SHORELINE CHANGE DETECTION USING MULTITEMPORAL REMOTE SENSING IMAGES

Ping Liang *1 and Jihn-Fa Jan*2
[1]Graduate Student, Department of Department of Land Economics, National Chengchi University, NO.64, Sec. 2, Zhinan Rd., Wenshan, Taipei City 11605, Taiwan; Tel: + 886-2-9393091#50610;
Email: 99257027@nccu.edu.tw

[2]Associate Professor, Department of Department of Land Economics, National Chengchi University, NO.64, Sec. 2, Zhinan Rd., Wenshan, Taipei City 11605, Taiwan; Tel: + 886-2-9393091#51647;
E-mail: jfjan@nccu.edu.tw

KEY WORDS: Shoreline Change Detection, Image Classification, DMC, SPOT-5

ABSTRACT: In this study we used multitemporal remote sensing data, including DMC aerial images and SPOT-5 satellite images, to detect shoreline change of I-Lan coastal zone. We chose wet-dry line, vegetation line and water line as proxies for shoreline position, and then classified the images into different classes by means of supervised image classification. Based on the classification results obtained from images acquired on different dates, shoreline changes was assessed. The study shows that using DMC images can detect shoreline efficiently; however, its high spatial resolution causes serious salt and pepper effect. On the other hand, using SPOT-5 satellite images can only get little information of shoreline due to its limited spatial resolution.

1. INTRODUCTION

Abundant coastal natural resources provide the public with leisure and recreation, fisheries, aquaculture and other diverse functions. However, recent years due to population growth, industrial development, overexpansion of aquaculture, inappropriate land use and other factors, the coastal environment is getting worse and leading environmental pollution, and reduction of fishery resources. That’s why natural coastal conservation is important, and the most important part to manage coastal corrosion is to realize the change of shoreline.

The remote sensing data used for this study included 3 SPOT 5 images acquired on 6/1/2003, 4/11/2006, and 5/29/2009 and DMC aerial images acquired on 5/22/2009. Using supervised classification to extract the information of shoreline, we can clearly get the information of shoreline position.

2. MATERIALS AND METHODS

2.1 Study Area

The study area selected for this research was part of I-Lan plain and costal zone located in north-eastern Taiwan, with a total of about 7,571 ha (Fig.1). Affected by human activities, topographic and climatic conditions, the main land use patterns of I-Lan plain are crop lands and aquiculture, and there are coastal forest and sand dunes in coastal zones (Jan and Hsu, 2010).

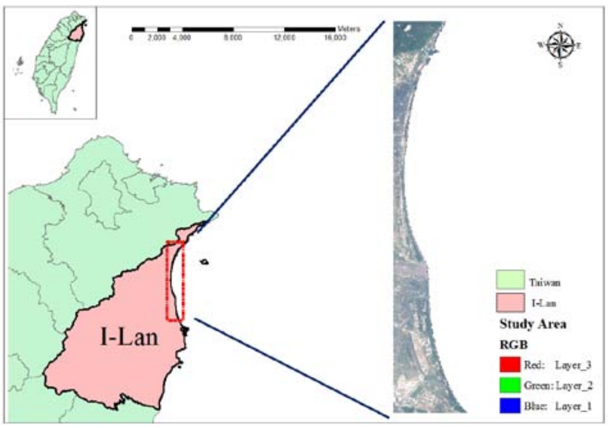


Fig.1. Location of the study area.

2.2 Data

2.2.1 SPOT 5 Images

The remote sensing data used for this study included 3 SPOT 5 images acquired on 6/1/2003, 4/11/2006, and 5/29/2009, respectively (Fig. 2). The images were level 3 orthophotos with TWD97 (Taiwan Datum 1997) coordinate system, and atmospheric and spectral corrections were done by the provider. The spatial resolution is 10 meters, the spectral resolution includes four bands: red (0.61 to 0.68μm), green (0.5 to 0.59μm), near-infrared (0.78 to 0.89 μm) and short wave near-infrared (1.58 to 1.78μm).

