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Information extraction of Baiyangdian wetland based on GF-2 remote sensing data

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Abstract: The study on monitoring the water body range of Baiyangdian and the change of wetland information by means of remote sensing is of great significance to ensure the ecological security of Xiong'an New Area. This paper was conducted using the GF-2 remote sensing data on March and October 2018. The study was to provide an extraction model basing on NDVI-NDWI method, which compare with traditional supervised classification method. The selected sample points by using visual interpretation verified the extracted wetland information. The results show that the classification and extraction of Baiyangdian wetland information are carried out by using the model and supervised classification method respectively, and the wetland area (in which) is obtained in March. The precision of the sample points and the extracted wetland information are all above 90%, and the NDVI-NDWI method is constructed based on the NDVI-NDWI method. The extraction model is more accurate. Since the bare waters in March were 102.31 km², 28.27 km² more than in October; the area of aquatic plants extracted in October increased significantly from 122.57 km² in March to 154.5 km². It can be seen that the information of Baiyangdian wetland changes with the growth of aquatic plants. The model established by the institute can accurately extract the information of Baiyangdian wetland and provide a scientific reference for the planning and management of Xiong'an New District.

1. Introduction

Baiyangdian is the largest freshwater lake in North China. It is the most typical and representative lake and herb swamp-type wetland in northern China. It brings together nine rivers in the south, west and north, and then passes through the Daqing River in the east of Dianbo. Flowing down the river into the Bohai Sea, Baiyangdian has a significant impact on the ecological environment of North China. It is known as the "Kidney of North China" and has many natural ecological service functions such as regulating climate, conserving water sources, purifying pollutants, and maintaining biodiversity [1]. In particular, in 2017, with the



implementation of the national strategic plan for the establishment of a new state-level new district, Xiong'an New District, Baiyangdian, as the core water area of Xiong'an New District, carries a more special ecological, production and living service function [2]. The aquatic plants have always been the dominant vegetation type in the Baiyangdian wetland. The area of the reed marshes in Baiyangdian wetland is much higher than that in the Mingshui surface. In recent decades, due to improper protection and unreasonable utilization of water resources in the region, the water area in the area has decreased, the proportion of aquatic plants in the wetland has gradually increased, and the lake wetlands have the trend of ecological reverse succession towards the marsh wetland [3],[4].

There are many studies on monitoring, analysis and extraction of wetland information at home and abroad. Pan *et al.* [5],[6] carried out remote sensing extraction of wetland waters and gave a quantitative method for obtaining water body information by remote sensing. In recent years, research on the water body changes in the Baiyangdian Basin has achieved certain results. Zhang Suzhen [2] also carried out corresponding remote sensing extraction of the water body area of the Baiyangdian wetland. Shen Zhanfeng *et al* [7] used the NDWI and GNDWI methods to calculate the water body information of the Baiyangdian wetland, which improved the water body extraction accuracy. Lin Yibo *et al.* [8] used the NDWI index method to extract the information of Baiyangdian wetland and studied the relationship between wetland area and water level. However, these studies are limited to the classification and extraction of water surface and vegetation area in Baiyangdian wetland, and the research on the classification of wetland information by fine-resolution data is almost blank. Therefore, on the basis of previous studies, this paper uses the high-resolution satellite high-resolution satellite (GF-2) remote sensing image to study the spectral law of various wetland information in Baiyangdian, and establishes a model for extracting Baiyangdian wetland information. It also analyzes the variation characteristics of different vegetation growth stages in the dewatering area, and it is of great significance to effectively identify various types of ground information. It provides technical support for the ecological protection and restoration of Baiyangdian Lake. Integrated environmental management has important guiding significance.

2. Data source and method

2.1. Overview of the study area

Located in the central part of Hebei Province, Baiyangdian is located in the hinterland of Beijing-Tianjin-Hebei, a large plain in the middle of the Daqing River system. It is the largest natural freshwater body in the North China Plain. It consists of Baiyangdian, Algae Lake, Mazhandian, Yaolulu Lake, etc. a combination of different sizes of lakes, rich in aquatic organisms such as plankton, benthic animals, fish and aquatic plants, etc. Baiyangdian Administrative Region is subordinated to five counties and cities such as Xiongxian, Rongcheng and Anxin in Baoding City and Zhangzhou City [9]. It is the most important water body functional area for maintaining ecological balance within the jurisdiction of Xiong'an New District. It has a non-negligible effect on the construction of the new district [10]. Baiyangdian area overview is shown in Figure 1.

