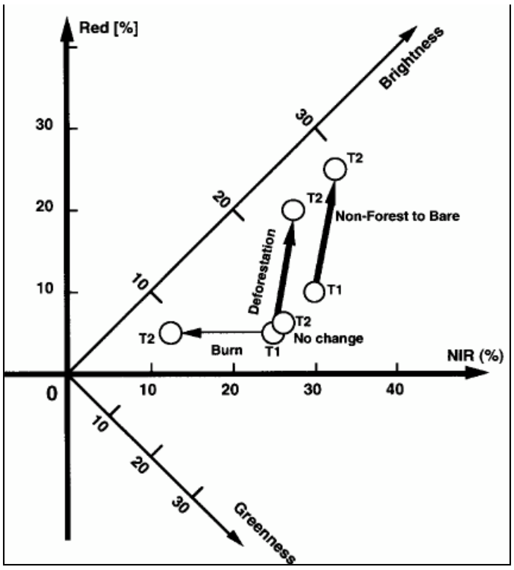


Figure 5. Red-NIR space and brightness-greeness space show changes of land cover

Table 3. LUTs show the range to detect the change

Water to Forest	**Water to non-forest**	**Non-forest to Bare**	**Non-forest to water**	**Forest to non-forest**	**Forest to Bare**
A > 30% and (θ > 340° or θ < 10°) and (red^{T2} < 9.5% and nir^{T2} > 25%)	A > 30% and (θ > 340° or θ < 10°) and red^{T2} > 9.5%	A > 11% and 80°<θ<160° and red^{T1}<9.5 and nir^{T1}< 30	A >10 and 160 < θ <250 and 38 < nir^{T2}< 50	A < 10% and (θ < 10 or θ > 350) and nir^{T1}> 20	A > 11% and 80° < θ<160° and red^{T1}< 9.5 and nir^{T1}> 30 and nir^{T1}< 35

4.3 The modified delta space threshold method

This method depends on delta-red and delta-nir space which presents the difference between time 1 and 2 (Figure 6). Its advantage is to reduce of difference reflectance caused by the seasonal deviation. The following Equation is used

$$\begin{aligned}\delta\rho_{\mathrm{Re}d} &= \Delta\rho_{\mathrm{Re}d} - (M_{\mathrm{Re}d2} - M_{\mathrm{Re}d1}) \\ &= \rho_{\mathrm{Re}d2} - \rho_{\mathrm{Re}d1} - (M_{\mathrm{Re}d2} - M_{\mathrm{Re}d1}) \\ \delta\rho_{NIR} &= \Delta\rho_{NIR} - (M_{NIR2} - M_{NIR1}) \\ &= \rho_{NIR2} - \rho_{NIR1} - (M_{NIR2} - M_{NIR1})\end{aligned} \quad (6)$$

where:
M_{red1}, M_{red2}, M_{nir1}, M_{nir2} are the average reflectance values in Red, Nir band in time 1 and time 2.

The magnitude A and direction θ are calculated as in equations (4), (5)

The cover change will then be classified by the LUT in Table 4.

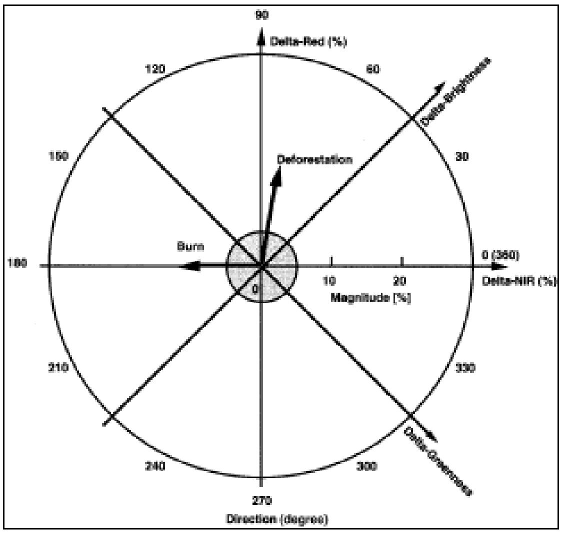


Figure 6. Delta spaces

Table 4. LUTs for the method delta space threshold

Water to Forest	Water to non-forest	Forest to Bare
A > 60%	A > 60%	25% < A < 50%
& θ >350° &	& θ >350°	& 160°<θ<176°
red^{T2} > 9.5%		

