Heritage landscape structure analysis in surrounding environment of the Grand Canal Yangzhou section

Huan Xu
Department of Landscape Architecture, School of Geography, Geomatics and Planning, Jiangsu Normal University, Xuzhou 221116, China
xuhuan@jsnu.edu.cn

Abstract. The Yangzhou section of the Grand Canal is selected for a case study in this paper. The ZY-3 satellite images of 2016 are adopted as the data source. RS and GIS are used to analyze the landscape classification of the surrounding landscape of the Grand Canal, and the classification results are precisely evaluated. Next, the overall features of the landscape pattern are analyzed. The results showed that the overall accuracy is 82.5% and the Kappa coefficient is 78.17% in the Yangzhou section. The producer’s accuracy of the water landscape is the highest, followed by that of the other landscape, farmland landscape, garden and forest landscape, architectural landscape. The user’s accuracy of different landscape types can be ranked in a descending order, as the water landscape, farmland landscape, road landscape, architectural landscape, other landscape, garden and forest landscape. The farmland landscape and the architectural landscape are the top advantageous landscape types of the heritage site. The research findings can provide basic data for landscape protection, management and sustainable development of the Grand Canal Yangzhou section.

1. Introduction
The Grand Canal represents a crystallization of wisdom of ancient Chinese, and is a major heritage site of mankind flowing with vigor. On June 22, 2014, the 38th Session of the World Heritage Committee of the UNESCO decided to put the Grand Canal in the “World Heritage List” according to I, III, IV and VI selection criteria. Currently, protection of the Grand Canal is faced with a grim situation. Danger of further damage is looming. In particular, the heritage sites within the downtown areas and the built-up areas are suffering from continuous impacts from the urban development and construction. The Grand Canal is no longer the one in history. The surrounding environment of many heritage sites is worsening, with diversification of land uses and erection of high-rises. Mixture of modern styles has destroyed the overall harmony of the heritage itself, thus seriously influencing protection and demonstration of the canal heritage.

In the current stage, protection of the Grand Canal mainly concentrates on overview of the heritage application status (Zhu, 2012), overall management of the heritage (Wang, 2016), quantitative analysis (Wu, 2014), urban governance (Xu and Li, 2017; Zhong, 2017), and ecological environment protection (Shi and Zhang, 2015). Current research findings suggest that most scholars care about how to protect the Grand Canal itself, but usually ignore protection of the surrounding environments and landscapes closely connected with the Grand Canal. There are even fewer attempts are made to apply the RS and GIS technology to analysis and research of the surrounding environments and landscape pattern of the Grand Canal.
In this paper, the Yangzhou section of the Grand Canal is selected for a case study. The ZY-3 satellite images of 2016 are adopted as the data source. RS and GIS are used to analyze the landscape classification of the surrounding landscape of the Grand Canal, and the classification results are precisely evaluated. Next, the overall features of the landscape pattern are examined. All in all, this research is conducted at an attempt to provide basic data for better protection, management and sustainable development of the Grand Canal heritage sites.

2. Materials and methods

2.1. Overview of the research area
In Yangzhou City, there are six riverways listed in the first batch of heritage application. They are the Huai-Yang Canal Yangzhou section, the Ancient Hangou Riverway, Gaoyou Ming and Qing Dynasty Former Grand Canal Riverway, Jiangdu Shaobo Ming and Qing Dynasty Former Grand Canal Riverway, Yangzhou Ancient Canal, and Hanjiang Guazhou Canal. The research scope in this paper is determined by extending the remote sensing images of the heritage to 3km in the surrounding area with the Grand Canal riverway central line. The total area of the Yangzhou section is 827.68km2.

2.2. Data preprocessing
The ZY-3 satellite multispectral images of 8 landscapes captured from June 2016 to September 2016 are adopted as the remote sensing data of this research. The ZY-3 satellite is the first domestic high-resolution, stereo mapping satellite in China. The main payload of the ZY-3 satellite includes a camera aligned normal to the Earth’s surface, which can produce images with a spatial resolution of 2.1 m; another two cameras, offset at 22 degrees forward and after, with a spatial resolution of 3.6m; and one multispectral scanner (IRMSS) with a spatial resolution of 5.8m. ENVI 5.1 and Arc GIS 10.0 are used for preprocessing of the remote sensing images.

