Research on Water Body Information Extraction and Land Use Status of Nansi Lake Based on high-resolution images

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Abstract. The acquisition of surface water information is of great significance to environmental protection and rational development and utilization of water resources. With the rapid development of remote sensing technology, it has many advantages, such as large coverage, fast acquisition of information, short period, large amount of information, etc. It can provide large-scale and multi-dimensional data, which plays an important role in further research of Nansi Lake. In this paper, the PMS multi-spectral data of January 2019 was used as the data source, and the land use classification of Nansi Lake based on the eCognition software. Normalized water index extraction (NDWI) was used to extract water body information of Nansi Lake.

1. Introduction
Located in the southwestern part of Shandong Province, Nansi Lake is the largest freshwater lake in North China, the most important water source and biodiversity conservation area in Shandong Province, and an important water source storage area for the South-to-North Water Diversion Project. It has the functions of regulating River runoff, providing agricultural and living water sources and improving regional ecological environment[1]. The lake basin is shallow and flat, with a high terrain in the northeast and a low one in the southwest. Nansi Lake, as a small-scale watershed in natural region, has unique hydrological cycle and energy exchange characteristics, so its land use has far-reaching impact on its own and even larger-scale natural ecosystem[2]. Using remote sensing to study water information and land use status of Nansi Lake can provide scientific basis for environmental protection and sustainable development of ecosystem in Nansi Lake Basin, and will have a profound impact on climate, ecological process and biodiversity of natural ecosystem.

Figure 1. Remote Sensing Image Map of Nansi Lake.

2. Land use classification
2.1. eCognition Object-Oriented Classification
eCognition is a professional classification software for remote sensing images, which uses a new object-oriented image classification technology to classify images and extract information. Compared with traditional image classification and information extraction, object-oriented remote sensing image analysis technology is mainly characterized by information extraction based on image space and spectral information. It is more suitable for high resolution images with rich geometric and structural information[4]. The core idea adopted by eCognition is the fuzzy classification method of decision support, which gives the degree of membership of the object to all defined types, and the maximum degree of membership will determine the type of the object[5].

ECognition makes full use of the rich spatial information of high-resolution images, automatically extracts ground objects and outputs polygons with attribute tables, which makes the classification results closer to visual interpretation and effectively improves the classification accuracy.

2.2. Land Use Status of Nansi Lake

Traditional methods of Lake field survey need a lot of manpower and material resources, and it is difficult to obtain the whole land use information of Nansi Lake by conventional observation methods due to the limitation of environmental conditions. Remote sensing information has become an important means of land use research because of its wide coverage, strong real-time and high accuracy. Therefore, using remote sensing images to analyze the water body information and land use status of Nansi Lake can obtain more real-time and accurate results.

The remote sensing image data source in this study area is the high score No. 1 PMS full-color spectral image. The image acquisition period is January 2019, which is basically cloudless and has good image quality. Through the PIE high-resolution image processing software, the image fusion Pansharp fusion is used to fuse the high-resolution PMS8m multi-spectral data into 2m image data, including blue band, green band, red band, near-infrared band, and radiation correction. Image stitching and image cropping. According to the actual situation of Nansi Lake Basin and the National Land Classification in 2001, the land features in the study area are divided into nine categories: waterway, urban land, river, Lake area, forest land, irrigated land, paddy field, unused land and aquaculture water surface, as shown in Table 1.

In this paper, the eCognition image processing software is used to classify the land use in the Nansihu watershed. The structure performs hierarchical layering on the ground objects to mask the non-target land types[6]. The land use classification results of Nansi Lake Basin in 2019 are finally obtained by assigning different color representations to different land types, as shown in Figure 2. The total area of the study area is 2643.44 km². The statistical results of the area and percentage of bells and fields are shown in Table 2. In 2019, the vegetation area of the study area was 1205.22 km², including woodland, irrigated land and paddy field, accounting for 45.59% of the total area of the study area, as shown in Figure 3. In 2019, the water area of the study area was 916.09 km², including waterways, rivers, lakes and aquaculture waters, accounting for 34.66% of the total area of the study area. A large area of open water was mainly distributed in Dushan Lake and Weishan Lake, as shown in Figure 4.

