MONITORING LAND COVER CHANGE OF HANOI CITY CENTER UNDER IMPACTS OF URBANIZATION BY USING REMOTE SENSING

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ABSTRACT

Hanoi is witnessing the accelerative economic development time with the annual GPD increase of about 9%. Rapid urbanization deeply impacts to land cover changes in the outskirts of the city. In order to monitor the urban growth, this study used Landsat and ASTER images over past 30 years. The conventional maximum likelihood classification method was utilized to extract the surface information in the images. The results showed visually the rapid urban expansion as well as land cover changes of Hanoi over time. However, the validation indicated that the mix pixel (mixel) problem regularly occurred in the results of classification. To improve accuracy of classification, this study applied VSW index. The VSW index was applied to decompose vegetation, soil and water index for each date. Integration of the conventional classification and the VSW index provides the improved urban area detection. Quantitative assessment of the urban growth revealed that Hanoi city area had been increasing 6 times from 1975 to 2003. The results of this study are expected to be useful to support the decision makers to build an appropriate land use plan.

1. INTRODUCTION

Hanoi has experienced rapid urbanization under impacts of the economic development. Rapid urbanization brought modern life and better living conditions for the citizens. In recent decades, the migration flows to the city center from other provinces is steadily increasing. This led rapid population increase in the city from 1.4 million people in 1975 to 3 million in 2003. As a result, social activities require more and more land to develop and thus pressure on land use. Urbanization is occurring in unprecedented rates, whereas the information related to land use management of Hanoi is inconsistent and insufficient. The question how to monitor the urbanization of Hanoi effectively is getting very important.

The problem can be overcome by using remote sensing to some degrees. Remote sensing provides consistent data sets to detect dynamics of urban growth. It should answer the question like where change happened. This paper presents the integrated method of a conventional classification and the VSW index to improve the accuracy of surface classification for monitoring the urban growth. The results are expected to be useful to support the decision makers to build an appropriate land use plan.

2. STUDY AREA AND DATA SOURCE

2.1. Study area

Hanoi is located in the central part of Red River Delta. It covers 921 km^2 and its population is about 3 million in 2005. With the increase of GDP around 9% each year, Hanoi has become the biggest city in the northern half of Vietnam.

This study focuses on the center of Hanoi city. Government headquarters, commercial and business activities mainly concentrate in the city center area. Under the impact of economic development, the land use in the outskirt around Hanoi is dynamically changing.

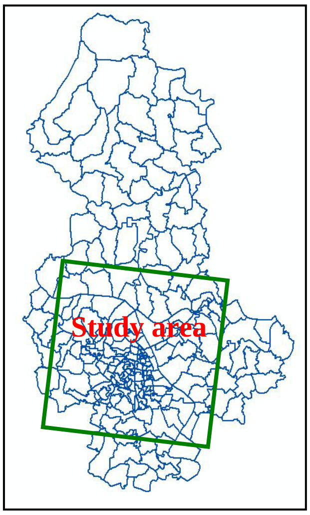


Figure 1.Study area

2.2. Data Source

The multiple spatial-temporal satellite data were obtained from Earth Remote Sensing Data Analysis Center (ERDAS) for ASTER image and from Tropical Rain Forest Information Center, Michigan State University, U.S.A for Landsat images.

Table 1: Detailed characteristics of satellite images used in the study

Satellite images	Time	Resolution (m)
Landsat MSS	1975 / 12 / 29	80
Landsat MSS	1984 / 08 / 05	80
Landsat TM	1992 / 10 / 21	30
ASTER	2001 / 12 / 01	15
Landsat ETM+	2003 / 10 / 13	30

3. METHODOLOGY

3.1. Image classification

Geometric correction was performed to rectify Landsat satellite images to Transverse Mercator coordinate system with the 15m spatial resolution. The image registration made an image conform to the others to create a series of spatial-temporal satellite images over Hanoi area from 1975 to 2003.

The supervised maximum-likelihood classification method was utilized to generate surface cover maps from the satellite images. Data extraction in the training sites was carried out by interpreting in the IKONOS image (4m spatial resolution) and Hanoi land use map of 2001. Land surface was classified into 9 classes: urban area, water, bright vegetation, dark vegetation, marsh, road, wet land, sand, and fallow.