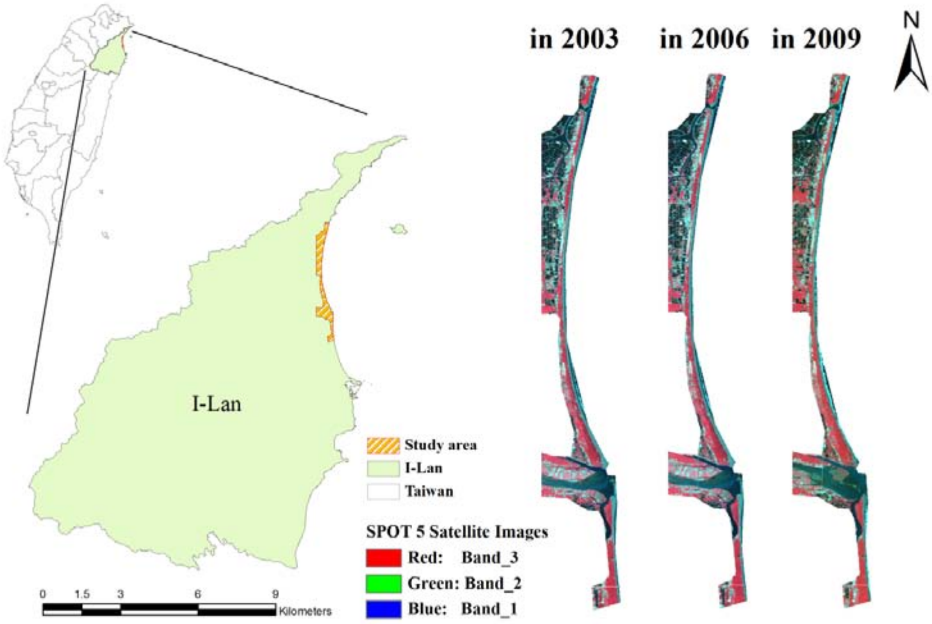


Fig. 2. SPOT images of the study area.

2.2.2 DMC Aerial Images

Another remote sensing data used for this study is the DMC aerial images, which acquired on 5/22/2009, respectively (Fig. 3). The spatial resolution is 0.15 meters, and the spectral resolution includes four bands (red, green, blue and near-infrared). Compared with SPOT images, DMC aerial images have higher spatial resolution which can provide more information of shoreline such as the position of wet-dry line.

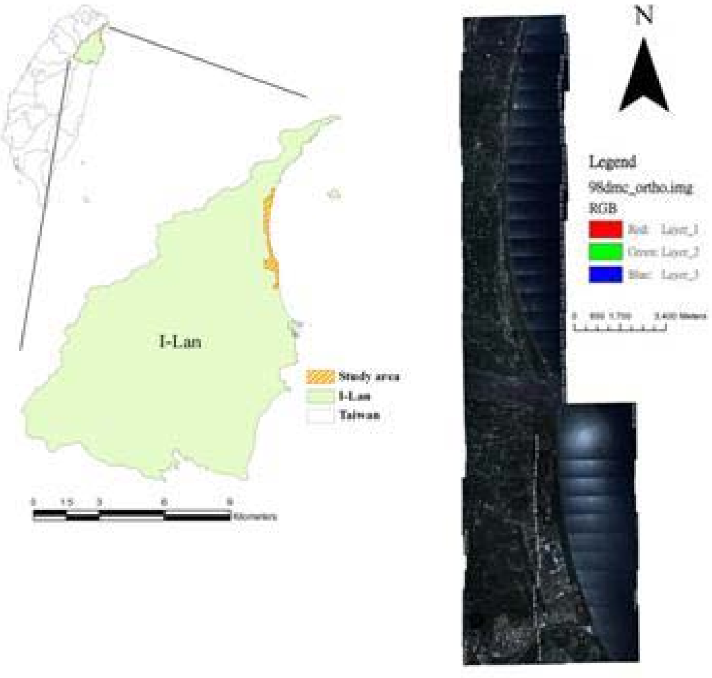


Fig. 3. DMC aerial images of the study area.