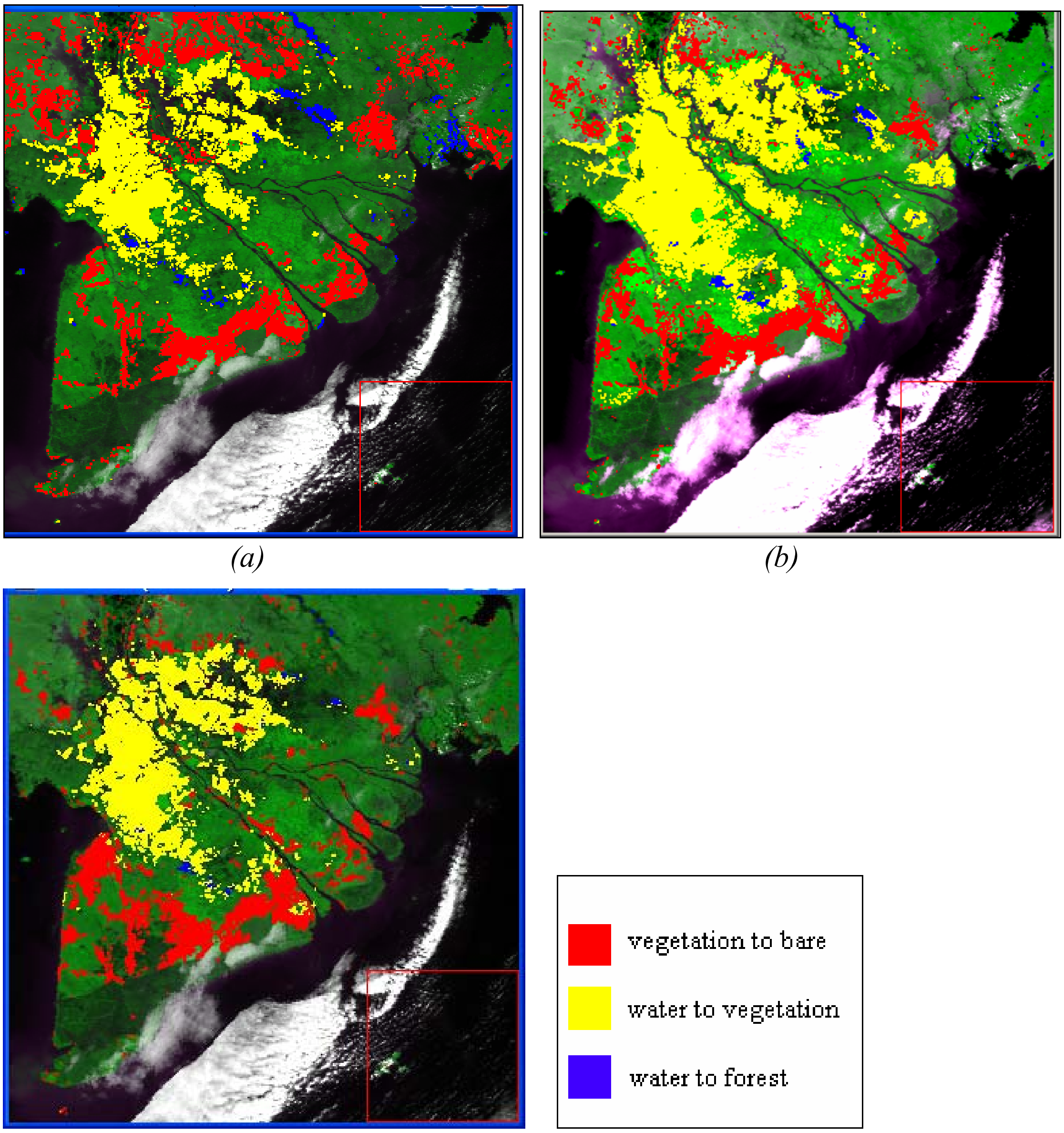
4.4 Changes in linear features

This method depends on the change of the linear feature such as roads, electric lines, gas lines. First the reflectance spectral are enhanced to recognize the linear features in the satellite image by various filterings. After that, features in time 1 and time 2 are extracted and compared, and we can detect where the linear features appeared and disappeared.

For the data in this study of Mekong delta there was not any remarkable changes in linear features, as the period between the two dates are quite short.

5. RESULTS

Figure 6 shows the result of applying three methods mentioned above for Modis satellite images. A large area of the Mekong delta had cover change from water to forest and non-forest, and from non-forest to bare. That is due to seasonal change. The time 1 (24/12/2001) is in the flood season in Vietnam Mekong delta so Can Tho, An Giang, Dong Thap provinces are in water. The change from water to forest and non-forest is just the flood trace. The change from non-forest to bare land is not urbanization (because the short period between two dates is only 2 months), rather it is the result of rice field after harvesting.



(a) *(b)*

(c)

Figure 7. Results of cover change detection of the Mekong on MODIS imagery
(a) From the Red-NIR space partition method
(b) From the Red-NIR space change vector method
(c) From the Modified delta space threshold method

Differences in change detection results can be seen in Figure 7. These could be analysed by ground data or from higher resolution images to locally assess the accuracy. However, the scope of this paper is limited to current level and we would like to leave this task to a further study.

6. DISCUSSIONS

This study is in the first step to apply the techniques in (X.Zhan et. al. 2002) for Modis satellite data. It is a good way for mapping land cover changes in wide area like the Mekong. Modis data is available at a daily frequency which is quite reasonable for monitoring purposes. In rainy season, radar imagery would be a good complement for Modis in this study. A semi-automatic processing software tool may be very useful for analysing time-series data using these techniques. The results of this study could help decision makers in natural resouces management, disaster mitigation and regional planning at a macro level, in the sense that the cover change could reveal "hot spots" in the images. Detail study of these spots in question would then follow for an in-depth analysis that could provide the managers with more appropriate strategies or decisions. Ground truthing should also be accomplished to improve the accuracy.

7. REFERENCES

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