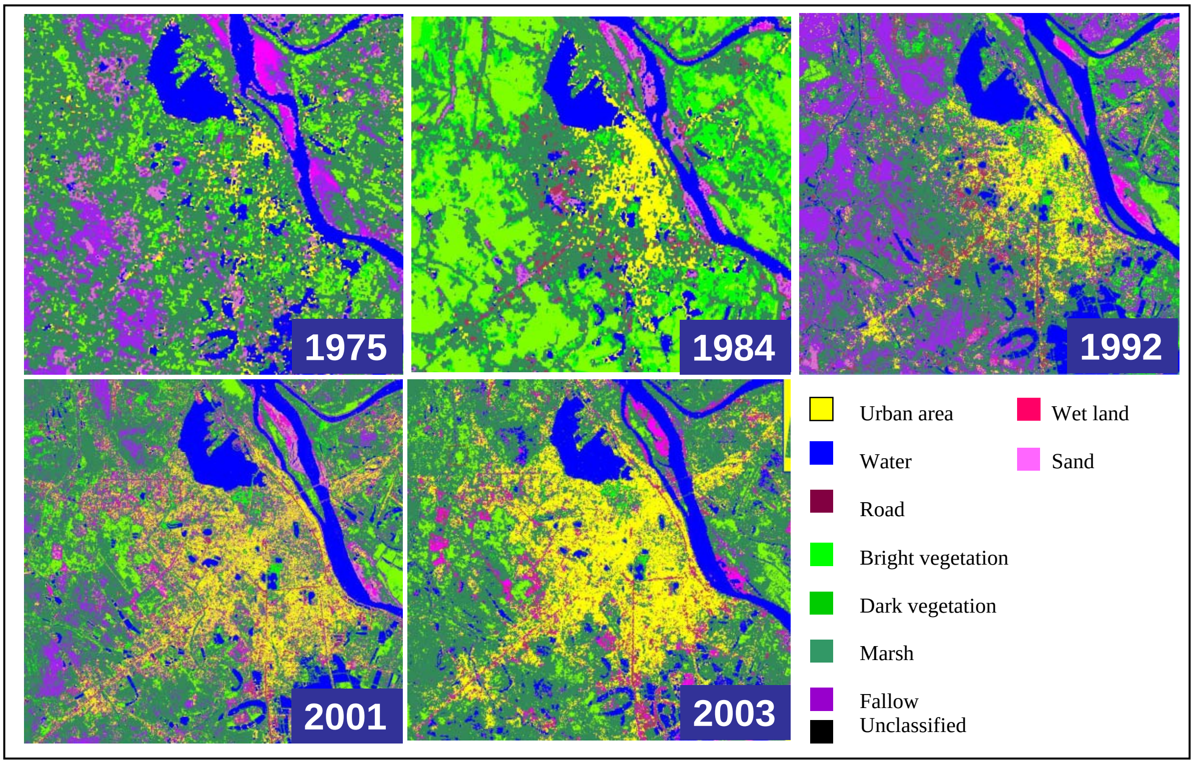


Figure 2.Hanoi land cover maps 1975 -2003

Low quality of the raw 1975 image due to coarse resolution restricted the detection of land cover information. The city generally expanded to the west, southward, and on the other side of the Red River from 1975 to 2003. Especially, major trends of urbanization primarily occurred along the transportation lines.

However, the urban areas in the image are composed of various components such as build up area, water, vegetation, and fallow. The combination of these components in one pixel, so-called mixel problem, severely contributes to reduce the accuracy of classification results. Figure 3 shows an example of the mixel effect to the classification. The result of classification was visually compared with the raw ASTER image in the same place to access the accuracy. In ASTER image, the green color is the water area. After classification, due to the mixel effect of the water and build up areas, these pixels were mistakenly classified as the build up area instead of water.

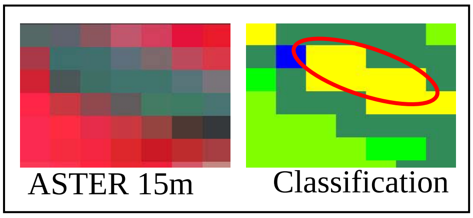


Figure 3.Accuracy assessment of classification results

3.2. Vegetation-Soil-Water (VSW) index

In order to improve the accuracy of classification, this study applied the vegetation-soil-water (VSW) index proposed by (Yamagata *et al.*, 1997).

