

REMOTE SENSING FOR CHANGE DETECTION OF SURFACE TOPOGRAPHY CAUSED BY URBANIZATION

Tran Thi Van, Bui Thi Thi Y, Ha Duong Xuan Bao

Ho Chi Minh City University of Technology, Vietnam National University Ho Chi Minh City,
268 Ly Thuong Kiet Street, District 10, Ho Chi Minh City, Vietnam;
E-mail: tranthivan@hcmut.edu.vn; thiy212@gmail.com; hdxbaobk@yahoo.com

ABSTRACT

The trend of urbanization in Ho Chi Minh City to the south on soft ground and low areas, where there are many lakes, lowland swamps, has made thousands of reservoir areas disappeared. This makes the drains from the city center prevented and causes the city suffered flooding situation worse and worse. This paper presents the research on application of remote sensing and GIS detecting and assessing surface topography variation through the change of the low-lying areas, ponds and lakes for District 7 and Nha Be District. The result was the construction of status and change maps as well as making analysis, evaluation, statistics proofing for the volatility and impact on the ecological environment. Since then, research have given flood mitigation measures in support of environmental management.

Keywords: flood mitigation, GIS, remote sensing, surface topography, urbanization

1. INTRODUCTION

The low-lying areas and wetlands represent the shape of the natural terrain of an area which is the location of the ecological balance and water flow regulation. Urbanization has led to the expansion of urban spatial development requirements, and gradually increase the impervious surface area. The low-lying areas are being filled make the water flow in multiple directions uncontrollably and cause massive floods. Urbanization is an inevitable process, however, if there is no specific plan developed under the spontaneous tendency to generate the disturbing problem, typical of which is the problem of flooding.

This paper presents the results of study evaluating the surface topography changes based on remote sensing and GIS integration for District 7 and Nha Be District of Ho Chi Minh City during the period from 1990 to 2010 (Figure 1). Object of study is the low-lying swamps. This is a structured form of geomorphology topography of an area as Ho Chi Minh City.



Figure 1. The study area in Ho Chi Minh City

2. METHODOLOGY

Time survey was conducted in the period 1990-2010. Basic data used in this study were Landsat TM remote sensing images taken on 01/11/1990 and 11/02/2010. GIS data layers including maps of land use status in 1995 and 2010 was used in order to make training sample and compare the results of classification. Besides, topographic base map at scale of 1:25,000, consisting of layers of hydrological systems, transportation and elevation were also collected.

Based on remote sensing image, the color composite analysis, band ratios and image classification (supervised and unsupervised) are made to separate the water and urban for determining the current state of the surface terrain. Image processing results are exported to vector transferred into ArcGIS to perform spatial analysis. Change detection after post-classification was done on 2 years to find the difference image and change the surface topography of the study area, while also assessing the situation of urban development. Large river shape was separated not consider fluctuations.

From the analysis using the test method, we found that the band ratio of B5/B2 can be applied to separate the water from the other components, while the ratio B7/B2 can be applied to separate urban area out other factors. The result of classification has high accuracy and over 80% for the case of overall errors and Kappa coefficient.

3. RESULTS AND DISCUSSION

3.1. Change in surface topography on the low-lying areas and water bodies in period 1990-2010

3.1.1. District 7

District 7 is one of the five newly established district of Ho Chi Minh City in 1997, taken from the north of Nha Be District. Before this timeline, District 7 is still wilderness, undeveloped urban, mostly rural residential spots scattered. Results on 01/11/1990 image (Figure 2a) shows that urban land area little, scattered and concentrated mainly in small clusters in the northern part of the county. According to statistics directly from satellite images, the urban area is 108.63 ha proportion of 3.06% compared to the total area of the county. Excluding the surface area of the large rivers, low-lying areas, ponds and small rivers within the infield were detected from satellite images is 338.76 proportion of 9.55%

