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SUITABILITY EVALUATION OF WATER INDEX UNDER EXTRACTION OF COMPLEX ENVIRONMENTAL WATER BODIES

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Abstract: With the development of remote sensing technology, remote sensing images are more and more widely used in water monitoring. This paper uses Landsat 8 remote sensing images as the data source, selects Poyang Lake, Taihu Lake and Dingnan County as the study area, and combines NDWI, MNDWI, EWI, SWI, TCW, MBWI, WI2015, AWEInsh and AWEIsh to extract water bodies and evaluate the accuracy of the study area. The results are as follows: 1. The overall extraction accuracy of TCW and MBWI is the highest. 2. For mountain shadow areas, AWEInsh and TCW have the best extraction effect. For shallow water area, TCW and MBWI have the b est extraction effect, and the spectral distinction between water and non water is greatly increased. For the eutrophication area of water body, the ten methods have high accuracy, and can distinguish the spectral characteristics of chlorophyll and non water body.
Keywords: Remote sensing image; Research area; water extraction; Water index method; Accuracy evaluation

1 INTRODUCTION

After decades of development, the water extraction of remote sensing images has made great progress. The process includes: artificial visual interpretation, spectral feature extraction, radar image extraction, automation, and the combination of various methods[1].The initial visual interpretation of water extraction can clearly distinguish water bodies but the efficiency is low, and then the semi-automatic water extraction method based on spectral feature extraction of water bodies has greatly improved the work efficiency. Water extraction has also been guaranteed, but in some complex environments, water bodies will be misclassified or missed. Up to now, the fully automated extraction of water bodies [2], scholars are studying deep learning, artificial intelligence and other directions to accurately and efficiently extract water bodies. In the future, more and more extraction methods will emerge in an endless stream.
Based on the automation method ; li Dan and other in-depth summary of the development of these years is very rapid response very popular water extraction based on radar image data, which has a profound significance for water extraction, remote sensing technology to improve rapidly [3]. In general, for water body extraction, we use more optical image information to extract water body, and radar image information to assist water body extraction. In recent years, the rapidly developing radar image has been applied to water resources extraction and water resources protection. Based on optical image data and radar image data, the extraction method and application field can be refined and clarified. The method is as follows. The threshold method can be divided into single-band method and multi-band method. The multi-band method can be divided into inter-spectral relationship method and vegetation index method. Classification can be divided into decision tree, SVM and object-oriented method. Other methods can be divided into deep learning, mixed element decomposition, GIS, spectral matching, BP network, MRF. Radar images are divided into threshold method, filtering method, DEM and GLCM. The method produced by the combination of the two classifications is the model method.

2 WATER EXTRACTION PROCESS

2.1 Pretreatment

The Landsat 8 and Sentinel-2 image data used in this paper need to perform atmospheric correction and radiometric calibration on the landsat 8 remote sensing image. Sentinel-2 remote sensing data can 't be opened directly in envi, so it needs to be processed in snap to get data that can be opened in envi. The 2A level data does not require radiometric calibration and atmospheric correction.

