USING SATELLITE IMAGE TO DETECT THE URBAN EXPANSION IN CAN THO CITY, VIETNAM

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ABSTRACT

Can Tho City in Vietnam, the biggest city in the Mekong Delta is located on the south bank of the Hau River, a major tributary of the Mekong River. It has been considered necessary to study the urbanization process for Can Tho City as the city now is the delta's most important centre of economics, culture, science, technology and is urged to become the Mekong delta economic hub by 2020.

The main objective of the study is to use multi-temporal satellite images (Landsat MSS, TM, ETM+, JERS-1 and ASTER) and topographic map to detect the direction and rate of urban expansion in Can Tho City, to understand the city's transition in different periods and to find out the trends in urban development. This will help in better monitoring of the city development and optimal land use planning. The dataset used for the study is from the year 1966 to 2007.

The research also attempts to find the relationship of the "My Thuan" Bridge constructed in the year 2000 with the urban expansion. The result can be applied to predict the urban grown after the "Can Tho" Bridge is completed.

1. INTRODUCTION

Can Tho City is an economic and cultural center of Mekong Delta with area of 1402 sq km and 8 districts (General Statistics Office, 2007). The center is located at 10°2'21"N and 105°46'54"E (Figure 1).

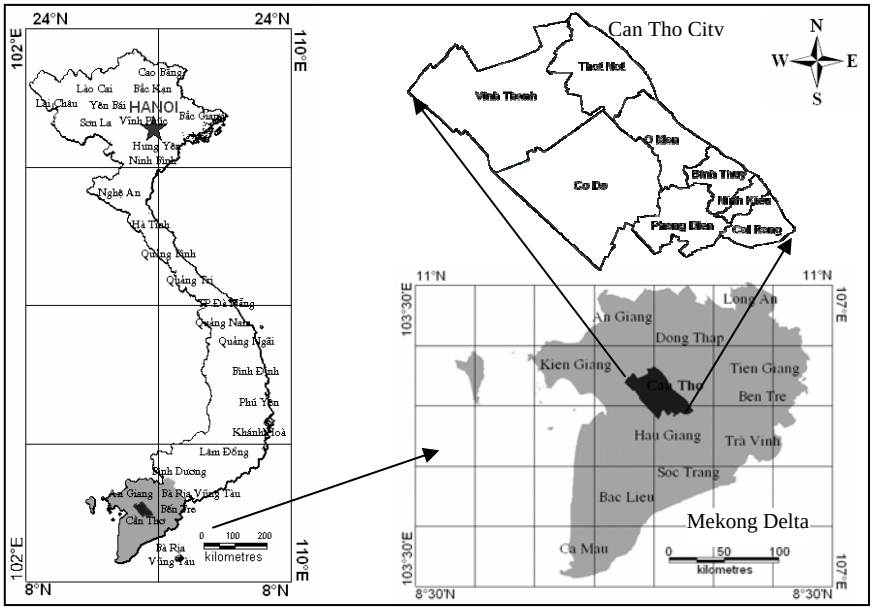

Figure 1. Study area map of Can Tho City.

In recent years, the urbanization of Can Tho City has been increasing rapidly and it is urged to become the Mekong Delta hub by 2020. An attempt to understand the direction and rate of urban expansion in Can Tho City has been made. For that purpose, this paper used multi-temporal satellite images obtained during different periods of time from 1966 to 2007. This would be useful for monitoring city development and also for optimal land use planning.

For this study the VSW (Vegetation-Soil-Water) Index method by Yamagata, (1999) has been used. The VSW method is an effective method to calculate the spectral index for soil, water and vegetation using the scatter plot obtained by using the red and near-infrared values of the images. This research also added the NDVI for better classification of urban area.

An attempt to understand the rise in urban growth with relation to the My Thuan Bridge has also been made in order to be able to predict expected changes in the near future after the Can Tho Bridge which is under construction is completed in the end of 2009.

2. METHODOLOGY

2.1 Data source

The multi-temporal dataset used are listed in Table 1. The data was collected through the GIS and Remote Sensing Center (GIRS), Ho Chi Minh City Institute of Resources Geography, Vietnam (Dataset 1, 2, 3 and 5) and the Graduate School for Creative Cities, Osaka City University, Japan. (Dataset 4 and 6)

Table 1. List of multi-temporal Dataset used.

	Data	Date	Resolution
1	Topographic map (1:50,000)	1966	-
2	Landsat MSS	1972 Dec	80m
3	Landsat TM	1989 Jan	30m
4	JERS-1	1997 Mar	18m
5	Landsat ETM+	2002 Dec	30m
6	ASTER	2007 Feb	15m

2.2 Geo-reference

ASTER image was chosen as base map for geo-referencing the multi-temporal dataset in WGS84 Datum, WGS84 ellipsoid, UTM (zone 48N) projection.

