COMPARISON OF ROW CHANNEL AND PHYSICAL INDEX CHANNEL CLASSIFICATION OF ASTER IN URBAN CHANGE DETECTION. THE CASE OF THANH TRI DISTRIC IN SUBURB OF HANOI, VIETNAM

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ABSTRACT

The advantage of ASTER data is its finer spatial resolution and its large number of spectral channels ranging from Visible Near Infrared VNIR, Short Wave Infrared SWIR up to Thermal Infrared TIR. This paper presents some results of a test aiming to maximize the use of all the channels for information extraction in the urban and suburb of Hanoi and for change detection of land cover in both study areas Hanoi between the 2 dates of acquisition: 29 September 2001 and 13 January 2003.

Due to the complex land cover characteristics of Hanoi the spectral confusion in the image is enormous obstacle of the classification based only on the most used channels in VINIR spectrum. It is necessary therefore, to select the most suitable channels for mapping the land cover in the suburb area. Thanks to their finest spatial resolution the VNIR channels are analyzed first to establish a reference for others channels analysis. The SWIR channels are tested for two purposes: combination in classification with VNIR channels and also for mono-channel segmentation of the constructed objects. The District Thanh Tri of Hanoi is selected as a pilot site.

As the land cover in the studied area is characterized by a complex intercalation between different types in small area the spectral confusion must very large. In this test different indices such as Vegetation Index (NDVI), index of brightness (IB) and Urban Index (UI) are computed to be used in classification to extract different land cover type with higher accuracy. The results of these classification are then used for change detection of urban sprawl in the studied sit.

1. INTRODUCTION

1.1 Urban Development Context of Hanoi

Now a days, urbanization is considered as one of many ways in which humans are altering the land cover of the globe. Most of these landscape transformations occur within a regional context, but the specific, year-to-year changes occur at local scales, often distributed in a seemingly random pattern (Masek et al., 2000). More than teen years after the New Economy Policy of Vietnam called Doi Moi has been introduced into to the life, Hanoi is now under an increasing pressure of population growth in which the urban population becomes predominant and the rural population is reduced progressively. This demographic change is causing important land use changes in the peri-urban areas of Hanoi and in its turns this latest is the reason of different socio-economic and environmental problems (Pham Van Cu et al. 2002). The

authorities of Hanoi are strongly interested in how to monitor these changes in urban and peri-urban areas and this issue is therefore becoming a pressing research need.

1.2. Characteristics of remote sensing data and application potential

Recently, remote sensing data present an evident interest in efficiently responding to different objectives including the observation and modelization of urban space (Weber, 1995). However, monitoring of urban expansion is not an easy exercise because of the lack of information in the past. The time series of remote sensing data covering the a certain period observation can fill up this lack (Shigenobu Tachizuka et al., 2002). On the other hand, in a circumstance where the rate of cultivating area is decreasing because of the increase of industrial land use and remarkable trend of city sprawl to urban and peri-urban agricultural areas a time series of remote sensing data can provide excellent possibility of detecting the land cover changes in this area.

In our study ASTER data are used for a simple reason: the advantage of ASTER data is its finer spatial resolution and its number of spectral channels ranging from Visible Near Infrared VNIR, Short Wave Infrared SWIR up to Thermal Infrared TIR as shown in table 1.

Due to the complex land cover characteristics of Hanoi the spectral confusion in the image is enormous obstacle of the classification based only on the most used channels in VINIR spectrum. It is necessary therefore, to select the most suitable channels for mapping the land cover in the suburb area. Thanks to their finest spatial resolution the VNIR channels are analyzed first to establish a reference for others channels analysis. The SWIR channels are tested for two purposes: combination in classification with VNIR channels and also for mono-channel segmentation of the constructed objects. The District of Thanh Tri (fig. 1) is selected as a pilot site for Hanoi.

