Analysis of dynamic change of Hongjiannao Lake based on MNDWI

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Abstract. In order to understand recent changes in inter-annual trends in water area of Hongjiannao Lake and to explore influence factors affecting the changes, the Landsat data during the year from 1988 to 2014 was processed by Modified Normalized Difference Water Index (MNDWI) and the water body boundary of Hongjiannao Lake was extracted. Then the water area was calculated in ARCGIS, and also the variation was analysed. The results show that the water area of Hongjiannao Lake is overall decreasing from 1988 to 2014. The possible causes of its shrinking by preliminary analysis are mainly continuous underground mining, climate drought, upstream reservoirs and so on.

1.Introduction

Lake area and water fluctuation in China had a shrinking trend over the past decades, the decrease of the lake area not only results in wetland shrinking in the lake district, but also damage the stability of the river's lake aquatic ecosystems [1]. Lake water in arid and semi-arid area is a vital recourse and plays an important role in ecological balance. Some studies pointed out that some lakes have shrunk or vanished in North China and reaches of the Yangtze River have lowered to be driven by climate variability and agricultural irrigation [2]. Therefore, it is necessary to extract water bodies from non-water features and evaluate the spatio-temporal distributions and changes of land surface water [3-4]. Remote sensing is an effective approach in monitoring water resources because of providing large-scale, long-term, repeated and real-time information [5-7]. McFeeters [8] noted that high resolution Quick Bird imagery combined with Normalized Difference Water Index (NDWI) can extract swimming pools for mosquito abatement. Xu [9] replace the NIR band with the middle infrared (MIR) band, and then establish the Modified NDWI (MNDWI). The open water features can be enhanced using this index, and the built-up land noise, as well as vegetation and soil noise, can be suppressed and even removed efficiently. This paper used MDNWI to extract Hongjiannao Lake area from the year 1988 to 2014 based on Landsat and HJ-CCD data.

2.Study area and data

2.1 Study area

Hongjiannao Lake is the largest desert freshwater lake in semi-arid and arid region of China, which played an important role in adjusting the local climate, water resource balance and biological diversity. It located at the border of Shaanxi Province and Inner Mongolia Autonomous Region, centered at (110 ℃52′30″E, 39°06′N). The position in the south-west of Shendong mining area, which was one of China's biggest coal-producing regions (Fig.1). The lake-water area was 61.93 km^2 in 1978. However, some studies found that the area of Hongjiannao Lake decreased rapidly in the past decades, influenced the ecological and economic functions of Hongjiannao Lake, many possible reasons exist

for the rapid decrease in lake-water area. These reasons include that climate change, human activities and especially the underground mining activities. Therefore, it is necessary to obtain the accuracy area and monitoring the dynamic change.

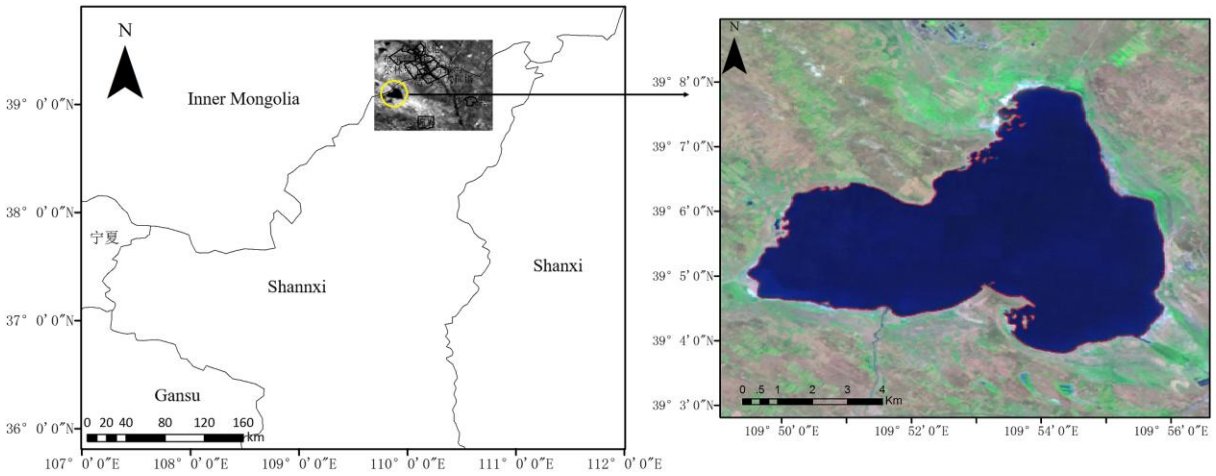

Figure 1. Location of Hongjiannao Lake.