2.3 VSW Index

The VSW (Vegetation-Soil-Water) Index by Yamagata, (1999) was based on the PVI (Perpendicular Vegetation Index). VSW Index uses the scatter plot of red wavelength (on x axis) and near-infrared (NIR) wavelength (on y axis) for the pixels (Figure 2). After forming a triangle for the scatter plot, the vectors representing the line for water, vegetation and soil can be obtained. Then the distances from spectrum point P to each edge of the triangle PW, PV, PS (value for water, vegetation and soil respectively) can be calculated. This index can detect water, vegetation and soil as it can support three values. This study employed the method to detect urban areas to find the urban expansion using time series data.

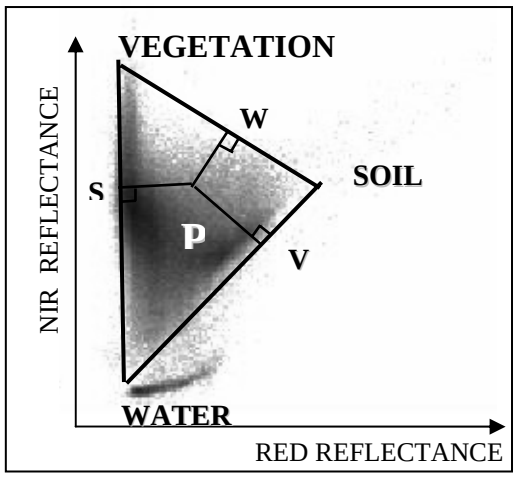

Figure 2. VSW Indices triangle with the scatter gram of Landsat TM in 1989.

2.4 Detection of urban area using VSW Index

The satellite images were used to derive the scatter gram (Figure 2) and the end member of the triangle were extracted manually. Each time period image was extracted into three images namely Vegetation, Soil and Water.

Because the source data was collected from different kinds of satellites and sensors, the ROI (Region of Interest) was chosen prior to the preparation of the study area and the graph showing the statistics derived from the VSW index for each image (Figure 3). Based on the statistics, a decision-tree was setup to classify urban areas for each year (Table 2).

However it was observed that in the graph of 2007 (Figure 3) *Dry bare soil and Urban* could be not separated clearly. As a solution NDVI values were also added to decision-tree. From the statistics of NDVI value of 7 classes, dividing *Wet – Dry bare soil* and *Urban* was possible (Figure 3).

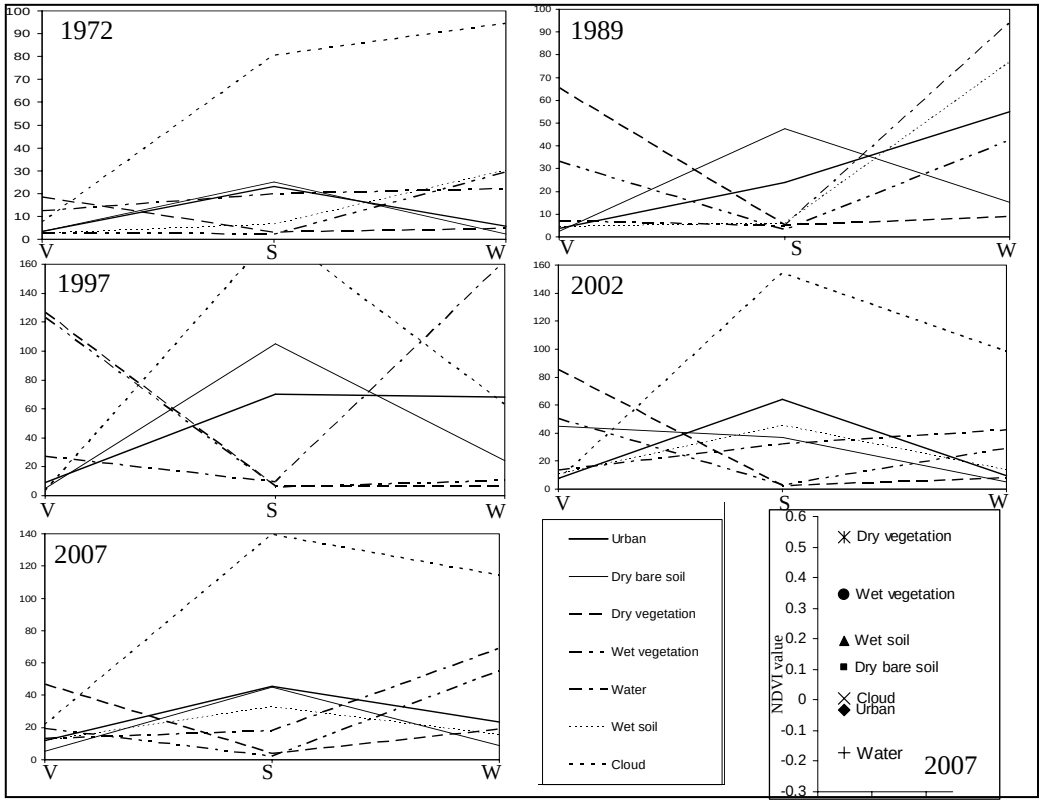

Figure 3. Graph of ROI statistic of VSW value in 1972-2007 and NDVI statistics in 2007.