2.3 Methods

2.3.1 Shoreline Indicators

The definition of shoreline is "the area between sea and land", and the position of shoreline changes when there is different weather or time. To measure the position of shoreline, we often use the reference which is called shoreline indicators. A good shoreline indicator should be continuous, steady and can be recognized easily (Pajak and Leatherman, 2002). Shoreline indicator which is continuous means that it appears continuous in space; a steady shoreline indicator will be in the same position in different time. Last, shoreline indicator which can be easily recognized means different people can define the shoreline in the same place.

According to shoreline indicator should be continuous, steady and can be recognized easily, this study choose wet-dry line, vegetation line and water line as proxies for shoreline position. The definition and the position based on map of these indictors are shown in Table 1.

Table 1. The definition of shoreline indicator in this study.

Shoreline indicator	Definition	Position based on map
Water line	Between the sea surface and land.	The front edge of white spray, where has biggest contrast.
Wet-dry line	Between wet sand and dry sand.	The boundary line between black and white ribbon of beach surface.
Vegetation line	Coast perennial shrub or tree distribution of the outer edge.	Shrub (the leading edge of non-herbaceous plants, which has darker color).

2.3.2 Supervised Classification

The actual multispectral classification can be performed using a variety of methods, including the use of supervised or unsupervised classification logic (Jensen, 2007). In order to extract the information of shoreline, supervised classification approach with maximum likelihood algorithm was used to classify all images data into four categories, including the water body (included deep water and white wave), wet sand, dry sand and vegetation. Maximum likelihood algorithm is the algorithm which is based on probability. It assigns each pixels having pattern measurements or features X to the class i whose units are most probable or likely to have given rise to feature vector X (Lo and Yeung, 2002). Maximum likelihood algorithm used in supervised classification is shown as Fig. 4.