Table 1: 14 Spectral channels of ASTER

Spectral channel	Spectral range	Spatial resolution	Dynamic range	Comment
1 (Visible Green)	0.520 to 0.600um	15m	8 bit integer	Near Infrared has 2 channels (3B and 3N) which are stereo pair images from which DEM can be generated. Orbit: 705km, 10:30am descending node, Sun-synchronous Swath=60x 60 km
2 (Visible Red)	0.630 to 0.690um	15m	8 bit integer	
3 (Near Infrared)	0.760 to 0.860um	15m	8 bit integer	
4 (SWIR)	1.60 to 1.70um	30m	8 bit integer	
5 (SWIR)	2.145 to 2.185um	30m	8 bit integer	
6 (SWIR)	2.185 to 2.225um	30m	8 bit integer	
7 (SWIR)	2.235 to 2.285um	30m	8 bit integer	
8 (SWIR)	2.295 to 2.365um	30m	8 bit integer	
9 (SWIR)	2.36 to 2.43um	30m	8 bit integer	
10 (TIR)	8.125 to 8.475um	90m	12 bit integer	
11 (TIR)	8.475 to 8.825um	90m	12 bit integer	
12 (TIR)	8.925 to 9.275um	90m	12 bit integer	
13 (TIR)	10.25 to 10.95um	90m	12 bit integer	
14 (TIR)	10.95 to 11.65um	90m	12 bit integer	

Selection of Study Zone

The pilot is selected base don the following criteria:

- High rate of urbanization
- Land cover types are representative for Hanoi
- Available of ground truthing information

Thanh Tri District has been selected according to the listed criteria with the geolocation as bellow:

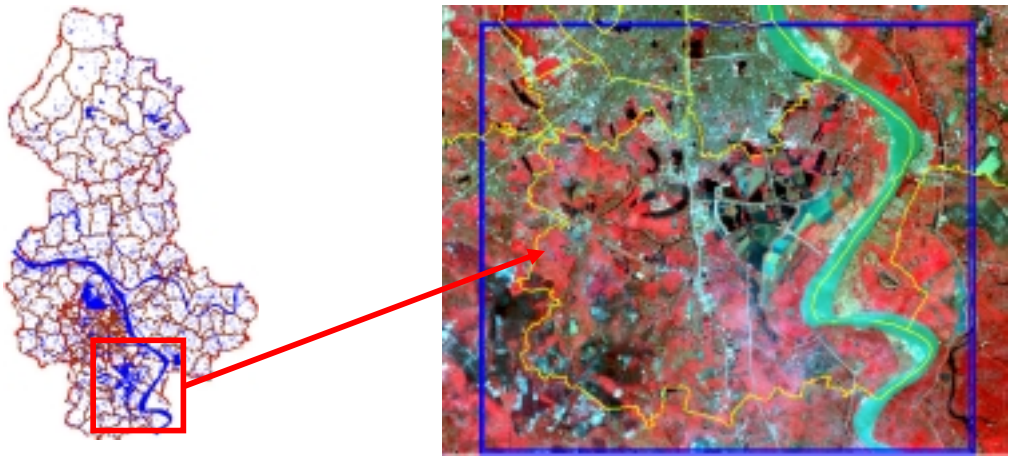


Figure 1: Pilot Site, Thanh Tri District of Hanoi (Color Composite ASTER 13/1/2003)

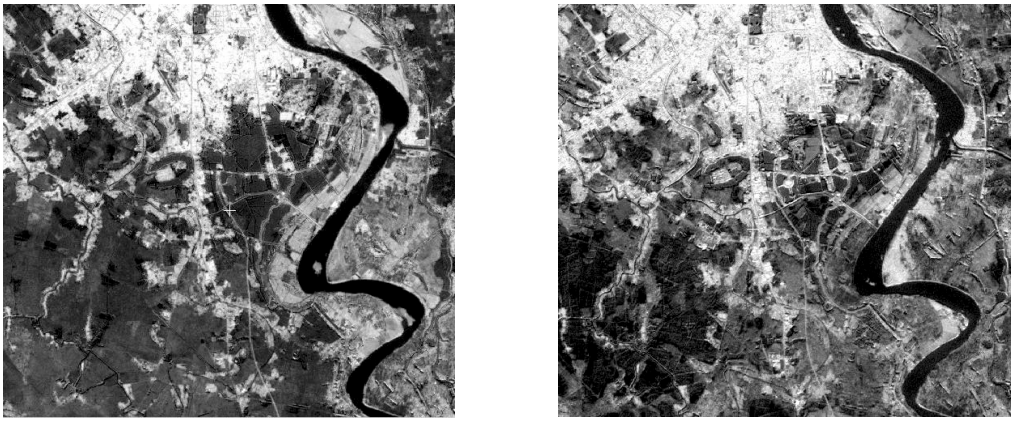
New Channel Creation:

As the land cover in the studied area is characterized by a complex intercalation between different types in small area the spectral confusion must very large. As experiences show different index can be established to extract different land cover type with higher accuracy than using the original channels. In this study, we try to use NDVI (Masek et al, 2000), Index of Brightness (IB) and Urban Index (UI) for the classifications of two set of data 29 September 2001 and 13 January 2003 (see fig.2, 3 and 4). The UI we are using in this study is adopted from those applied for ETM data as bellow:

The channel B_4 in this formula is replaced by channel VNIR 3 an relatively the B_7 by channel

$$UI = \left(\frac{B_7 - B_4}{B_7 + B_4} + 1.0 \right) * 100$$

SWIR6 of ASTER due to their approximate wave length.