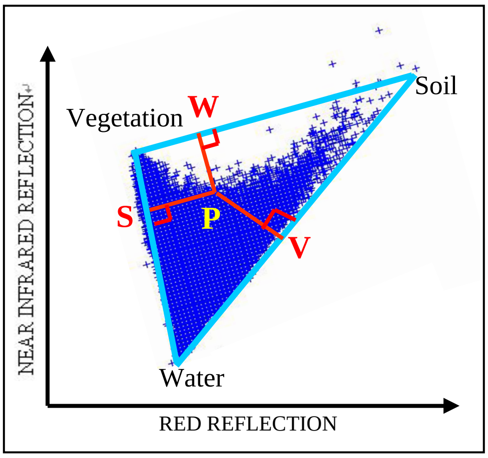


Figure 4.Concept of the VSW index

Figure 4 shows the relationship between VSW indices (PV, PS, PW) and the endmembers of vegetation, soil and water on the scatter plot of red and near infrared reflections. Proportions of vegetation, soil and water in one pixel are quantified simultaneously by measuring the distance PV, PS, PW. These results are called as the vegetation index, soil index and water index, respectively.

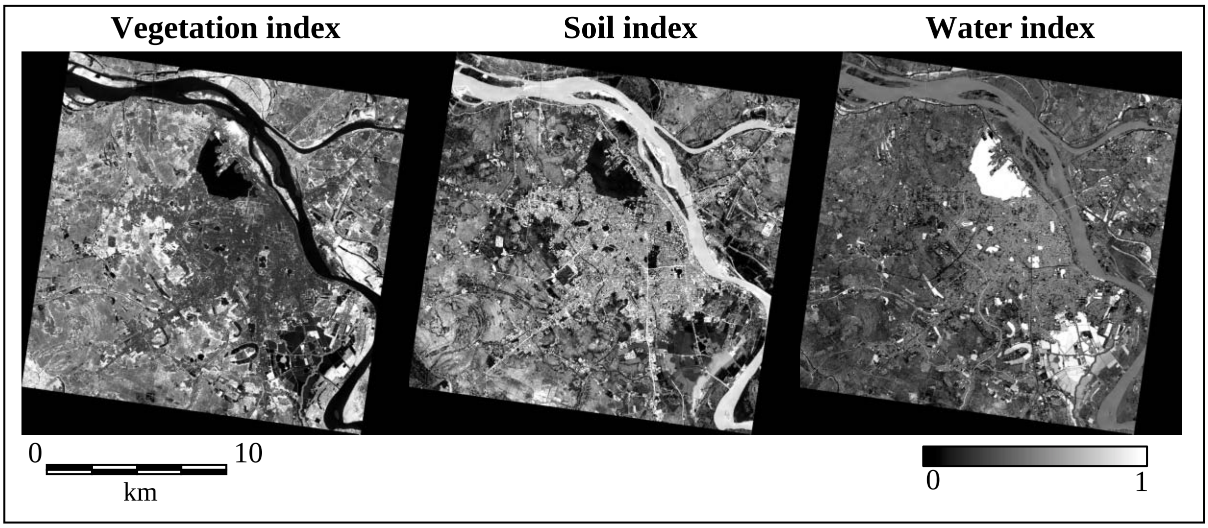
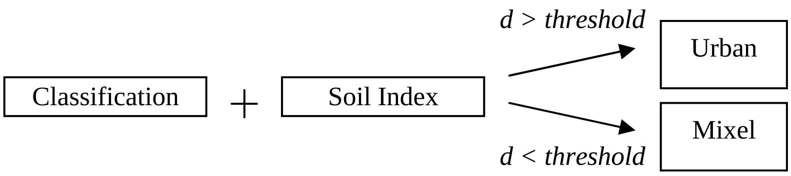


Figure 5.Results of VSW index

We can detect proportions of vegetation, soil and water through the VSW index. In the soil index image, the urban build up area, fallow, and the Red River together appear as bright areas. The water of Red River contains high concentration of soil, so that the Red River has high soil index instead of water index. In addition, there is a problem that it is difficult to separate the urban area and fallow (Tachizuka *et al.*, 2002).