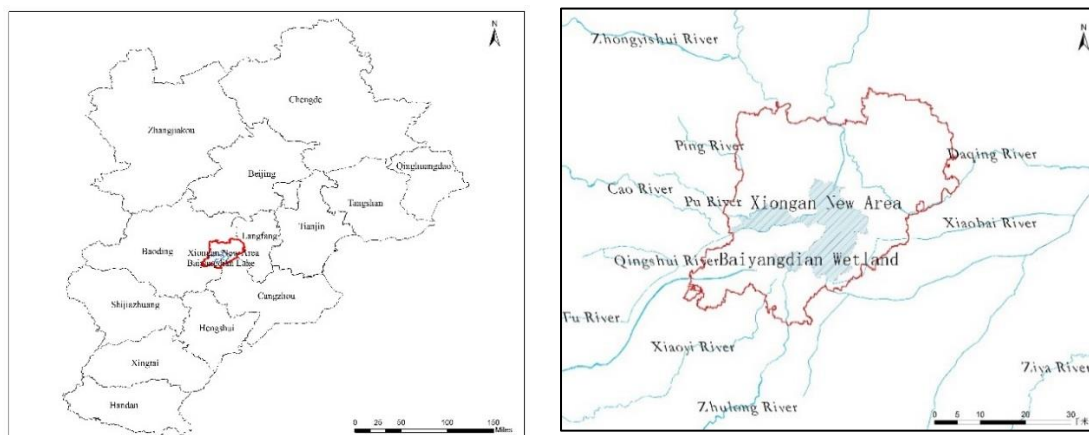


Figure 1. Overview of the study area.

2.2. Data source

2.2.1. GF-2 remote sensing data. In this paper, the high-resolution 2 (GF-2) satellite PMS2 L1A image is used as the remote sensing data source. The data is obtained from the China Resources Satellite Application Center. The data contains a full-color image with a resolution of 1 m and a multi-spectral image with a resolution of 4 m, representing different stages of the growth period of aquatic vegetation in the Dianchang District. The preprocessing of remote sensing image data is mainly done in envi5.3 software. Image preprocessing is processed as follows:

- Geometric correction: correction by ground control points; geometric fine correction of images can be performed by means of quadratic polynomial, etc., and other images can be registered by using the corrected images.

- Image fusion: Image fusion is processed by Gram-Schmidt method, which can maintain the consistency of spectral information before and after fusion. It is a high-fidelity remote sensing image fusion method. The fused image retains multi-spectral features with a spatial resolution of 1 meter.

- Mosaic and crop: The necessary inlays and crops are performed according to the calculation range, image coverage, and results.

2.2.2. Meteorological and hydrological data. The meteorological data comes from the Hebei Meteorological Information Center. The selected sites include Yixian, Gaobeidian, Rongcheng, Xushui, Baoding, Gaoyang, Anxin, Renqiu, Mancheng, Xiongxian, Dingxing and Qingyuan counties. Meteorological data includes monthly precipitation.

The Baiyangdian wetland water level data is derived from the Anxin County Water Resources Bureau. Due to the influence of the climate, the Baiyangdian wetland is in the icing period every year and February, so the local hydrological department only records the water level data from March to December.

3. Research method

There are many kinds of features in the Baiyangdian wetland, and the spectral segments of different features are closely related. The main performance is as follows: there is great similarity between similar features in GF-2 satellite imagery, but there are some differences among the spectral features. Therefore, according to the imaging characteristics of the study area, two classification methods, NDWI-NDVI method and supervised classification method, were selected for comparative analysis.

3.1. NDWI

The core idea of water body remote sensing recognition technology is to use the spectral reflectance characteristics of water bodies at different wavelengths and the difference between

them and the background objects, to find the strongest reflection band and the weakest reflection band of the water body, and then through the ratio calculation method, etc. The water body obtains the maximum brightness enhancement on the generated index image, and other background objects are generally suppressed, so as to enhance water information, suppress confusing non-water features, and further widen the gap between water and other features. In general, the reflectance of water has the strongest reflection in the visible light and the strongest in the green light band, and the difference in the band is large, and then gradually decreases as the wavelength increases. This is obviously different from the spectral characteristics of the non-water object. Many scholars have constructed a ratio-type water body index to achieve the effect of highlighting water information in images [7]. However, the widely used one is mainly the normalized difference water index (NDWI) proposed by Mcfeeters [11]. The index is calculated as follows:

$$NDWI = (p(Green) - p(NIR)) / (p(Green) + p(NIR))$$

R_{NIR} represents the near-infrared channel reflectivity and R_{Green} represents the green channel reflectance. They each correspond to the 2nd and 4th bands in the GF-2 image.