2.2 Data

Selected 1988-2014 Landsat images which containing Green and MIR bands that used to extract water information to reduce the impact of coarse resolution. The cumulative 26 years' total of 23 scene satellite remote sensing data which listed on table 1, including 21 scene data from Landsat satellites and 2 scene HJ-CCD satellite data will be used to supplement. Data acquisition time are mainly concentrated in cloudless summer, but as a result of Landsat and HJ satellite revisit cycle is 16 days and 2 days respectively, so it is hard to get the same remote sensing images. The Landsat data download mainly from International Scientific Data Service Platform, the University of Maryland Global Land Cover Database Exchange Sites, the US Geological Survey and Chinese Academy of Sciences Institute of Earth Observation Data Sharing Plan; HJ-CCD data download in China Resources Satellite Application Centre.

Table 1. Remote Sensing Data using in paper

Sensor	Time	Sensor	Time	Sensor	Time
TM	1988.9.24	TM	1998.7.2	TM	2006.9.10
TM	1989.9.11	ETM+	1999.10.17	TM	2007.8.12
TM	1990.8.29	ETM+	2000.7.31	TM	2009.6.30
TM	1992.7.17	ETM+	2001.5.31	HJ1A-CCD2	2010.8.5
TM	1993.5.17	ETM+	2002.8.6	HJ1B-CCD2	2011.7.30
TM	1994.8.24	ETM+	2003.5.21	OLI	2013.9.13
TM	1995.6.8	TM	2004.7.2	OLI	2014.7.30
TM	1996.6.10	TM	2005.7.5		

3.Method

The Normalized Difference Water Index (NDWI) from Mcfeeters, which uses MIR (TM5) instead of NIR (TM 4) to construct the MNDWI. The MNDWI has been tested in the ocean, lake and river areas with the background of built-up lands and vegetated lands, and with both clean and polluted water bodies using Landsat TM/ETM+ imagery. Land categories of Hongjiannao lake region can be roughly divided into water, vegetation, bare land and buildings, etc., use the NDWI index model is utilized to

extract water body, bare land and buildings in the background will be wrong fall into water body, reach satisfactory result of extraction. The MNDWI can depress the built-up land information effectively while high lighting water information, and accurately extract the water body information from the study areas. This reveals that the MNDWI can significantly enhance the water information, especially in the area mainly with built-up and bare land as background. In the end, transform to extract the waters diagram for vector data, using the ArcMap field calculator waters polygon area calculation to get the lake area. The formula of NDWI and MNDWI showed as below:

$$NDWI = (Green - NIR)/ (Green + NIR) \quad (1)$$

$$MNDWI = (Green - MIR)/ (Green + MIR) \quad (2)$$

Where Green, NIR and MIR are the surface reflectance values of the green, NIR and MIR bands, respectively.