Table 2. Lookup Table for decision tree.

Year	PV	PS	PW	NDVI
1972	PV < 4	PS < 25	PW < 7	
1989	PV < 12	PS > 20	PW > 40	
1997	PV < 15	50 < PS < 100	35 < PW < 80	
2002	PV > 5	40 < PS < 80	PW < 10	
2007	PV < 25	20 < PS < 60	15 < PW < 40	NDVI < 0

Urban areas in 1972, 1989, 1997, 2002 and 2007 were extracted. By using GIS technique (convert vector, overlay and calculate), the urban were obtained the urban expansion information.

3 ACCURACY ASSESSMENT

The extent of urban area for each year were found to be 1966 (350ha) 1972 (610ha), 1989 (259ha), 1997 (426ha), 2002 (907ha), and 2007 (2012ha).

The calculation for urban areas in 1966 and 1972 were restricted by the scale of the topographic map (scale 1:50,000) and the resolution of the Landsat MSS (80m) image. Therefore this study just used it for showing the shape of the urban area.

According to the land use statistics obtained from the government records in 2004 (Can Tho City construction project) the urban area in Can Tho City was 4,667ha and very different with the results in 2002 (906ha) and in 2007 (2011ha) as shown in Table 3 for each district.

Table 3. Urban area results in each district at Can Tho City in 2002, 2007 compare with Land use statistic 2004.

District	Urban 2002 (ha)	Statistic 2004 (ha)	Urban 2007 (ha)
Ninh Kieu	**442.31**	**528.35**	**651.13**
Binh Thuy	**220.19**	**341.06**	**469.40**
Cai Rang	**73.89**	**286.81**	**295.17**
O Mon	87.42	571.92	210.46
Phong Dien	9.54	351.70	82.77
Co Do	34.85	846.24	89.43
Thot Not	38.43	878.13	213.31
Vinh Thanh	0	863.26	-
SUM	**906.63**	**4667.47**	**2011.67**

From Table 3, the districts (Ninh Kieu, Binh Thuy, Cai Rang) which lie in the urban areas and the growth rate were correct when compared to the records provided by the government. But the districts in the rural part of Can Tho City (O Mon, Phong Dien, Co Do, Vinh Thanh, Thot Not) showed very different results in terms of land use statistic in 2004. The reasons being first, the maximum resolution of remote sensing image was about 15m so it could not recognize small houses in the countryside, second the height of houses in rural being low were covered by the trees in the surrounding areas. Lastly, the government statistical yearbook, does not take into account the houses which are located in different landuse areas other then the built–up area or urban landuse.