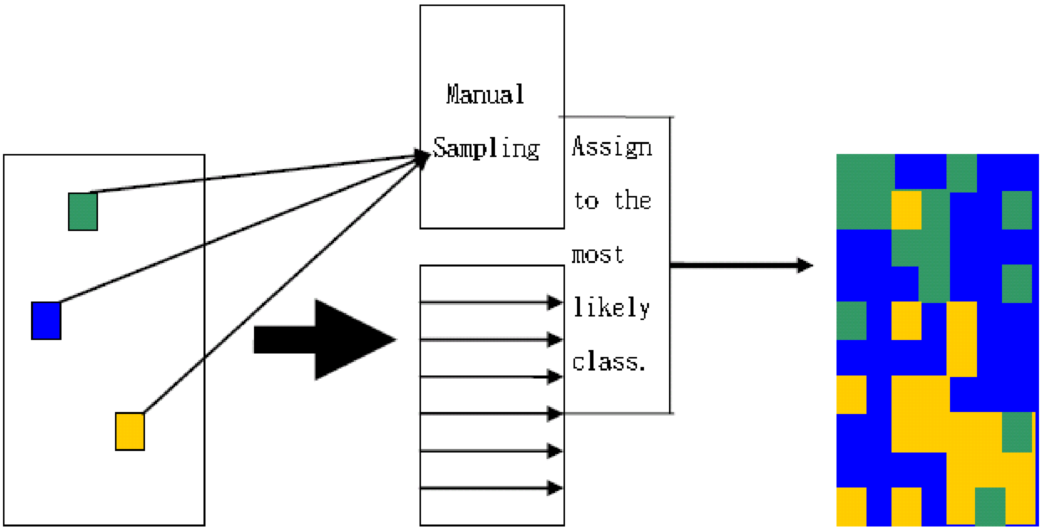


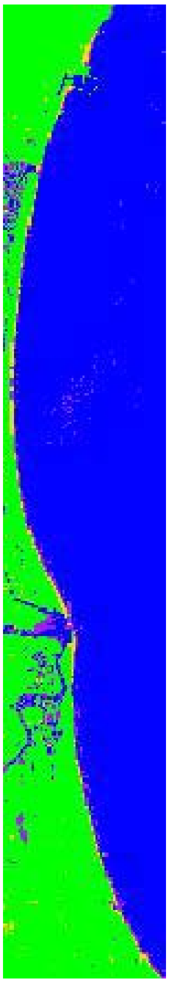
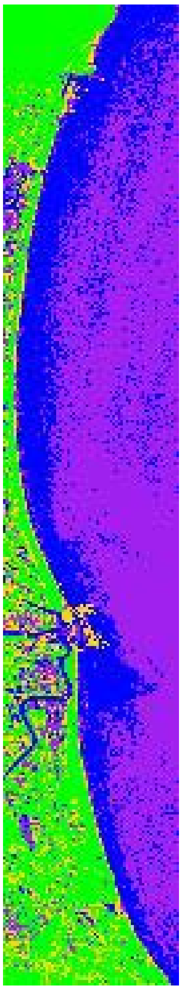
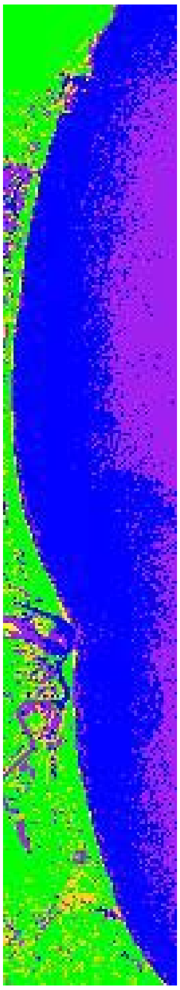
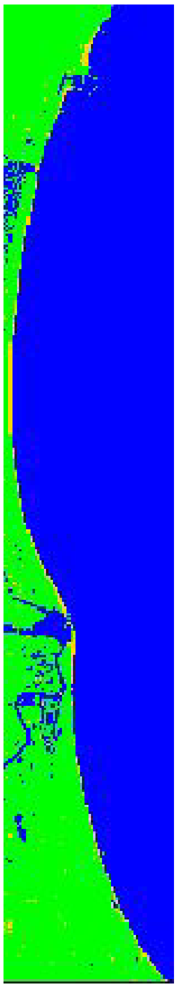
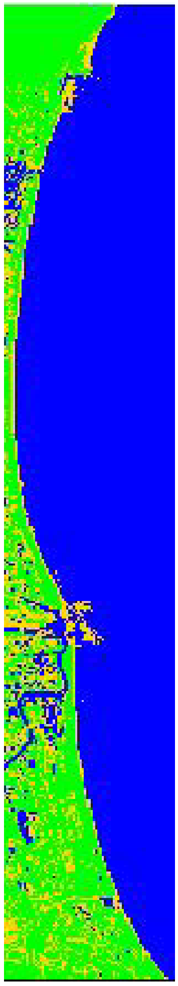
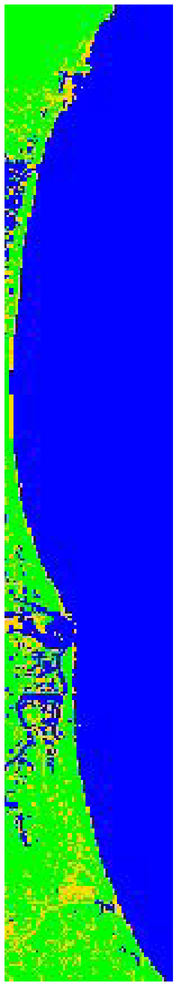
Fig. 4. Maximum likelihood algorithm used in supervised classification (Tsai, 2007).

3. RESULTS

3.1 Shoreline extraction using SPOT 5 Images

Shoreline extraction using SPOT 5 Images is shown as Table 2. As Table 2, the left part of the images are classified into four classes including the water body (blue, which included deep water and white wave), wet sand (purple), dry sand (yellow) and vegetation (green). We can easily find the right position of water line and vegetation line. However, the wet-dry line cannot define well because the spatial resolution is not high enough to distinguish wet sand and dry sand. Moreover, SPOT 5 classified images in 2006 and 2009 have some problem in classify wet sand and deep water, some deep water is classified into wet sand, that’s because the spectral of deep water is like wet sand. The right part of Table 2 is the results of classified images which only classified into three classes including water body (blue), sand (yellow, wet sand and dry sand together) and vegetation (green). The result shows that the deep water is classified into water body, and the water line and vegetation line can be extracted well.

