

SATELLITE IMAGERY IN THE STUDY OF NATURAL RESOURCES AND ENVIRONMENT OF THE RED RIVER DELTA, VIETNAM

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ABSTRACT

This paper presents some results of the application of optical satellite imagery to study natural resources and environment in the Red River Delta, Vietnam. It resulted from the need to better understand and manage spatial and temporal changes associated with natural resources and environment of the area for sustainable development. The study areas covered both urban and suburban districts in the delta. The satellite data used include Spot digital imagery taken on different dates between 1986 and 1995. With the aid of digital image processing and GIS techniques, presence and variations in extent and condition of different major classes of land use/land cover in the study area were detected and analyzed. The utility of the data and analysis techniques was demonstrated. Further studies are required to take full advantage of digital satellite imagery in providing timely and reliable information for wise management of natural resources and environment in the delta in the years to come.

1. INTRODUCTION

The Red River is one of the largest rivers in Asia. Its delta plays an important role in the socio-economic development of Vietnam. Therefore, natural resources and environment in the delta need to be properly planned and managed. This calls for the integrated collection and analysis of different types of data. Satellite images are synoptic and repetitive data that can be taken with sensors mounted on artificial satellites. They truly represent historical records containing rich spatial information on earth resources and environment that can and should be extracted using various techniques of visual interpretation and digital image processing.

In this paper, the author describes the use of optical satellite imagery, digital image processing and GIS techniques to derive useful information on natural resources and environment in two selected areas of the Red River Delta. The highlighted value of the data and analysis techniques provides a strong basis for further applications to support future regional development decisions.

2. STUDY AREA

The Red River Delta is located in the SE part of North Vietnam (Fig. 1).

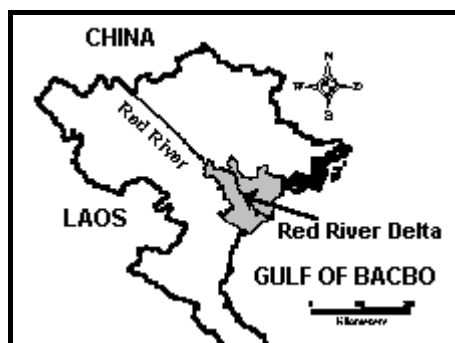


Figure 1. Location of the Red River Delta

In the delta, two study areas were selected based on their reported rapid changes and availability of digital satellite imagery and reference data. These are called the Sontay and Hanoi areas representing the top and centre of the Red River delta respectively. Sontay is a town of Hatay province while Hanoi is the capital of Vietnam. They are about 60 km apart. Both areas are characterized by abundant water resources, tropical climate and fertile soils deposited inside and outside the Red River dike. However, there are differences between these areas in terms of the Red River characteristics such as water level and suspended sediment concentration. The mean water level of the Red River at Sontay is always higher than that at Hanoi (Fig. 2).

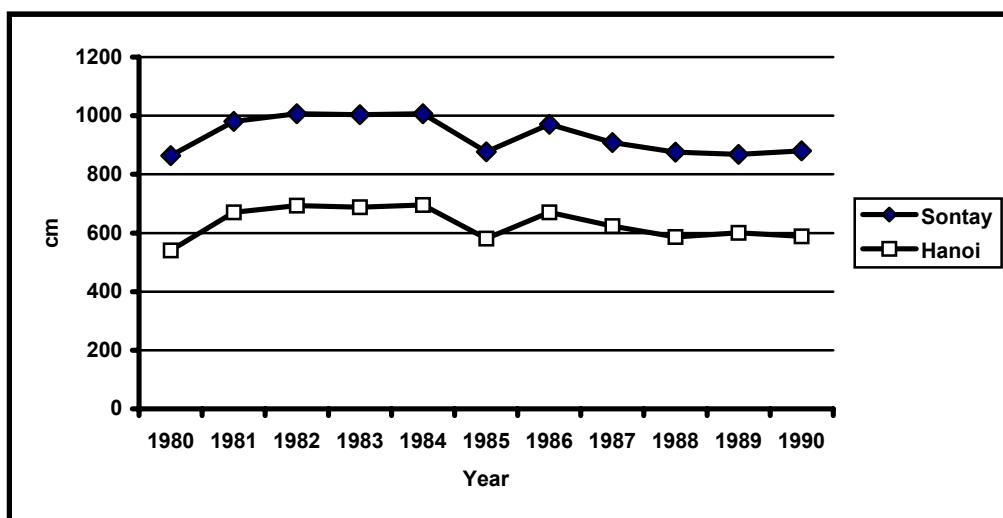


Figure 2. Mean water level of the Red River at Sontay and Hanoi in October, 1980-1990

(Source: Binnie *et al.* 1994)

The suspended sediment concentration in the Red River water at Sontay is generally higher than that at Hanoi (Fig. 3).