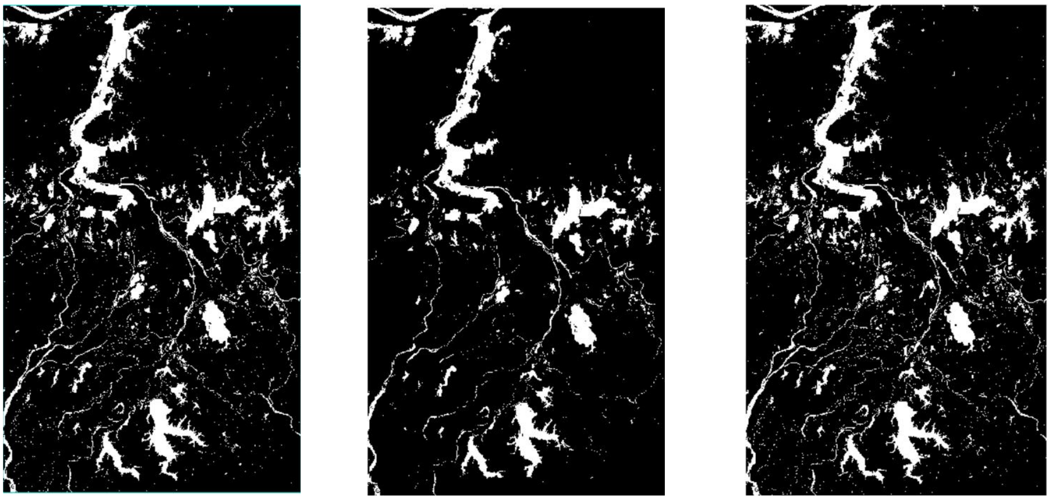
2.2 surface Water Extraction Method

The research areas of this paper are Poyang Lake area, Taihu Lake area and Dingnan County area. The main difficulty of water body extraction research is to eliminate the influence of shallow water area, water eutrophication, mountain shadow area and other factors on water body and improve the accuracy of water body. In this paper, ten water body index models are used, including NDWI, MNDWI, EWI, SWI, TCW, MBWI, RNDWI WI2015, AWEInsh, AWEIsh..Ten water index models are shown in Table 1.

Table 1 Ten water index methods and their index models

Index	Source	Equation
TCW[4]	Crist（1985）	$0.0315\rho_{b1}+0.202\rho_{b2}+0.3102\rho_{b3}+0.1594\rho_{b4}-0.6806\rho_{b5}-0.6109\rho_{b7}$
NDWI[5]	Mcfeeters(1996)	$\rho_{b2}-\rho_{b4}/\rho_{b2}+\rho_{b4}$
MDNWI[6]	Xu(2006)	$\rho_{b2}-\rho_{b5}/\rho_{b2}+\rho_{b6}$
MBWI[7]	Gao(2004)	$2\rho_{b2}-\rho_{b3}-\rho_{b4}-\rho_{b5}-\rho_{b7}$
AWEInsh[8]	Feyisa(2014)	$4(\rho_{b2}-\rho_{b5})-(0.25\rho_{b4}+2.75\rho_{b6})$
AWEIsh[8]	Feyisa(2014)	$\rho_{b1}-2.5\rho_{b2}-1.5(\rho_{b4}+\rho_{b5})-0.25\rho_{b7}$
WI2015[9]	Fisher(2014)	$1.7204+171\rho_{b2}+3\rho_{b3}-70\rho_{b4}-45\rho_{b5}-71\rho_{b7}$
RNDWI[10]	Cao(2008)	$\rho_{b3}-\rho_{b5}/\rho_{b3}+\rho_{b6}$
EWI[11]	Yan(2007)	$\rho_{b2}-\rho_{b4}-\rho_{b5}/\rho_{b2}+\rho_{b4}+\rho_{b5}$
SWI[12]	Chen(2013)	$\rho_{b1}+\rho_{b2}-\rho_{b4}$

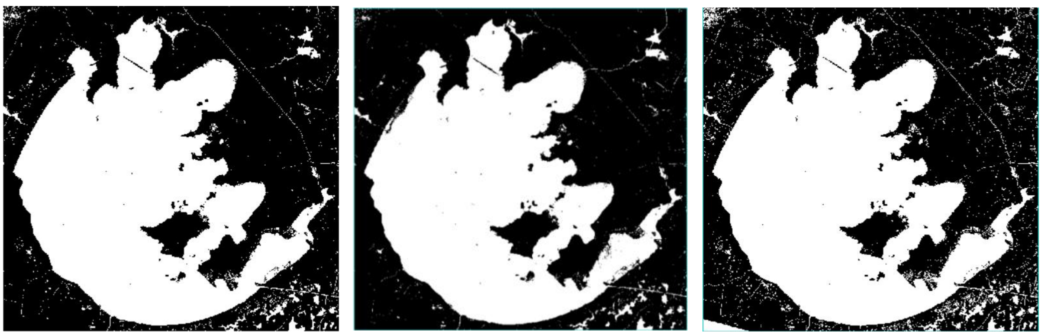
The extraction of Poyang Lake water bodyThe extraction effect of the water body is relatively poor, and the water body is affected by sediment, chlorophyll and some mountain shadows. The size is 3146 * 5155 pixels, including mountains, buildings, lakes, rivers, ponds and other parts. Three kinds of result maps with better extraction effect were selected. Figure 1