With the decision to establish the Tan Thuan export processing zones in 1991 located in Tan Thuan Dong ward, the construction of the Phu My Hung urban area has attracted the spontaneous migration into the county and the surrounding areas. Followed by the separation of the county in 1997, it has gradually changed and flourished. Northern part of the districts was almost entirely urbanized. Urban land area by 2010, according to 11/02/2010 satellite image (Figure 2b) was rapidly increased nearly 45% compared to 1990 and accounted for nearly 47.78% ratio of the county area, focusing primarily on the Tan Kieng, Tan Quy, Tan Thuan Tay and Binh Thuan wards. Urban development is mainly on the part of land with crop plants, there are also growing urban areas in the region even before the water surface (Figure 3 and 4). Results of change mapping combined with field surveys showed that lakes and wetlands were disappeared scatteredly across the county. The statistics table 1 shows, the area of low-lying areas, ponds, swamps disappeared in 2010, nearly 140 hectares by the filling for urban development, is approximately 35% compared with 1990, losing nearly 1/3 water storage area for the county, causing flooding usually occurs when rain combined with high tides. This said, urban construction has raised terrain elevation of the county. This is a big fluctuation of surface topography District 7, because according to topographic distribution of the whole city District 7 is natural drainage for the inner city's districts due to the low topography.

Table 1. Change in land cover area in District 7

| Land cover | Changes 1990 - 2010 | |
|--------------------------------|---------------------|----------|
| | Area (ha) | Rate (%) |
| Main rivers | -16,62 | -0,46 |
| Low-lying areas, ponds, swamps | -138,14 | -3,84 |
| Urban | 1585,80 | 44,10 |
| Vegetation | -1431,04 | -39,80 |

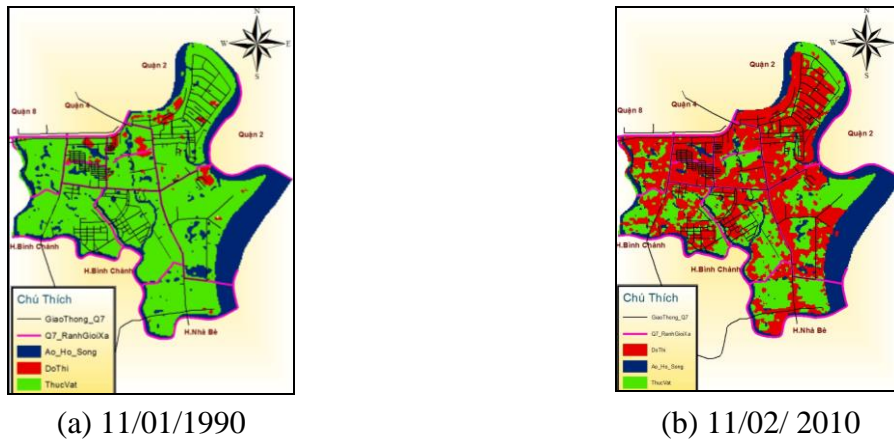


Figure 2. Land cover maps of District 7

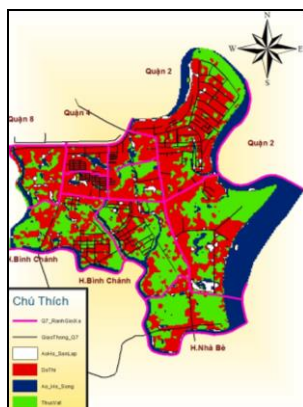


Figure 3. Water change map of Dist. 7 in 1990-2010



Figure 4. Location of low-lying areas disappeared by urban construction

3.1.2. Nha Be District

Before being separated in 1997 Nha Be was existed with weak infrastructure, undeveloped urban, only small and scattered residential cluster. Results on 01/11/1990 image (Figure 5a) shows that urban area in Nha Be very little, concentrated mainly in the town part. According to statistics directly from satellite images, the urban area is 43.65 hectares, proportion of 0.43% compared to the total area of the county. Excluding the surface area of the large rivers, low-lying areas, ponds and small rivers within the infield detected from satellite images is 2501.33 ha proportion of 24.88%.