Table 1. Nansi Lake Land Use Classification Details

| Classification | Code | Meaning | Legend |
|----------------|------|---------|--------|
| The channel    | 10   | South-to-North Water Transfer Channel |
| Classification    | Area (km²) | Percentage (%) |
|-------------------|------------|----------------|
| Urban land        | 11.16      | 0.42           |
| River             | 484.72     | 18.34          |
| Lake District     | 497.86     | 18.83          |
| Woodland          | 7.62       | 0.29           |
| Irrigated land    | 947.82     | 35.86          |
| Paddy field       | 249.78     | 9.45           |
| Unutilized land   | 37.41      | 1.42           |
| Aquaculture water| 401.61     | 15.19          |

**Table 2. Statistical tables of various types of areas**
3. Water information extraction

Normalized Water Index (NDWI) is a normalized ratio index based on near infrared band and green band. It extracts water body by restraining vegetation and soil information. NDWI is widely used in water body extraction from remote sensing images. The formula is as follows

\[ NDWI = \frac{(\rho_{\text{Green}} - \rho_{\text{NIR}})}{(\rho_{\text{Green}} + \rho_{\text{NIR}})} \]  \hspace{1cm} (1)

In the formula: Green represents the green band; NIR represents the near infrared band.

Remote sensing image records the reflection information of surface objects to electromagnetic wave and their radiation information emitted outward. The spectral characteristics of surface objects are the basis of remote sensing image recognition. Lakes have the characteristics of water spectral curve, and generally show a weak reflectivity compared with other land information. The reflectivity of water body decreases gradually from visible to mid-infrared bands, and the blue light reflects the most in visible light. It absorbs the strongest in the range of near infrared, mid-infrared and short-wave infrared wavelengths, and almost absorbs all incident energy. Soil and vegetation absorb less energy in infrared band and have higher reflectance, which is different from water body. Therefore, NDWI extraction method is more suitable for water body information extraction with vegetation background\(^7\). The NDWI values are in the range of -1 to 1, where the threshold value is between 0 and 1, and the reflectivity of clear water is close to 0 in the range of visible light. NDWI increases the brightness of the water body by ratio calculation, and inhibits the non-water body generally, so as to achieve the purpose of highlighting the water body\(^8\). Selecting green band remote sensing data and near infrared band remote sensing data to construct NDWI can restrain vegetation information to the greatest extent. In NDWI data, the water body value is the largest, and the information of Nansihu Lake area can be extracted accurately by appropriate threshold.

Expansion or atrophy of lake surface is an important indicator of lake ecological environment change. By extracting the water information of Nansi Lake, we can get a better understanding of the ecological environment of Nansi Lake. There are 80 sampling points in Nansihu Lake in this paper. The NDWI index of each sampling point and its corresponding topographic details and distribution are shown in Figure 5. The distribution of NDWI index in Nansihu basin is shown in figure 6. According to NDWI index, the Nansihu Lake area is divided into turbid water area, aquatic grassland area, clear water area and Wumaosong aquatic grassland area, as shown in figure 7. The water area extraction, the inversion period based on NDWI index is January to December, 2015. The water area of the lake is shown in Figure 8. According to area statistics, the lake area in January is 109.65 km\(^2\), the maximum area in April is 1254.867 km\(^2\), the minimum area in July is 854.033 km\(^2\), and the lake area rises to 914.961 km\(^2\) in October.
4. Conclusion

By using eCognition image processing software to classify the land use of high-resolution images in Nansi Lake basin in 2019, the results show that Irrigated land area is the largest, accounting for 35.86%, mainly distributed in the northeastern part of the lake area; followed by Lake area and urban land, accounting for 18.83% and 18.34% respectively; aquaculture water surface is scattered throughout the lake area; paddy field is mainly distributed in the area of Dushan Lake and Weishan Lake, and a large area of open water is concentrated in Dushan Lake and Weishan Lake.

Using the method of normalized water body index extraction to extract the water body information of Nansihu Lake area, we can see that the southern water body of Nansihu Lake area is turbid, the clear water area is mainly concentrated in the central part of Nansihu Lake area, the aquaculture area is scattered, and the water grass area of Wumao Song is distributed in Weishan Lake area; in the water body area extraction based on NDWI index in 2015, the maximum lake surface area in April is 1254.867 km², and the lake in July. The minimum area is 854.033 km².

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