(a) (b) (c)

Figure 1 Extraction results of Poyang Lake water body;(a)MBWI;(b)TCW;(c) AWEInsh

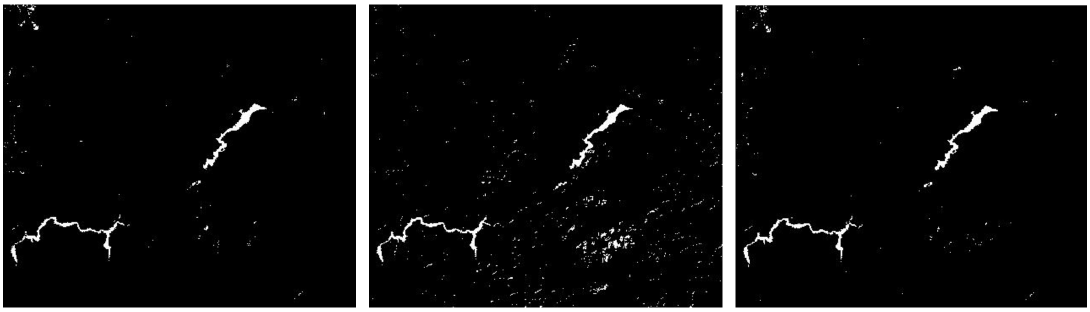
Due to the increasing eutrophication of water bodies in Taihu Lake area, some water bodies in the lake are green, which makes it difficult to extract some water bodies well. The image used in this paper is 2480 * 2415 pixels, including surrounding towns and small rivers. Due to image reasons, the blank in the lower left corner is not the research area and does not enter the calculation. Select three kinds of results with better results which can be seen in Figure 2.



(a) (b) (c)

Figure 2 Extraction Results of Taihu Lake Water Body; (a) TCW;(b) MBWI;(c) WI2015

The water body is extracted from mountainous areas such as Dingnan County, with a size of 11428 * 8515 pixels. Because the selected area is relatively large and there are many image factors, the extraction effect is relatively poor. Including high reflectivity cities, mountain shadows, clouds and other factors. Select three better results Figure 3



(a) (b) (c)

Figure 3 Water Extraction Results of Dingnan County; (a)MBWI;(b) AWEInsh;(c)TCW

3 ACCURACY EVALUATION

In this paper, the method of accuracy evaluation is the confusion matrix method. Its calculation formula is:

$$C_M = \begin{pmatrix} x_{11} & x_{12} & \cdots x_{1n} \\ x_{21} & x_{22} & \cdots x_{2n} \\ \vdots & \vdots & \ddots \quad \vdots \\ x_{n1} & x_{n2} & \cdots x_{nn} \end{pmatrix} \quad (1)$$

In the formula, x_{ab} (a, b = 1, 2, 3,n) elements, this paper only divided into two categories: water and non-water. A is set to 2, which represents the probability that the training samples are divided into non-water bodies, and b represents the probability that the water samples in the training samples are divided into non-water bodies, where the sum of these probabilities is 1. In this paper, the effect map obtained by the water index of ten methods is used to evaluate the accuracy.

Table 2 NDWI Water Extraction Confusion Matrix Results

classification	Water bodies	Non-water bodies	Total
water body	1473300	1026738	2500038
Non-water bodies	119852	13717592	13837444
Total	1593152	14744330	16337482

Table 2 shows the number of pixels in water and non-water bodies. Under this method, the total accuracy is (1473300 + 13717592) / 16337482 = 92.98 %. The total number of pixels in the planned water body is 2500038, of which 1026738 pixels are misclassified into non-water body pixels. The error of misclassification is called misclassification rate, 1026738 / 2500038 = 41.06 %, of which there are 1593152 pixels in the real water body. There are 1373300 pixels in the water body that are correctly distinguished in this area, and there are 119852 pixels in the water body that are not distinguished. The leakage error is 119852 / 1593152 = 7.52 %. The accuracy of these errors provides a basis for the accuracy and evaluation of the method extraction.