The formula using the absolute radiometric calibration coefficient to convert the digital number (DN) of the multispectral image into the DN of the radiance image can be written as below:

\[ L = \text{Gain} \times \text{DN} \quad (1) \]

Where, \( L \) is the converted radiance (in W·m\(^{-2}\)·sr\(^{-1}\)·μm\(^{-1}\)); \( \text{Gain} \) is scaling gain; \( \text{DN} \) is satellite load observation.

2.3. Classification of landscape types
The Support Vector Machine (SVM) is combined with visual interpretation for classification of images after preprocessing. According to classification of previous scholars and the land use remote sensing classification system of China, and combining the research area with the remote sensing images, the surrounding landscape of the Grand Canal Yangzhou section is divided into six types, namely the farmland landscape, garden and forest landscape, water landscape, architectural landscape, road landscape, and other landscape.

2.4. Accuracy assessment
The confusion matrix is an analytical method widely adopted for accuracy classification of remote sensing classification (Foody, 2002). In this research, the accuracy assessment indexes include the overall accuracy, producer’s accuracy, user’s accuracy, and Kappa coefficient based on the confusion matrix.

3. Results and analysis

3.1 Remote sensing image preprocessing results
The absolute radiation calibration coefficient of the ZY-3 satellite multispectral camera is shown in Table 1. The radiance images of remote sensing image can be obtained using Eq. (1). After radiation correction of remote sensing images, image registration is realized through the image-image method.
The registration control points are located on the road intersections, corner points and the center of identifiable surface features. The control points are on the whole evenly distributed, covering the whole heritage area. The math precision is controlled within 0.5 pixel.

**Table 1.** The absolute radiation calibration coefficient of the ZY-3 satellite.

| Satellite payload | Band  | Spectral range(μm) | Coefficient gain |
|-------------------|-------|--------------------|-----------------|
| ZY-3 multispectral camera | Band-1 | 0.45 ~ 0.52        | 0.2525          |
|                   | Band-2 | 0.52 ~ 0.59        | 0.2253          |
|                   | Band-3 | 0.63 ~ 0.69        | 0.1791          |
|                   | Band-4 | 0.77 ~ 0.89        | 0.1942          |

Then, the 2.1m high-resolution image CCD (Charge Coupled Device) data and the 5.8m multispectral data obtained by the ZY-3 satellite are integrated. Pansharpening algorithm of PCI Geomatica, a remote sensing desktop software package, is employed to not only improve the spatial resolution rate, but also preserve the primitive multispectral image. Finally, images are embedded and undergo color unification to avoid color differences caused by differences of imaging dates and weathers, and ensure the overall color unity (Fig. 1).

**Figure 1.** The image preprocessing results of Yangzhou section

3.2 Accuracy evaluation

Verification of the image landscape classification is an indispensable link, and it is the linchpin to accuracy and reliability of classification. 200 points are randomly chosen from the Yangzhou section for verification. The overall accuracy, producer’s accuracy, user’s accuracy and Kappa coefficient of landscape classification are computed, respectively. According to the confusion matrix generated by the verification process, the overall accuracy of the Yangzhou section is 82.5%. The producer’s accuracy and user’s accuracy of the heritage areas can be obtained by confusion matrix. The results are shown in Figure 2.
In the Yangzhou section, the producer’s accuracy of the water landscape is the highest (85.29%), followed by that of the other landscape (83.33%), farmland landscape (83.05%), garden and forest landscape (82.35%), and architectural landscape (81.82%). The road landscape has the lowest producer’s accuracy, which is 78.57%. The user’s accuracy of different landscape types can be ranked in a descending order, as the water landscape (87.88%), farmland landscape (84.48%), road landscape (81.48%), architectural landscape (80.00%), other landscape (78.95%), garden and forest landscape (77.78%).

The Kappa coefficient of the Yangzhou section is 78.17%. The computing results suggest that the overall accuracy of the heritage areas as well as the producer’s accuracy and user’s accuracy of different landscape types has exceeded 75%. Thus, these data can serve research of this paper.