3.2. NDVI

The Baiyangdian wetland type is more complicated. In addition, the NDWI index uses a normalized ratio operation, which can eliminate the influence of terrain differences to some extent. However, when the vegetation in the local-shaped shadow area is dominated by vegetation, the NDVI index, which is more sensitive to plant growth status and spatial distribution density, can weaken the influence of topographic shading more than the NDWI index [12]. Therefore, the NDVI and NDWI indices are used to analyze the performance characteristics of confusing objects such as water bodies, construction land and terrain shadows, and other features. The specific calculation method for this index is:

$$NDVI = (p(NIR) - p(Red)) / (p(NIR) + p(Red))$$

R_{NIR} represents the near-infrared channel reflectivity and R_{Red} represents the red channel reflectivity. They each correspond to the 4th and 3rd bands in the GF-2 image.

3.3. Supervised classification

The supervised classification method of remote sensing image is also called the training field method. It extracts the training samples of each category on the training ground of known categories. By selecting the characteristic variables, the discriminant function or discriminant is determined, and each pixel point in the image is classified. To each given classification is a method of pattern recognition [13]. The advantage of this method is that the classification result is in good agreement with the actual ground object, but the model is more complicated, the workload is larger, and subjective influence is serious. The purity requirement of the classification template is relatively high, and the training area is required to be typical. And representative, its accuracy is higher, but the scope of application is limited, it needs to manually select samples, can not achieve automatic extraction and needs to be used in places with prior knowledge. In this paper, a large number of samples are randomly selected in Baiyangdian image, and the classified wetland information extraction image is obtained.

3.4. Classification of wetland information in the study area

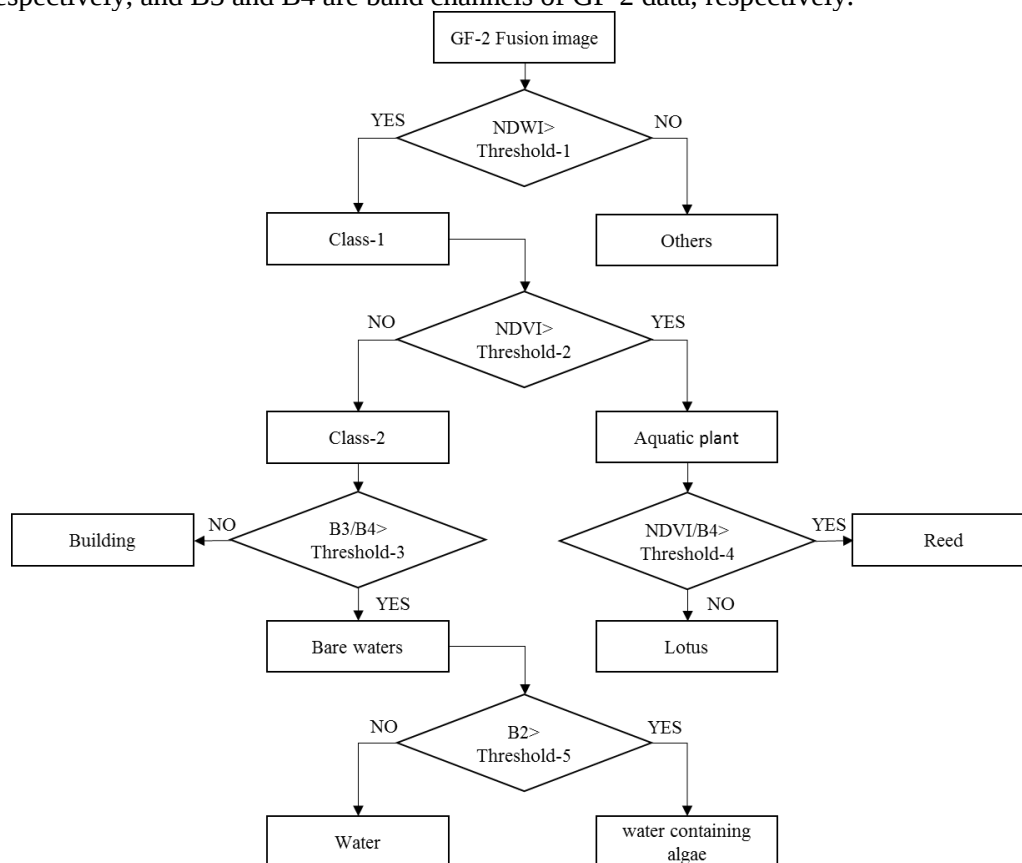
This research area is a typical wetland ecological environment. There are various types of wetland information in the area. Typical features include water bodies, buildings, and aquatic plants. Therefore, according to the actual geographical situation of Baiyangdian wetland, combined with the national wetland classification standard, a three-level classification system of Baiyangdian wetland was established, as shown in Table 1.