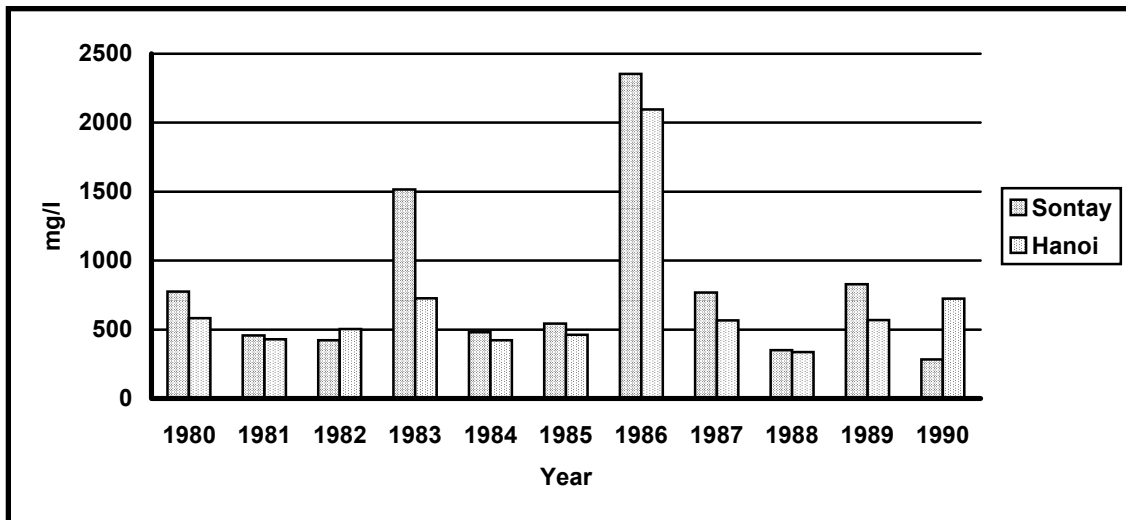


Figure 3. Mean suspended sediment concentration of the Red River water in October at Sontay and Hanoi, 1980-1990 (Source: Binnie *et al.* 1994)

The use of satellite imagery will provide useful information on natural resources and environment in these areas.

3. MATERIALS AND METHODS

Four Spot XS digital images were collected and analyzed in this study. Their characteristics are listed in Table 1.

Table 1. Characteristics of digital satellite data

Satellite	Sensor	Date of acquisition	No. of bands	Area
Spot 1	HRV	21/06/86	3	Hanoi
Spot 3	HRV	22/10/94	3	Sontay
Spot 2	HRV	24/10/94	3	Hanoi
Spot 3	HRV	26/10/95	3	Hanoi

Reference data include topomaps at scales of 1: 50.000, 25.000 and 10.000, thematic maps and ground truth collected to support image processing and GIS analysis.

The hardware used includes PC and peripheral devices. IDRISIW, an integrated GIS and image processing software was used for information extraction from Spot digital images.

All Spot data were geometrically corrected using GCP taken from the topomap sheets of Sontay and Hanoi at 1:50.000, UTM coordinates. Based on the availability of digital satellite images and reference data, two study windows was extracted from Spot XS images. The Sontay window is defined by the coordinates: X= 552000-565500 m, Y= 2332000-2344500 m. Its area is 168.75 km² ranging from Sontay town to Danphuong district. The Hanoi window is bounded by X=584000-594000 m, Y=2322150-2331000 m covering both urban and suburban districts with a total area of 88.5 km²

The image windows were further analyzed using different established image processing and GIS techniques such as image enhancement, transformation, classification, statistical, geometrical and overlay analysis (Eastman, 1997, Erdas, 1997; ITC, 1997; Jensen, 1996; Lillesand and Kiefer, 1994; Mather, 1999). All the above mentioned operations allowed detection and quantification of land use/land cover changes in the study area.

4. RESULTS AND DISCUSSION

Fig. 4. represents the near infrared (NIR) images of the Sontay and Hanoi areas in late October 1994. These single band images allow identification of surface water resources as black areas in the image due to their low spectral reflectance in the NIR region. In both Sontay and Hanoi the Red River channel can be seen clearly with different oxbow lakes on both sides attesting the changing course of the river in space and time. However, the extent of these water features in Hanoi is more impressive. The West Lake known as the largest oxbow lake in the Red River Delta appears in a large black area in the upper left corner of the image.

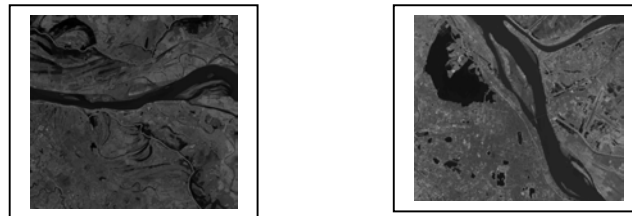


Figure 4. NIR images of the Sontay (left) and Hanoi (right) areas

Looking at multitemporal NIR images (Fig. 5) we can see a clear change in the Red River area in Hanoi represented by the emergence of a large sand bar in 1994 and 1995.