3.1 Accuracy Evaluation Results

Table 3 Evaluation of Water Extraction Accuracy of Poyang Lake

Water extraction method	Error/%	Lost/%	accuracy /%
MDNWI	0.391	0.139	0.931
AWEInsh	0.297	0.116	0.951
AWEIsh	0.368	0.110	0.938
EWI	0.462	0.100	0.914
WI2015	0.261	0.100	0.958
MBWI	0.010	0.164	0.982
NDWI	0.455	0.146	0.915
SWI	0.228	0.105	0.963
TCW	0.006	0.081	0.991
RNDWI	0.353	0.096	0.942

From Table 3, the total accuracy of different water extraction methods in Poyang Lake area from high to low is TCW, MBWI, SWI, WI2015, AWEInsh, RNDWI, AWEIsh, MNDWI, NDWI, EWI. The water body error rate extracted by EWI water index is the highest. MBWI water index extraction water omission extraction is the most.

Table 4 Evaluation of Water Extraction Accuracy of Taihu Lake

Water extraction method	Error/%	Lost/%	accuracy/%
AWEInsh	0.005	0.002	0.996
AWEIsh	0.041	0.003	0.978
EWI	0.009	0.009	0.959
MBWI	0.001	0.029	0.985
MNDWI	0.039	0.016	0.973

NDWI	0.103	0.021	0.937
RNDWI	0.040	0.021	0.971
SWI	0.057	0.016	0.964
TCW	0.005	0.010	0.992
WI2015	0.004	0.007	0.973

From Table 4, the total accuracy of different water extraction methods in the Taihu Lake area from high to low is AWEInsh, TCW, MBWI, AWEIsh, WI2015, MNDWI, RNDWI, SWI, EWI, NDWI. The water body error rate extracted by NDWI water index is the highest. MBWI water index extraction water omission extraction is the most.

Table 5 Evaluation of Water Extraction Accuracy in Mountain Shadow Area

Water extraction method	Error/%	Lost/%	accuracy/%
WI2015	0.447	0.050	0.989
TCW	0.009	0.262	0.996
SWI	0.783	0.067	0.953
RNDWI	0.528	0.285	0.985
NDWI	0.852	0.273	0.939
MNDWI	0.130	0.130	0.980
MBWI	0.273	0.273	0.989
EWI	0.281	0.281	0.978
AWEIsh	0.607	0.015	0.979
AWEInsh	0.069	0.287	0.995

From Table 5, the total accuracy of different water extraction methods in Dingnan County from high to low is AWEInsh, TCW, MBWI, AWEIsh, WI2015, MNDWI, RNDWI, SWI, EWI, NDWI. The water body error rate extracted by NDWI water index is the highest. MBWI water index extraction water omission extraction is the most.

4 CONCLUSION

In this paper, starting from different environments (shallow water area, water eutrophication area, mountain shadow area), taking Poyang Lake, Taihu Lake and Dingnan County mountain area as the research area, 10 water body index methods were found to compare the suitability evaluation of water body index in complex environmental water extraction. The conclusions are as follows:

The water index of NDWI and EWI is high in missing extraction rate, high in wrong extraction rate, and low in total accuracy compared with other methods. The error rate of MBWI water index is low, but the missing rate is high and the total accuracy is high. The missing rate and error rate of TCW and AWEInsh water index are relatively low and the total accuracy is very high. Other index methods are similar, and some methods are a special environment. For example, the WI2015 water index is very suitable for water extraction with mountain shadows[13].

2.Shallow water area: The middle of Poyang Lake is on the right side of the water body. The extraction effect of TCW and MBWI is good among the ten methods. The MBWI model greatly improves the spectral distinction between water body and non-water body, so that water body and non-water body can be well distinguished.

Eutrophication area: most of the Taihu Lake, these ten methods for eutrophication area water extraction effect is good, are relatively clear extraction, TCW, MBWI, AWEInsh for Taihu Lake overall

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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