Table 1.Baiyangdian wetland information classification.

Level-1	Level-2	Level-3
Wetlands	Bare waters	Water
		Water containing algae
	Aquatic plant	Reed
Other		Lotus
	Building	Villages
	Farmland	Agricultural land

3.5. Wetland information extraction model

According to the GF-2 data, the variation of the spectral characteristics of Baiyangdian wetland information was analyzed. The information extraction model of Baiyangdian wetland based on NDVI-NDWI method was established. The wetland information extraction process is shown in Figure 2. The model uses the spectral reflection characteristics of the local object information to classify the wetland information. The threshold 1, the threshold 2, the threshold 3, the threshold 4, and the threshold 5 are feature determination thresholds, respectively, and B3 and B4 are band channels of GF-2 data, respectively.

**Figure 2 .**Wetland information extraction model.

4. Wetland information extraction analysis

The Baiyangdian wetland belongs to the warm temperate and semi-arid areas of the eastern monsoon region. The continental climate is characterized by significant characteristics. The wetland information is greatly affected by precipitation, and the seasonal changes are obvious. The main changes are in the area of vegetation and water, and the icing period (1) February) is longer. The best growth period of main aquatic vegetation such as reeds and lotuses in Baiyangdian wetland is from June to October every year. It is determined that March and October are typical months of the dry and wet seasons of the Baiyangdian Wetland. After data screening, two high-resolution images were extracted, and the imaging time of the data was

2018-03-22 and 2018-10-10.

Using the wetland information extraction model and the supervised classification method, the two-stage wetland information classification results in the study area were obtained (see Figure 3). It can be seen that the wetland information extraction model and the supervised classification method can extract most of the wetland information of the Baiyangdian wetland. The main constituents include bare water and aquatic plant areas, and some of the ground objects are relatively fragmented. In March, there were many bare water bodies in the Baiyangdian wetland, and some paddy fields were bare. The wetland information extraction model and the supervised classification method can accurately identify the water body. However, since the main aquatic plants (reeds and lotuses) in the Baiyangdian wetland have not yet entered the growth period, the spectral characteristics of the plants are not obviously, there are some differences between the two methods in the recognition of reeds and lotuses. In October, the main aquatic plants in the Baiyangdian wetland were at the end of the growing season, and the plants grew vigorously. Most of the waters were covered by reeds and lotuses. The wetland information extraction model and supervised classification method were effective in identifying aquatic plants, but in some local areas. There are still some differences in the extraction results of the two.