Figure 5. Multitemporal NIR images of the Hanoi area

The creation of normalized difference vegetation index (NDVI) images based on NIR and red channels of Spot XS data emphasizes the presence and variation of green vegetation in Sontay and Hanoi. It means that the vegetation resources in the delta can be easily differentiated from water and soil resources with Spot NDVI images.

The false color composite (FCC) images as combinations of all three bands of Spot data again allow us to see the Red River channel, ponds, lakes, vegetation, sand bar and built up areas in characteristic colors. That is an advantage of FCC images over NIR images. The vegetation appears in different shades of red, sand in white while ponds and lakes are generally in black. The Red River water appears in different shades of green, light and milky

blue on different dates of imaging with different extent reflecting its varying levels of medium and high turbidity classified based on FCC colors (Chopra *et al.*, 2001).

A comparison of FCC and NDVI images of the Sontay and Hanoi areas derived from Spot XS images taken only two days apart (24/10/94 and 22/10/94) shows that the Red River water turbidity and NDVI in the Son tay area are higher than in the Hanoi area. This information on the Red River water quality and environmental greenness is supported by recorded suspended sediment concentrations at Sontay and Hanoi stations (Fig. 3) and other reference data.

The results of image classification show spatial distribution of land use/land cover types in the study area. A quantification of three main cover types such as land, water and vegetation is illustrated by Figs.6-7. This kind of information is very useful for understanding the status of natural resources and environment in the Red River Delta in space and time as a result of combined effect of natural and cultural processes.

Fig. 6 shows the areas (%) occupied by the above cover types in Sontay and Hanoi in late October 1994. In the Sontay window, the water area is smaller than that of vegetation. The reverse is true in the Hanoi window.

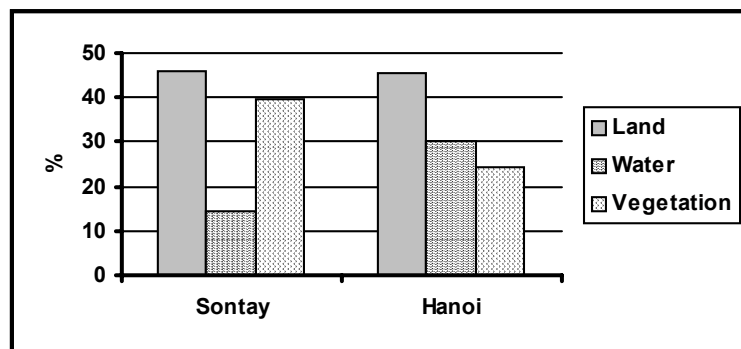


Figure 6. Distribution of land, water and vegetation in Sontay and Hanoi, 10/94

Distributions of land, water and vegetation in Hanoi at three points in time are shown in Fig. 7.

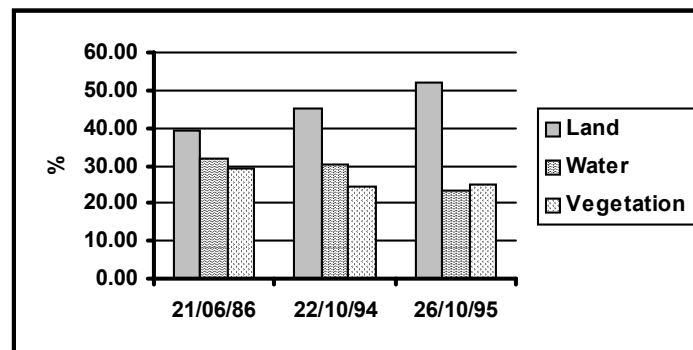


Figure 7. Distribution of land, water and vegetation in Hanoi over time

As seen in Fig. 7, the vegetation cover in Hanoi decreased in area between 21/06/86 and 22/10/94 and occupied almost the same area between 22/10/94 and 26/10/95. The land

area increased steadily from 39.19 % in 1986 to 45.36 % in 1994 and 52.03 % in 1995 while the water area including rivers, ponds and lakes followed a reverse trend from 31.61 % in 1986 to 30.28 % in 1994 and 23.25 % in 1995. These sharp changes in land use/land cover as detected and quantified with the aid of satellite imagery need further investigations. They deserve special attention from resource and environmental managers.

5. CONCLUSIONS AND RECOMMENDATIONS

Good results can be obtained in mapping, measuring, monitoring and modelling the complex system of natural resources and environment in the Red River Delta using Spot digital data and well established techniques of digital image processing and GIS.

Between 1986 and 1995 several changes were observed in the Red River Delta from Sontay to Hanoi in terms of river channel, water turbidity, environmental greenness and extent of land use/land cover types on the flood plain of the Red River. These are best characterized by an increase in the land cover area and a decrease in the water cover area mainly due to population growth and urbanization. This trend can and should be closely monitored using satellite imagery.

Further studies should be carried out taking full advantage of existing and future digital satellite data to better understand dynamics of the Red River Delta as part of the Red River Basin through domestic and international cooperations.

6. REFERENCES

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