Urban Change Detection of Pingtan City based on Bi-temporal Remote Sensing Images

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Abstract. In this paper, a pair of SPOT 5-6 images with the resolution of 0.5m is selected. An object-oriented classification method is used to the two images and five classes of ground features were identified as man-made objects, farmland, forest, waterbody and unutilized land. An auxiliary ASTER GDEM was used to improve the classification accuracy. And the change detection based on the classification results was performed. Accuracy assessment was carried out finally. Consequently, satisfactory results were obtained. The results show that great changes of the Pingtan city have been detected as the expansion of the city area and the intensity increase of man-made buildings, roads and other infrastructures with the establishment of Pingtan comprehensive experimental zone. Wide range of open sea area along the island coast zones has been reclaimed for port and CBDs construction.

1. INTRODUCTION
Currently, the development of marine economy and population has caused great pressure to coast areas as the immigration from inland to the developed coastal cities, and push the human beings to find new living space. Island coastal zones, which are specific ecosystems along east China, make great opportunity to the Chinese people. With the proposed strategy of “Marine Ecological Civilization (MEC)” and “One Belt, One Road” [1], more and more efforts have been made to exploit the islands. It is quite essential to monitor the dynamic spatio-temporal changes of islands caused by human actives such as urbanization and reclamations etc. Much more researchers have turned their focus to islands ecosystems monitoring using remote sensing images [2-4], and reasonable results have been achieved. The Pingtan city is located on the Haitan Island, which is the 5th largest island of China. As the starting point of the Maritime Silk Road and also an important strategic propeller to Taiwan, the state input on the economic development of the Pingtan has increased, and the infrastructure of the city has greatly improved. The extent of the city and the density of man-made features have increased obviously, which result in great pressure to ecosystem of the island and also the surrounding open sea as the increase of reclamation and the port constructions etc. It is quite essential to monitor the spatio-temporal urban changes over the whole city using multi-temporal and wide range remote sensing images.
Numerous applications and methods have been used for detecting urban LULC types and changes through time [5-6]. The post-classification change detection was used in this study. The object-based classification method was performed to two high resolution Worldview-II images, while a post-
classification change detection method was carried out in the following. Accuracy assessment was carried out and the performance of the results was discussed.

2. TEST SITE AND DATASETS
The study area is the city of Pingtan, Fujian province, China, and is located on the middle of Haitan Island which covers an area of more than 300km$^2$. The island is spread from 119º32´ E to 120º10´ in longitude and 25º15´ N to 25º45´ N in latitude. It is a tourist place as the specific landscape and the long shorelines with white beach all around the whole island. The main LULC types in and around the city are man-made object as buildings, roads and natural features as farmland, forest, unutilized land and water.

A pair of high resolution SPOT images was used in the study, and the images were shown in Fig1. The SPOT5 image was acquired on December 26th 2006, while the SPOT6 image was acquired March 7th 2013.

![Figure 1](image1.png)

Figure 1 Color images of the SPOT5-6 images, (a)-SPOT5 acquired on December 26th 2006, and (b)-SPOT6 acquired on March 7th 2013.

3. METHODOLOGY

The object-based classification method is utilized to the high resolution SPOT images using PCI and ArcGIS software. The PCI software was used for the image pre-processing and object-based classification, and the ArcGIS software was used to extract the change information of the LULC types. Both images were segmented into five classes as man-made object, forest, farmland, unutilized land and water. An auxiliary ASTER GDEM was used to improve the classification accuracy of features along the coastal areas. Post-classification comparison change detection was carried out to the classified images. And the change information about the LULC types was analysed finally.

The procedure can be described as follows: (1) Image preprocessing was done to two SPOT images including radiometric calibration, data fusion, and geometric registration. (2) Object-based classification using PCI images processing software was done the processed images. (3) Change detection using ArcGIS spatial analysis was performed. (4) Result analysis and discussion was carried out finally. The flowchart is shown in Fig.2.
4. RESULT AND DISCUSSION

4.1 Object-based classification

Image pre-processing was done firstly to the bi-temporal SPOT data, and then the object-based classification using PCI software was conducted in the following. Five classes were segmented as man-made object, water, forest, farmland and unutilized land from both the two SPOT images. Accuracy assessment of the two classified images was evaluated with the random selected 100 testing samples for each image. The overall accuracy is 86.66% with the Kappa coefficient 0.83 for the SPOT5 image, while the overall accuracy is 80.00% with the Kappa coefficient 0.69 for the SPOT6 image. The results were achieved and shown in Fig.3.

The results show that the spatial distribution of the five classes is quite different which indicate significant changes have been occurred to the whole island. Urban or man-made object has greatly extended, large area of open water has changed to man-made objects, and the road network has been formed across the island preliminarily. The area of agriculture land has decreased obviously. Forest has also increased especially in the south part of the island. The changes of unutilized land are also quite significant with the area around the city center and the marine reclamation areas changed into man-made objects.
4.2 Change detection

In order to get more precise change information and the possible reasons during this period, a post-classification change detection based on the ArcGIS spatial analysis was conducted. The result was shown in Fig.4.

Fig.4 shows the changes during the periods of the two images. The pink areas represent the LULC feature that stays the same, while the green ones indicates the features that changed from 2006 to 2013. Further analysis shows that great changes were occurred all over the whole island, and the most dramatic changes were detected on the west part. Accuracy assessment was conducted, and an overall accuracy of 70.00% with the Kappa coefficient 0.67 was achieved.

More analysis was conducted to identify the change types from the previous change image, and four different change images were got in Fig.5. The pink areas represent ground feature that are not changed. The blue, green, gold and grey color indicates the ground feature in 2006 is waterbody, forest, farmland and unutilized land respectively.

The first image in Fig.5 described changes from other ground features to man-made objects. It shows that a large amount of water areas has changed to man-made object, especially on the west side of the island. As the propose of “Pingtan comprehensive experimental zone” and the “Free trade zone” strategies, the development of the city infrastructure has become quite intense, and the pressure of limited land in the island pushed the development of reclamation industry, and forced the human beings to live near shore. The development of road network resulted in the changes from agriculture land and forest into man-made objects. The constructive activities also caused the changes from unutilized land into built-up areas.
The second image in Fig.5 shows the changes from the ground types to farmland. Further analysis revealed that most of the changes were from unutilized land to farmland, which may result from the growth of crops.

The third image in Fig.5 shows the changes to forest. We learn that most changes were from farmland and the unutilized land. This may be caused by the reforestations as the development of Pingtan International Tourism Island.

The last image in Fig.5 shows the changes to unutilized land. We find out that most changes were from water area, forest and farmland. Further analysis indicates that changes from water are also caused by human reclamation, and the changes from forest are probably deforestation caused by the strong and salty wind of the island in the east part of the island. Most changes from farmland were around the road construction areas.
5. CONCLUSIONS
In order to investigate the urban changes of the Pingtan Island, a pair of high resolution SPOT images was used. An object-based classification method using PCI software was performed firstly, and the post-classification comparison change detection method was carried out using the ArcGIS spatial analysis. Most of the changes occurred from 2006 to 2013 was detected, and the mainly change LULC type was the one changed into man-made object because of reclamation for port and CBDs constructions, and the type changed into forest came next. The main reason is possibly the propose of a series strategies to exploit the island with high state inputs and supports, which results in rapid development of the city area from the original inland to the reclamation land near the shore beach and the development of urban afforestation.

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