The authors developed an integration method to solve this problem along with the mixel problem. Combination of the conventional classification and the soil index can clearly delineate the urban areas. Based on the visual interpretation, the thresholds were manually decided to reduce the error areas (mixel areas). Then, the NIR band is utilized to mask the water bodies including the Red River in order to diminish the effect of suspended water.



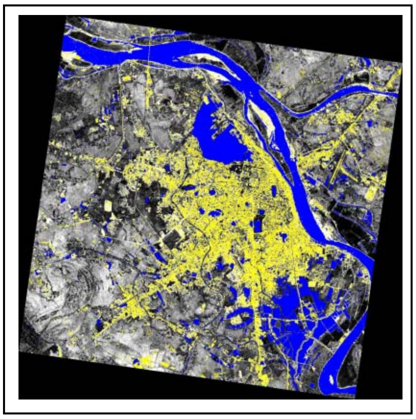


Figure 6.Integration

The result of the integration method was then validated by using the Hanoi aerial photos taken in 2001 and Hanoi land use map of 2001. It was proven that the mixel problem is considerable reduced. Based on the assessment of estimating the build up areas in some sample sites, it can be concluded that the integration method provides the best result to detect urban areas with the accuracy of about 80%.

4. RESULT

4.1. The urban area detection

Integration of the conventional classification and VSW index provides an effective approach to detect the urban growth of Hanoi from 1975 to 2003. The change areas as well as the directions of urban expansion can be visualized and detected. It can be seen that the urbanization primarily occurred along the main transportation lines and then expanded in the outskirts of the city. In addition, disappearance of some lakes inside the city in the period of 1992-2001 was the result of the urbanization, and gave impacts to the city environment. Quantitative assessment of the urban growth showed that the Hanoi city area had been increasing 6 times from 1975 to 2003 from about 10 km^2 to more than 60 km^2, and the rapid increase of the urban area is recognized in the period of 2001-2003.