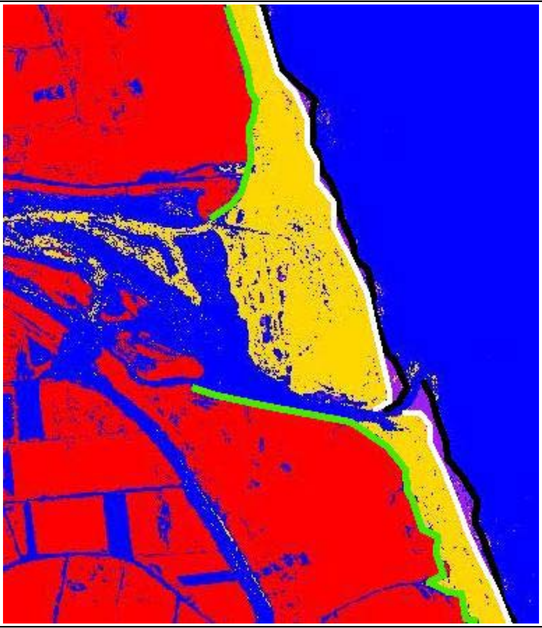
Table 2. Shoreline extraction useing SPOT 5 Images.

2003	2006	2009	2003	2006	2009
Wet sand and dry sand classified into different classes.			Wet sand and dry sand classified into same classes.		
					

3.2 Shoreline extraction using DMC Aerial Images

DMC aerial image has high spatial resolution, also, it includes the band of near-infrared, so it is very helpful for image classification. The result of shoreline extraction using DMC aerial images is shown as Table 3. Take the area of I-Lan estuary for example, we classified the images into four class, including vegetation (red), dry sand (yellow), wet sand (purple) and water body (blue). Than we can extract not only water line and vegetation line, but also wet-dry line. Furthermore, using the result, we can digitize the shoreline efficiently. As Table 3, the green line which is digitized is vegetation line; the black line is water line and the white line is wet-dry line. Jump to conclusion, it’s possible to classify DMC Aerial Images to extract the information of shoreline and get the detail information such as wet-dry line.

Table 3. **Shoreline extraction using DMC Aerial Images**

Original image	Result
	

3.3 Shoreline Change Detection Using Multitemporal SPOT 5 Images

We use SPOT 5 images acquired in 2003, 2006, and 2009 to extract the position of shoreline, and using GIS software to make overlay analysis. The result shows that shoreline changes was assessed. For example, the area of Nanya River (Fig. 5) has some changes about the water line; however, the vegetation line changes little. As Fig. 5, the red, green and blue lines which has been digitized represent the water line of 03, 06 and 09. And the white, gray and black lines represent the vegetation line of 03, 06 and 09 (they are almost overlapping). The results show that the grown of vegetation near costal changes little, but the area of sand has bigger difference. From 03 to 06, the area of sand piles up, and from 06 to 09 the area of sand erodes.

Fig 5. The change of Nanya River.

4. CONCLUSION

Using supervised classification to classify SPOT 5 images and DMC aerial images into classes including the water body, wet sand, dry sand and vegetation can extract the information of shoreline position or shoreline indicator such as water line and the vegetation line. However, the spatial resolution of SPOT 5 images are not high enough to get detail information. On the other hand, DMC aerial images have high resolution so that they can extract more information such as wet-dry line, but it might also cause salt and pepper effect which makes classification difficultly.

5. References

Lo C.P. and Yeung A.K., 2002. Concepts and Techniques of Geographic Information Systems, Upper Saddle River, NJ: Prentice Hall, pp.429.

Jan J.F., Hsu Y.C. and Wu C.D., 2010 Monitoring Landscape Changes of Coastal Zone Using Multi-temporal Remote Sensing Images. In: Asian Conferencr on Remote Sensing, Vietnam.

Jensen, J.R., 2007. Remote Sensing of the Environment, 2nd Edition, Prentice Hall, pp. 337.

Pajak, M.J. and Leatherman, S.P., 2002. The High Water Line as Shoreline Indicator, Journal of Coastal Reserach, Vol. 18, No. 2, pp. 329-337.

Tasi W.S., 2007. Applying SPOT-5 Satellite Imagery in Urban Area Green Degrees and Change Analysis–A Case Study in Tainan City Area, Master's thesis of Department of Earth Sciences, National Cheng Kung University.