After 1997, possesses a favorable position, Nha Be is located very near the center of Ho Chi Minh City. From Nha Be to the city there are two major directions, one is Huynh Tan Phat Street towards to the city, the second is the direction of Le Van Luong and Nguyen Huu

Tho to district 7. With the advantage of abutting District 7 and Nha benefit from the projects of infrastructure and the Phu My Hung urban area brings. In addition, there are other infrastructure projects are being implemented as roads north - south connecting Nha Be to District 7 and District 4 , Nguyen Luong Bang connecting Phu My Hung to Nha Be. Thus Nha Be district is considered one of the potential areas of development. In the future this land will be the largest urban area located in the southern gateway to the city. A series of real estate projects is constructed in Nha Be to catch the infrastructure of the area. These projects were also removed and leveled much of the ponds, lakes (Figure 6 and 7). Within 20 years (1990-2010), the speed of urbanization in Nha Be district increased significantly. According to statistical area, urban built-up in Nha Be increased proportion of 20.27% equally 2037.51 hectares land area of the district. The area has a high rate of urbanization is the town of Nha Phu Xuan ward, Long Thoi and the northern part of Hiep Phuoc ward.

Results of change mapping combined with field surveys showed that lakes and wetlands were disappeared on the location of main transport routes and built-up land. Notably, Urban area in Hiep Phuoc Port less than 20km HCM away, including industrial zones, urban areas and ports, with full infrastructure facilities and services of a big city. Areas with high urbanization rate and low-lying areas of large lakes are disappeared as Phu Xuan ward, Long Thoi and the northern part of Hiep Phuoc ward.

The statistics table 2 shows, the area of low-lying areas, ponds, swamps were disappeared in 2010 near 437.27 hectare due to process of urban development, losing 17.48% compared with 1990, lost nearly 1/5 water storage area. This is a figure seemed to be not very big but when planning projects completed in the future this number will increase significantly. According to the topographic distribution of the whole Ho Chi Minh City, is natural drainage for the inner city's districts due to the low topography.

Table 2. Change in land cover area in Nha Be District

| Land cover | Changes 1990 - 2010 | |
|--------------------------------|---------------------|-----------|
| | Area (ha) | Area (ha) |
| Main rivers | -18,67 | -0,19 |
| Low-lying areas, ponds, swamps | -437,27 | -17,48 |
| Urban | 1993,86 | 19,83 |
| Vegetation | -1537,92 | -15,30 |