4. RESULTS

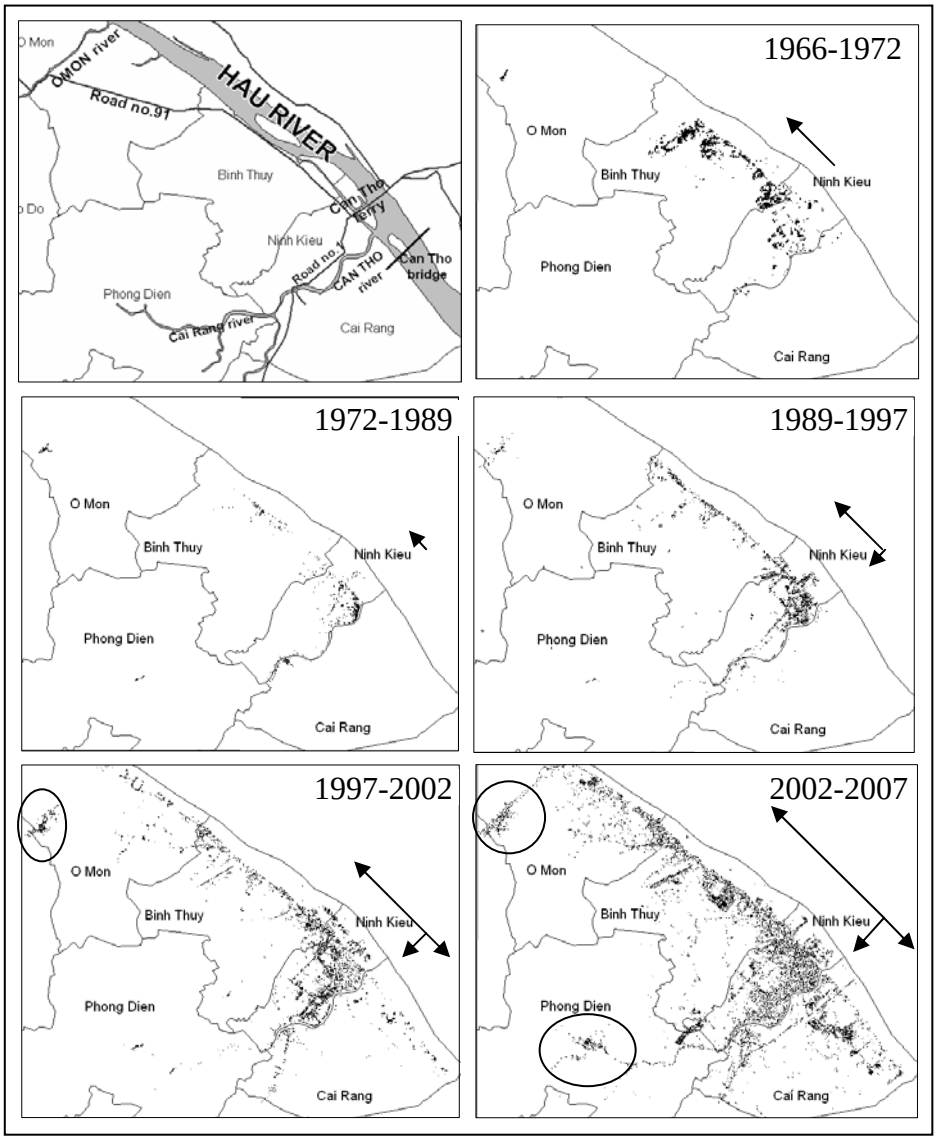

Figure 4. Arrows of the urban expansion direction.

From Figure 4 we can visually see the expansion of urban area in Can Tho City from 1966-2007. According to the result, from 1966-1972 the urban expansion was in North-West direction along the Hau River and Road number 91. Ninh Kieu district connected the city with National Road number 1. The road looked like the "main bond" of Vietnam in generally and Mekong Delta in particular. It connects Ho Chi Minh City (the main economic center in Vietnam) and Mekong delta.

From 1972-1989 (17 years period), there were rarely any changes in the urban areas. Although in December 1986, Vietnam entered the "Economic Renovation Policy" (Doi Moi) but Can Tho City did not change so much. Some areas along Can Tho River and Hau River became urban area.

From 1989-1997 (8 years period), Can Tho City expanded more in North-West and expansion also began in the South-West. Because of the limit of Can Tho River, the urban in Cai Rang district (the right side of Can Tho River) could not be developed.

From 1997-2002 (5 years period) besides the North-West direction, South-East (along Hau River) and South-West (along Can Tho River and National Road number 1) was seen to have increased a lot. My Thuan Bridge built in 2000 was the key factor for this development. It made the transportation by road through Tien River from Ho Chi Minh City to Can Tho City possible. Ninh Kieu district was the center of Can Tho City with rapid urban expansion rate. In O Mon district, O Mon town also the important point where urban increase was observed.

From 2002-2007 (5 years period), the South-West was still the main direction of expansion. Can Tho port was widened and rapid development of industrial parks were seen. All was located along the Hau River. The areas of O Mon district along OMon River and Phong Dien district along Cai Rang River - Can Tho River, Center of Thot Not district along Hau River - Thot Not River had high point of urban expansion. Besides, the South-East was increasing continuously with the start of the Can Tho Bridge project in 2004.

5. CONCLUSIONS

Through this research, urban expansion of the study area during different periods using multi-temporal satellite images (Landsat MSS, TM, ETM+, JERS, ASTER) could be detected. The VSW Index was able to delineate the urban areas, incorporating NDVI with this method proved useful to separate *Dry bare soil* and *Urban* areas effectively.

From this it was observed the main direction of urban expansion in Can Tho City was detected to be in the North-West direction Hau River seaming as the main transportation by waterway. Before 1997 urban areas along the National Road No. 1 were not so developed because of limitation in transportation. There were two ferries: Can Tho ferry and My Thuan ferry connected this road. That was the barrier to transport goods from Can Tho City to Ho Chi Minh City.

But from 2000 when My Thuan Bridge started operating, the time for transportation from Ho Chi Minh City to Can Tho City was shorter, then the growth in urban area increased more in South-East and South-West direction. After the construction of Can Tho Bridge started in 2004, the urban expansion on the side of Can Tho City was also seen to develop.

From the pattern of urban development, after the Can Tho Bridge construction will be over, the urban expansion is expected to extend much more in Cai Rang district and Phong Dien district. So Cai Rang and Phong Dien are the two main districts which would need instant planning when the construction of the Can Tho Bridge will be finished.

6. REFERENCES

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