4.Results

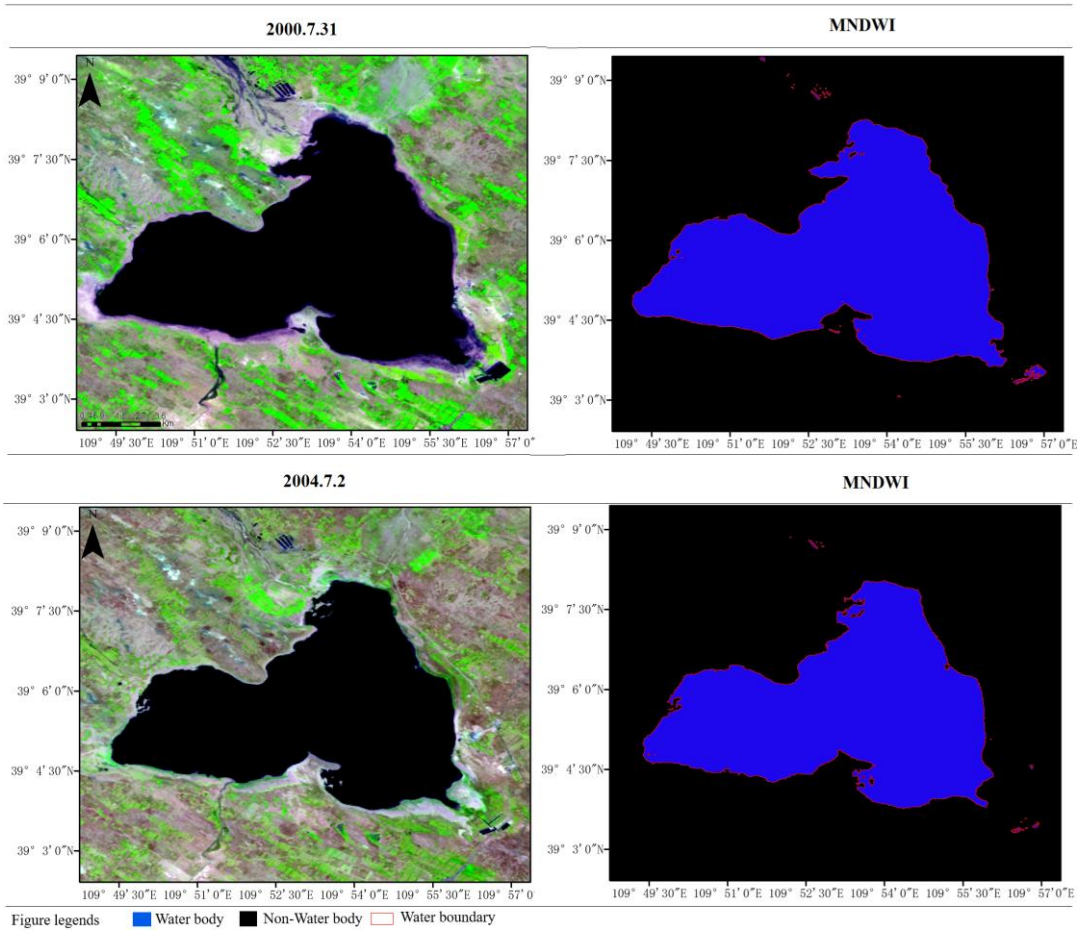

Figure 2. Map of water body extraction using MNDWI

MNDWI can extracted Hongjiannao lake boundary accurately, when extracting water body around the Hongjiannao lake (e.g., above the Hongjiannao lake area and bottom right of the lake), water boundary was showed clearly in Figure 2. Using the Hongjiannao measured lakes area of 2000 to verify the accuracy of water extraction method, MNDWI error was 2.07%. MNDWI was utilized to extract the Hongjiannao lake area in each year which showed in Figure 3, the lake area was generally a linear decrease trend (R^2=0.86), but its change trend can be subdivided into two stages: from the year of 1988 to 1999, the area of the Hongjiannao lake area showed a trend of fluctuations, the whole change is not obvious, but the partial variation is sharp; since 1999, the Hongjiannao lake area was a linear decreasing trend. In the year of 1988 and 1999, the lake area was 49.92 Km^2 and 47.92 Km^2 respectively, lake area decreased by 4.02%. In the year of 2009 and 2014, the lake area was reduced to 37.71 Km^2 and 31.69 Km^2 respectively, compared with the year of 1988 lakes area decreased by

24.45% and 24.45% respectively. Overall, Hongjiannao lake area is shrinking in the past 26 years, the average reducing speed was 0.87 Km^2/a.

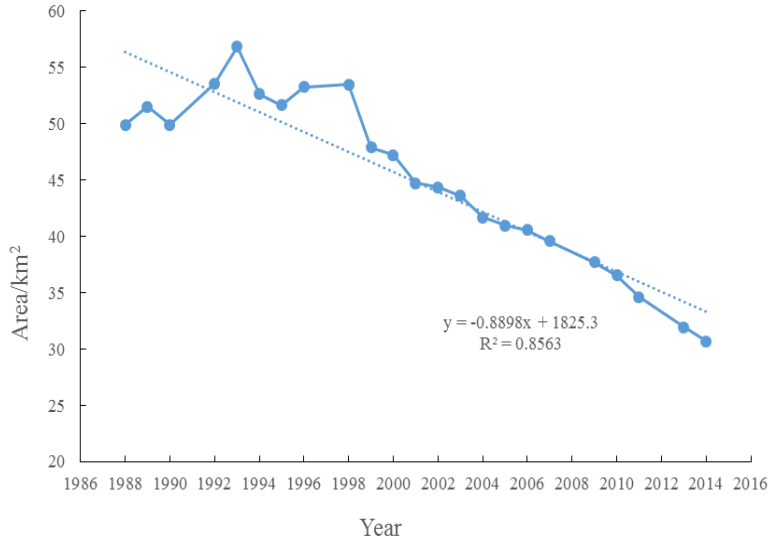

Figure 3. The area change of Hongjiannao Lake from 1988 to 2014

5.Discussion

As for the causes of the Hongjiannao lake atrophy, there are three main categories drought climate, upstream river closure and irrigation water consumption. In particularly, Hongjiannao Lake was 20-30 km away from Shendong core mining area. With the strength of the mining and mining method of mechanized, and the increase of mining depth, the shallow groundwater water bottom continuity is damaged which lead to changes in the local groundwater flow field, it would also affect the level and area of Hongjiannao lake. Meteorological factors such as rainfall and evaporation may not the main factors leading to the reduction of Lake area, irrigation, underground mining and reservoir construction may be the main reasons, all of these reasons need to be further investigated in the future research.

6.References

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Acknowledgements

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