3.3 Landscape structure analysis

Analysis of the landscape classification structure of the Grand Canal can help gain a better understanding of the regional landscape spatial distribution and the landscape functions. It is also a prerequisite for landscape protection and management. The landscape classification structure of the Grand Canal Yangzhou section is shown in Table 2. The total area of the Yangzhou section heritage area is 827.68 km², the farmland landscape covers the largest area, about 437.47 km², accounting for 52.86%. In the second place is the architectural landscape, which covers an area of 217.62 km², accounting for 26.29% of the total. It is followed by the water landscape, road landscape and other landscape, covering an area of 134.86 km² (16.29%), 16.95 km² (2.05%) and 13.95 km² (1.69%), respectively. The garden and forest landscape is the smallest, only being 6.83 km² and accounting for 0.82% of the total (Fig. 3).

According to the above percentage of different landscape types, it can be observed that the advantageous landscape type is the farmland landscape and the architectural landscape. The third most dominant landscape to both is the water landscape. This is because Jiangsu province is dominated by the landform of plains. Statistics suggest that the percentage of plains and waters in Jiangsu accounts for more than 90% of the total. That is why the farmland landscape is a dominant landscape, and the forest landscape is quite low in percentage. The Yangzhou section heritage area meanders through the suburbs, thus being connected with many lakes and rivers. This justifies for a higher percentage of the water landscape in the Yangzhou section.

**Figure 2.** The producer’s accuracy and user’s accuracy of Yangzhou section heritage area
4. Conclusions
In this paper, the ZY-3 satellite images are adopted as the data source. RS and GIS are used to analyze the landscape classification of the surrounding landscape of the Grand Canal, and the classification results are precisely evaluated. Next, the overall features of the landscape pattern are analyzed. The main conclusions are drawn as follows:

The total area of the Yangzhou section heritage area is 827.68 km², more than half of which is the farmland landscape (52.86%), followed by the area of the architectural landscape (26.29%), water landscape (16.29%), road landscape (2.05%), other landscape (1.69%), garden and forest landscape (0.82%). The farmland landscape and the architectural landscape are the top advantageous landscape types of the heritage areas, and the water landscape is the third most advantageous.
Based on the confusion matrix, the classification accuracy can be computed. Computing results show that, in the Yangzhou section heritage area, the overall accuracy is 82.5% and the Kappa coefficient is 78.17%. The producer’s accuracy of water landscape is the highest, reaching 85.29%, the producer’s accuracy of the road landscape is the lowest (78.57%). In terms of the user’s accuracy, the water landscape is the highest, reaching 87.88%, the garden and forest landscape has the lower user’s accuracy (77.78%).

Acknowledgments
This study was supported by the National Natural Science Foundation of China (Grant No. 31500579), and the Natural Science Foundation of Jiangsu Province (Grant No. BK20150231).

References
[1] Foody G. M. (2002). Status of land cover classification accuracy assessment, Remote Sensing of Environment, Vol. 80, No. 1, pp. 185-201.
[2] SHi L., ZHang C. (2015). Chinese Grand Canal Ecological Condition Analysis and Some Suggestions on Landscape Construction-A Case Study of Beijing-Hangzhou Canal, Journal of Anhui Agricultural Sciences, No. 28, pp. 197-200.
[3] Wang X. (2016). The Preservation of the Grand Canal(Hangzhou Section) in the Post-UNESCO-World-Heritage-Bid Period: “Integrity” as A Focus, Southeast Culture, No. 6, pp. 20-26.
[4] Wu D., Wang P., Zhou G., Mao L. (2014). Economic Evaluation of Huai’an Section of the Beijing-Hangzhou Grand Canal, Journal of Huaiyin Institute of Technology, Vol. 23, No. 4, pp. 1-5.
[5] Xu H., Li H. (2017). Total Amount Calculation and Health Benefit Assessment of PM2.5 Adsorbed by Urban Green Space in Xuzhou City, China. Nature Environment and Pollution Technology, 16(1): 81-88.
[6] Xu Q., ZHeng X. (2015). Tracing the Source of “Shan-shui City”: The Natural Resource Structure and the Development of Regional Landscape System in Suzhou City, Landscape Architecture, No. 10, pp. 85-91.
[7] Zhong X. (2017). The Contributions Of The Agencies Of Canal Watercourse Management To Urban Construction In Jining City On The Perspective Of Management System Operation In Qing Dynasty, Architecture & Culture, No. 4, pp. 181-183.
[8] Zhu G. (2012). The Cultural History and New Cause of the Grand Canal: A Review on the Making of the Master Protection Plan and Applying for the World Heritage Status, Southeast Culture, No. 5, pp. 6-17.