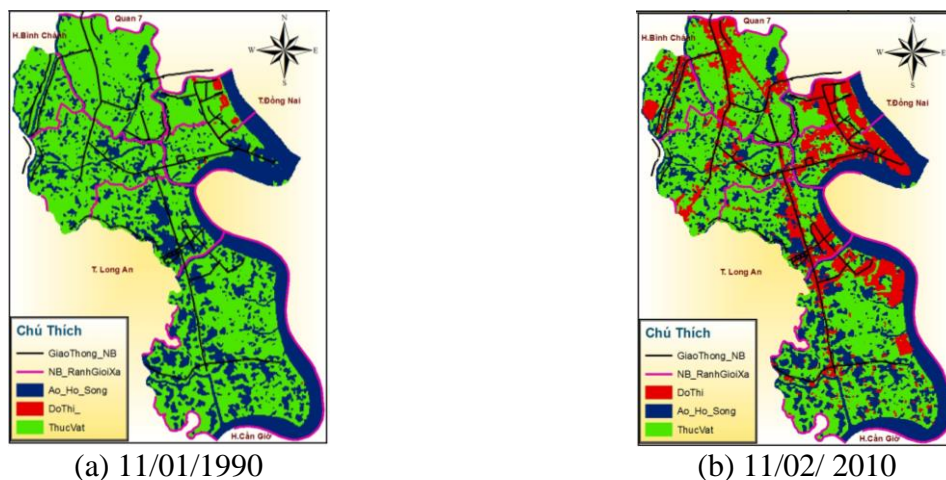


Figure 5. Land cover maps of Nha Be District

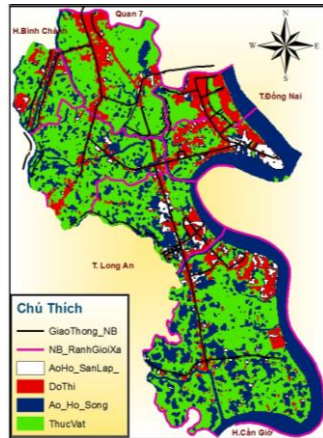


Figure 6. Water change map of Nha Be Dist in 1990-2010

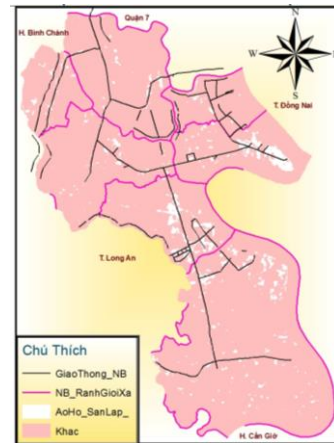


Figure 7. Location of low-lying areas, ponds and swamps filled with urban area

3.2. The impact of urban development when filling ponds causing flood

Causes of flooding in the study area were identified including multiple sources. In it, cause flooding of low-lying areas by filling is determined quite important. Due to the process of urbanization is increasing the area formerly depressed areas of water storage as ponds and canals, charge of water flow, is being filled today and encroached. Instead that hundreds of homes and many new buildings were springed up, breaking away the natural flow balance. Urbanization also brought about concreting the land where it was bare soils, lawns, fields ... losing pervious surface. Water can not be repellent into deep soil layers and groundwater level, causing surface flood increasing and annual groundwater supply decreasing, causing groundwater levels falling deeper every year, causing land subsidence.

In District 7, flooded area is focused mainly on the road of Huynh Tan Phat and Nguyen Thi Thap. At Nha Be district flooded area is Huynh Tan Phat street extended to District 7. The situation of the roads flooded is increasingly serious problem. According to public opinion surveys, the flood level is became more serious, sometimes extended whole day. To live with this situation, people have to build a wall to prevent water, housewares placed on high, and always in condition to cope with flooding.

Meanwhile, for the HCM City area, according to the handbook on planning and urban design to adapt to climate change for HCM (Quynh Chau et al. 2013), the increase in city intensity of flooding in HCM City has main cause by the rapid urban development, not by global climate change. The process of spontaneous urbanization or urbanization under the misguided policies of development locations and how to develop are the major causes leading to flooding problems today. Typically urbanization in the south direction of the city on weak low ground is main reason of a thousands of water container area disappeared (Nguyen Do dung, 2010). District 7 and Nha Be area are located in sensitive areas, their location is at the bottom of the sloping topography of the city, belong in the lower zone. The rapid urbanization in these areas has filled the natural water storage area makes the city center flooded more and more.

3.3. Proposed solutions support reduced flood HCMC

In master plan of the city, it is needed to harmonize the goals of economic, environmental and social. Not for the economy goals that ignores environmental issues. Must proceed from the principle of water balance, the total amount of rainwater and waste water shall not exceed the amount of water draining through the sewers, rivers and canals. District 7 and Nha Be are developed on tidal wetlands. Therefore, when constructing the drainage system it should be based on the situation of each river basin, including canals, ditches and tide. It should carefully calculate the land area, the open surface to maintain ecosystems, natural land, stormwater – tides regulation. To assist in reducing flood the City, the following specific measures should be considered:

- Dredging of canals to increase the drainage flow. Level dredging canals take size before sedimentation, encroachment.

- For low areas: building lakes containing water sink not drained, then when the tide withdrew, water will be flowed.

- Combine other solutions such as: Complete planning of urban drainage, to institutionalize specific criteria related to urban drainage, such as land leveling, the percentage of natural land, lakes, canals, construction of urban ecological criteria ...

- The non-structural solution: strengthen the management capacity of the drainage system and construction of a legal framework, improving public awareness... Allowing people to manage and control the flood mitigation project is also a key factor contributing to limited flooding in urban areas. But the basic measures is the vision of the planners, managers in the process of urban development.

4. CONCLUSION

With the advantage of monitoring changes over space and time, remote sensing technology has demonstrated the ability to monitor applications in environmental issues and resources, to support and to reduce the load for people in the work of fieldwork, fast analysis and evaluation. Results of the study was to determine the current status of the distribution of low-lying areas and ponds and their changes cause in surface topography area variability of District 7 and Nha Be District, to assist policy makers have a better overview and to detect areas where ponds are being filled, and the vegetation disappeared due to urban growth in order to have management measures in time, limiting the current flooding problems and prevention for the future, given the proper development.

5. REFERENCES

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