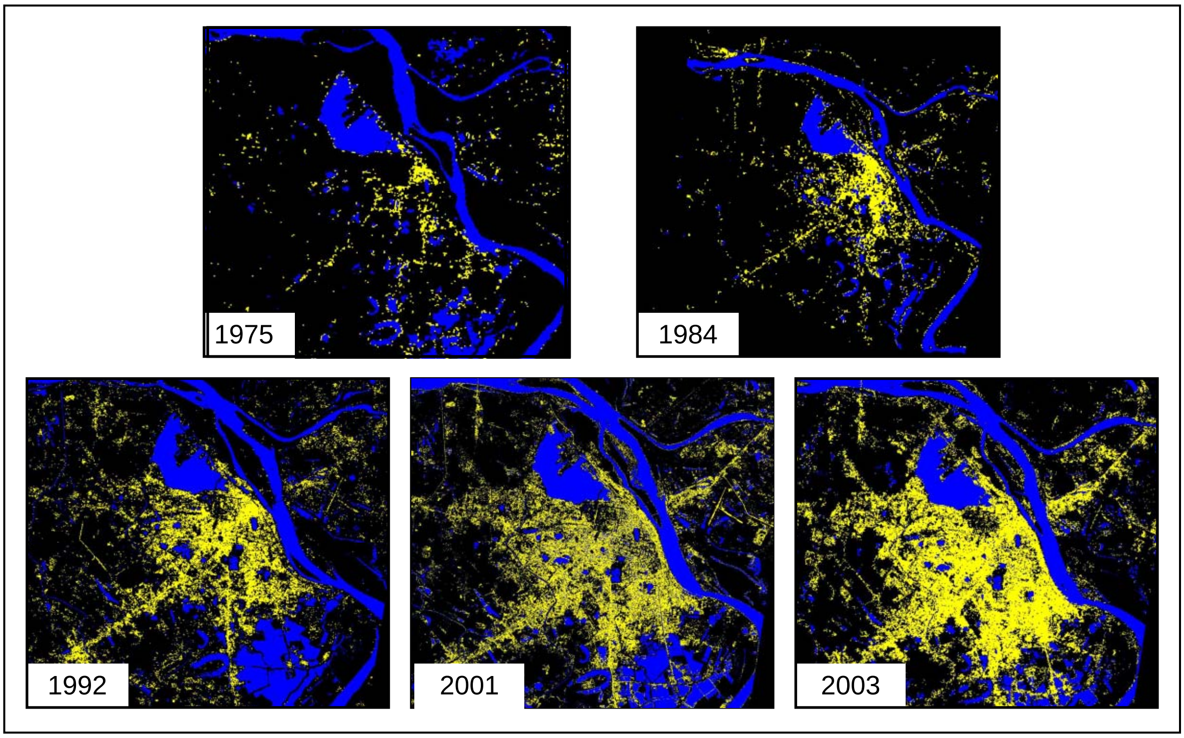


Figure 7. Urban area detection

4.2. Urbanization pattern detection

Two urban area detection maps of different dates were used to create change maps and to characterize the urban growth patterns. Four urban growth types such as infill, expansion, isolated, and linear branch (Wilson et al., 2002) were identified from the analysis.

The urbanization map of 1975-1984 shows the infill growth pattern. The non-develop areas in 1975 in the city center were conversed into the urban area. The city began expansion.

The 1984-1992 map expresses 2 directions of urban expansion of the linear branch type in the west and south. Expansion to the south-side was the major trend. In the south of the city, new roads appeared as a linear branch on the map, and houses and other infrastructures were then expanded along the road.

The 1992-2001 map indicates the linear branch of the transportation lines in the south, whereas the expansion continued to the west side of the city. The rapid urbanization led to the isolated urbanization on the other side of the Red River.

The 2001-2003 map reveals that the expansion type intensified in the west of city by building up My Dinh Stadium and related infrastructures in Tu Liem area. It can be seen that a large part of the non-urban areas were converted to the build up areas.

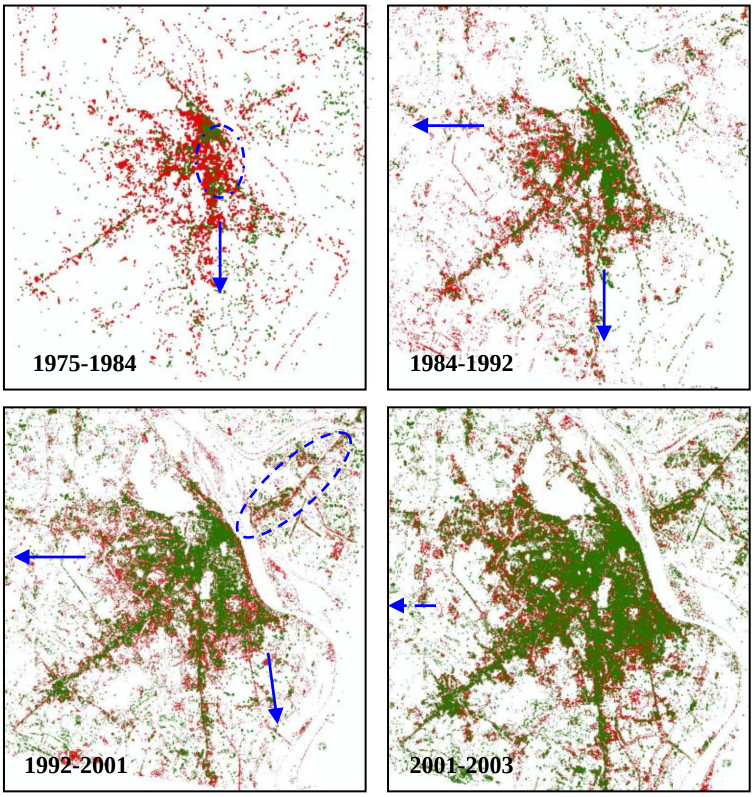


Figure 8. Urbanization patterns detection

5. CONCLUSION

This study developed a new integration approach to improve accuracy of the surface classification. The urban growth as well as urbanization patterns of Hanoi over past 30 years can be detected with high accuracy. We can conclude that the integration method allows us to monitor urban growth effectively and efficiently. For the further research, the result of this study will be integrated with socio-economic data to assess the impacts of economic development of the city to the urbanization. Regional analysis using this method with remote sensing data should be useful to assist the decision makers to improve understanding about urban dynamics in order to establish an appropriate land use plan.

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