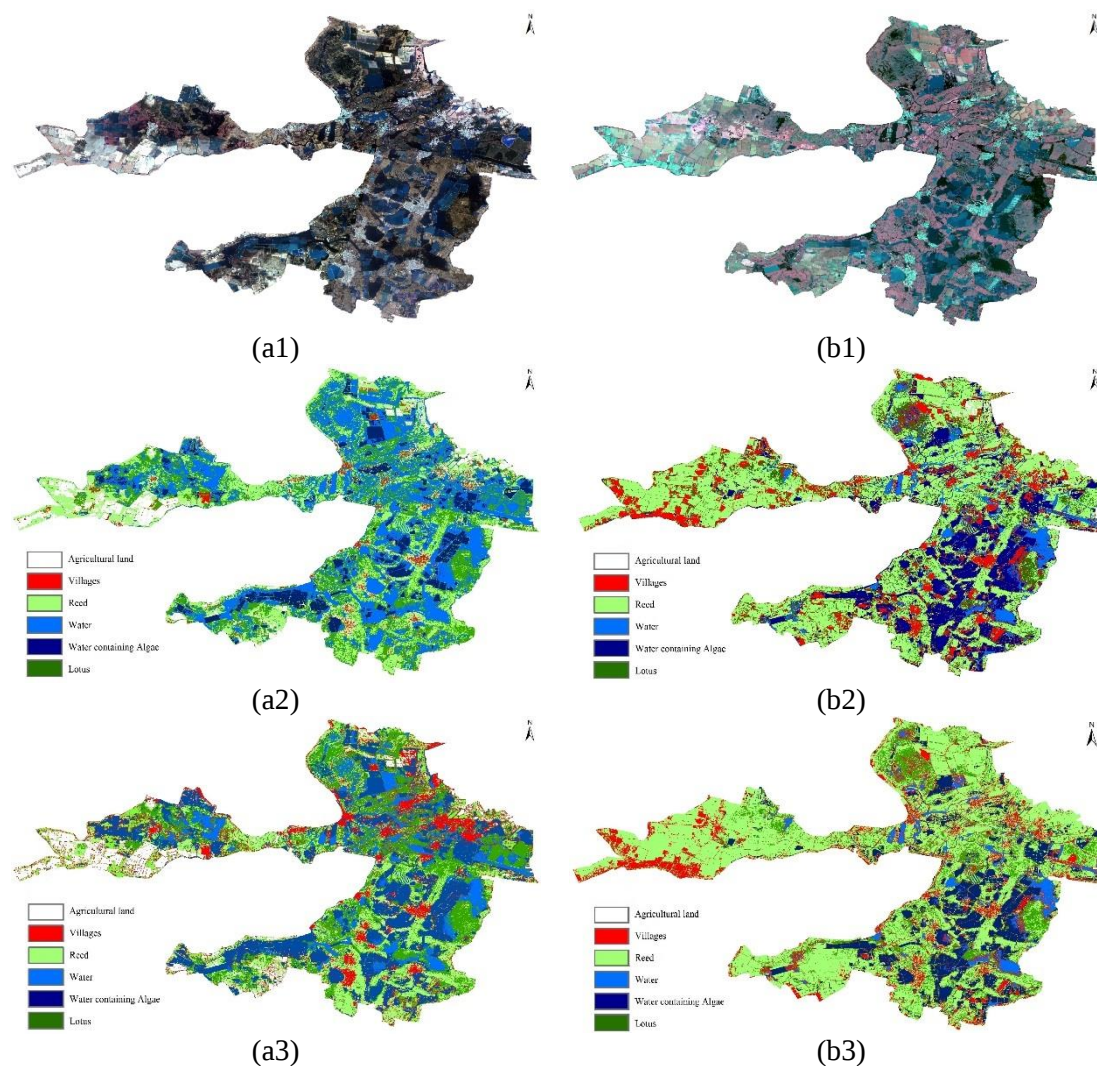


Figure 3. Baiyangdian wetland information. (a1. 3 month Baiyangdian wetland image; a2. model extracted March wetland type; a3. Supervised classification method to extract March wetland information; b1. 10 month Baiyangdian wetland image; b2. model extracted October wetland information; b3. Supervised classification method to extract wetland information in October.)

In order to quantitatively compare the extraction precision of the two wetland information extraction methods, the Kappa coefficient is used to evaluate the accuracy of the results. Due to the complex physical environment of Baiyangdian wetland, it is difficult to make an overall distinction between wetland information through ground survey. In this study, the visual interpretation results of remote sensing images are used as verification data. The Baiyangdian wetland area is large, and the localities are severely broken. The workload of visual interpretation in the whole study area is relatively large. This paper randomly selects 100 sample points in the study area, and compares the wetland information extraction model and the wetland information extracted by the supervised classification method. The composition of the sample points is similar to that of the entire Baiyangdian wetland, and is representative and can be used as verification data. Table 2 is a comparative analysis of the accuracy of the wetland information extraction model and the supervised classification method based on statistical analysis.

It can be seen from the table that the extraction accuracy of the wetland information extraction model is better, the total accuracy of the two-stage image extraction is more than 90%, and the Kappa coefficient is also above 0.9; the supervised classification extraction accuracy is slightly poor, Kappa The coefficients are divided into 0.91 and 0.87. Wetland information extraction model relative supervised classification method, when the wetland information extraction threshold is selected, it is less affected by subjective factors, and the extraction efficiency is high. The information of Baiyangdian wetland can be extracted quickly, and the extraction precision is relatively high.

Table 2 .Precision evaluation of wetland information extraction model and supervised classification.