UI of 29 September 2001 **UI of 13 January 2003**

Figure 2: Urban Index of Hanoi area of 2 acquisition dates

NDVI is frequently used in vegetation cover classification however Masek et al (2000) also apply it to minimize the confusion of urban object and agriculture land while Kawamura et al. (2003) consider that the Urban Index UI can be used to quantitatively evaluate the urban extending. To establish the UI, 2 channels ETM 4 and ETM7 of Landsat are used. In our study we replace the channel ETM7 by the SWIR channel of ASTER ranging from 2.185 to 2.225µm (SWIR 6). This channel is resized to 15m to fit the spatial resolution of VNIR 3 (0.760 to 0.860um) which is used for UI calculation. The results of these classification are then used for change detection.

Unsupervized Classification:

K-Mean algorithm is used for unsupervised classification of 2 set of combinations: 1) only 3 VNIR channels and 2) 3 VNIR plus Index Channels (NIDVI, BI and UI). As the comparison presented on the tab. 4 and 5 shows the classification of NDVI, BI and UI together with the 3 VNIR channels give higher class separabilties (tab. 2) especially the residential form the others land cover types unless the upland culture classes due to their close values in all the Index Channels.

Table 2: Class separability of two set of Classification

Class Separability within VNIR		Class Separability within VNIR+Index Channels	
Average Separability:	1.927422	Average Separability:	1.974062
Min. Separability:	1.379269	Min. Separability:	1.709840

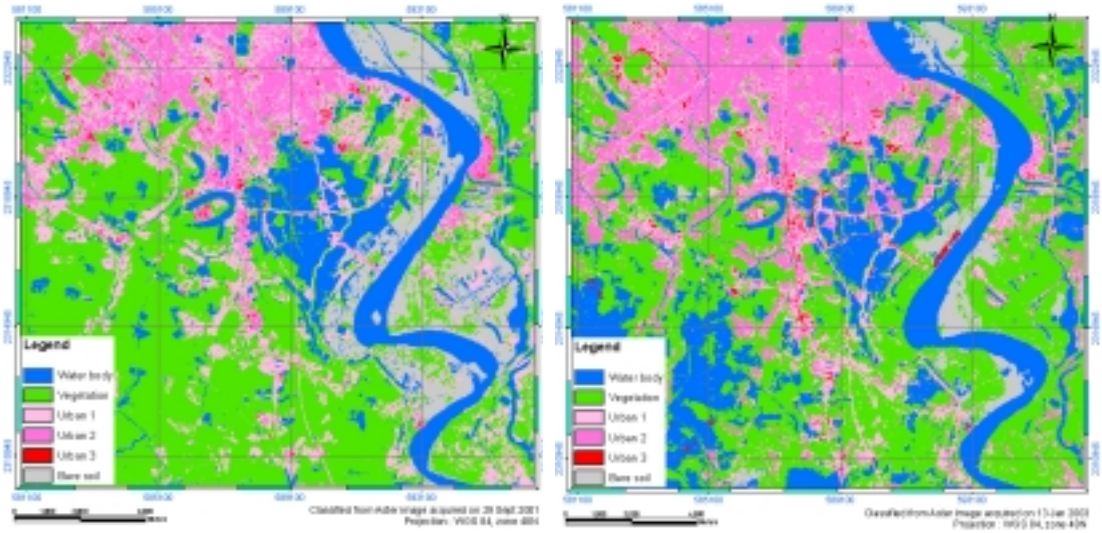
To separate the upland culture from residential and urban classes we segmented the upland cultures and used them as a mask for the overall image classification. The unsupervised classification with 9 classes primarily fixed (table 3) has been tested. In fact, some classes are not meaningful having no pixel assigned to. We have to regroup these 9 classes into only 6 classes (tab. 4). The classification results are shown in figure3.