Method of extraction	Image extraction results on March 22		October 10th image extraction results	
	Overall accuracy (%)	Kappa coefficient	Overall accuracy (%)	Kappa coefficient
NDWI-NDVI model	94.96	0.92	96.81	0.93
Supervised classification	92.57	0.91	94.5	0.87

Wetland information extraction model statistics on the main wetland information (naked waters and aquatic plants) (Table 3), the bare water area of Baiyangdian wetland in March is about 102.31 km², the aquatic plant area is about 122.57 km²; the bare water area falls in October. At about 74.04 km², the area of aquatic plants rose to about 154.5 km², which shows that the Baiyangdian wetland information changed significantly during the different growth periods of aquatic plants. The wetland area in October increased by 3.66 km² from March, Probably due to precipitation in July and August, the total precipitation is 336 mm, and the area is the largest in October due to the hysteresis of water growth. This may be due to rainy season precipitation or artificial hydration in the Baiyangdian wetland. Analysis of precipitation and water level data in the Baiyangdian wetland from March to October 2018 is shown in Figure 4.

Table 3 .Wetland information extraction model to extract the information of each wetland information area.

Main wetland information	Image extraction area on March 22 (km ²)	Image extraction area on October 10 (km ²)
Bare waters	102.31	74.04
Aquatic plant	122.57	154.5
Wetland area	224.88	228.54

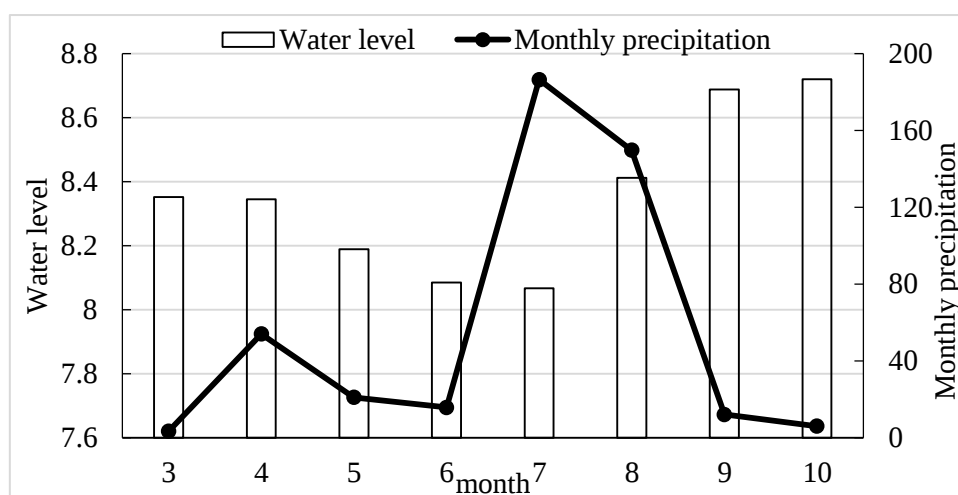


Figure 4. Average precipitation and water level in Baiyangdian area from March to October 2018.

5. Conclusion

In this paper, the wetland information extraction model and the traditional supervised classification method based on NDVI-NDWI method are used to extract the wetland information of Baiyangdian in different periods. The above two methods can completely determine the classification of Baiyangdian wetland information, and find the sample points and two. The error of the wetland information extracted by the method is above 90%, and the accuracy of the fitting is good, and the extraction model is optimal. Since the main aquatic plants (reed and lotus) in the Baiyangdian wetland have not reached the growth period in March, the exposed bare waters accounted for more; in October, at the end of the aquatic plant growth period, the area covered by the extracted aquatic plants increased significantly. The NDWI-NDVI wetland information extraction model was used to quantitatively extract aquatic plants and bare waters in the Baiyangdian wetland. The area of bare water and aquatic plants in March was 102.31 km² and 122.57 km², respectively. To October, Baiyangdian aquatic the area covered by plants increased to 154.5 km², and the bare waters decreased to 74.04 km². It can be seen that the information of Baiyangdian wetland changes with the growth of aquatic plants, and the overall area increases due to rainfall and water increase. Although the type of wetland extracted by this method is very accurate, there are still some areas to be improved in this model, such as the staggered growth of reeds and lotuses leading to misclassification; some small lakes have too small water area and may be divided into adjacent larger categories in the extraction process. For these special areas, field observation survey sampling methods can be adopted in the future to further improve the accuracy of wetland information extraction and provide more accurate wetland monitoring information for Xiong'an New District.

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