Table 3: Primarily classes

Image 29 Sep. 2001			*Image 13Jan. 2003*		
Primarily fixed Class	*Regrouped*	*code*	*Primarily fixed Class*	*Regrouped*	*code*
Class-01	Water	1	Class-01	0 pixel	
Class-02			Class-02	0 pixel	
Class-03	Vegetation	2	Class-03	0 pixel	
Class-04	Urban 1	3	Class-04	Water	1
Class-05	Urban 2	4	Class-05	Vegetation	2
Class-06	Urban 3	5	Class-06	Urban 2	4
Class-07			Class-07	Urban 1	3
Class-08	0 pixel		Class-08	Urban 3	5
Class-09	Urban 3	5	Class-09		
Mask	Bare Soil	6	Mask	Bare Soil	6

Table 4: New regrouped classes and their contain description

code	Name_classe	Description
1	Water	River, Ponds, Lakes
2	Vegetation	Paddy, Upland Culture, Vegetables
3	Urban 1	Urban, Villages mixed with orchard
4	Urban 2	Urban and concentrated Residential
5	Urban 3	Under construction
6	Bared Soil	Fallow, Sandy Bars, River Islands

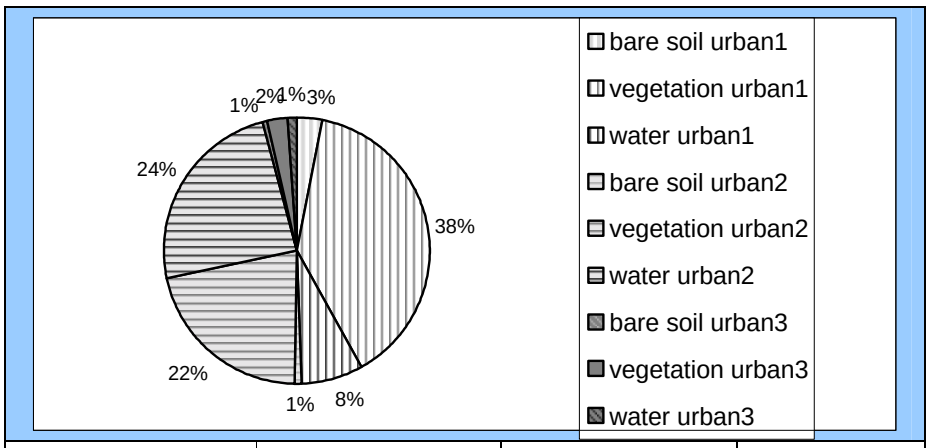


Classification of 2001 Image Classification of 2003 Image

Figure 3: Classified images of Thanh Tri District

Change Detection Evaluation

Crossing 2 classified images of 29 September 2001 and 13 January 2003 give the changes in urban area of Thanh Tri District. As mentioned, the main objective of image processing in this study is to evaluate the changes in urban land therefore others non-urban objects are rejected from the classification. The composition of the changes is presented in figure 9.



land_cover Sep. 2001	land_cover Jan. 2003	Number pixels	AREA (m2)
bare soil	urban1	2452	551700
Vegetation	urban1	30176	6789600
Water	urban1	5854	1317150
bare soil	urban2	610	137250
Vegetation	urban2	16767	3772575
Water	urban2	18767	4222575
bare soil	urban3	528	118800
Vegetation	urban3	1786	401850
Water	urban3	928	208800

Figure 4: Changes composition

CONCLUSION

During the period between 2001 and 2004 the changes in Land cover of Thanh Tri District can be described by the following features:

- The vegetation cover is mainly replaced by the classes Urban 1 and Urban 2
- Water surface disappeared and on their places we observe all 3 Urban classes
- However the pixel population others classes changed to Class Urban 3 is not important showing that there is no important development of new building (Class Urban 3)
- The changes take place even inside the urban area. Many pixels of Class Urban 1 in 2001 become Urban 2 in 2004 showing the increasing of house density. In contrary many pixels of Class Urban 2 in 2001 become Class Urban 1 in 2004 showing the decreasing of small houses giving the space to larger houses.
- The extension of Class Urban 3 shows the increasing tendency in the development of new residential construction in Thanh Tri.
- The most changed areas of Thanh Tri are situated in the South of the district due to the availability of land resource. In contrary, the changes of smaller size are situated in very scattered pattern.

The combination of VNIR channels with Index Channel such as NDVI, BI and notably UI give the best results for classification of urban objects in Thanh Tri District and is promising for urban sprawl monitoring in such mosaic and complicated land cover context as that of peri-urban area of Hanoi.

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