RESEARCH ON WETLANDS LANDSCAPE PATTERN CHANGE BASED ON REMOTE SENSING ——TAKING DUERBOTE COUNTY FOR EXAMPLE

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ABSTRACT: Duerbote Mogolian Autonomous County (Duerbote County for short), an important part of Zhalong Wetland, located in the farming-pastoral zone of North China, whose ecological environment is fragile, therefore, studying the wetlands landscape pattern change of this district has great significance. In this paper, the Landsat-ETM+ image acquired on August 11 2001 and Beijing-1 small satellite multi-spectral image acquired on August 30 2007 were selected to take a research on wetlands landscape pattern change in Duerbote County. Firstly, in order to improve change detection precision, relative radiometric calibration for the two temporal images was done based on "PIFs" method. Secondly, the object-oriented method with visual interpretation method was used for wetlands classification, meanwhile the high resolution panchromatic image of Beijing-1 small satellite was chosen for precision evaluation. Finally, the landscape pattern characteristic and its dynamic change were analyzed through several appropriate landscape pattern indices such as Fractal Dimension (FD), Landscape Diversity Index (H), Dominance Index (D) and the Internal Habitat Fragmentation Index (FI). The results show that in Duerbote County from 2001 to 2007, the values of H and FI ascend while the values of FD and D descend, which demonstrates the wetlands landscape pattern in Duerbote County turns more complex, and climate warming and strengthening of human activities are the important factors to lead to the dynamic change of the wetlands landscape pattern.

1. INTRODUCTION

Wetlands are special natural syntheses formed by the interaction between terrestrial system and aquatic system, which include natural or artificial, long or temporary marshland, peat land or water zone deep less than 6m. Duerbote County not only belongs to one of the most important international wetlands——Zhalong Wetland, but also locates in the farming-pastoral zone of North China and it is the representative district of Northeast China meadow grassland (Wei Wen-xia *et al*., 2008). Therefore, make a study of wetlands landscape pattern and its dynamic change in Duerbote County has great significance on the protection and management of Zhalong Wetland and zoology construction of farming-pastoral zone. Remote sensing has the advantages of wide observation field, efficient data acquisition, high-frequency revisit periods and so on, which has been a strong means of detecting wetlands (Zhou Wei-cai *et al*., 2007). In this paper, the wetlands landscape pattern characteristic and its dynamic change was analyzed using Landsat/ETM+ image and Beijing-1 small satellite multi-spectral image. Also Beijing-1 small satellite panchromatic high resolution image were used as assistant data.

2. STUDY AREA

Duerbote County is located in the middle of Song-Nen plain, next to Nenjiang River, which belongs to the southwestern part of Heilongjiang Province (Seen in Figure 1). Its geographic coordinates are $45^0$53'N-$47^0$08'N, $123^0$45'E-$124^0$42'E (Duerbote Mogolian Autonomous County Annals Compilation committee, 1995). The county belongs to the district from semi- wetness to semi-drought and it occupies the most flat area of Song-Nen Plain. The average elevation of this county is between 135m and 145m inclining appreciably from north to south parts (Bai Shu-ying *et al.*, 2007). Wuyuer River is flooding like a tailless one, so some part of water filters into underground to run up groundwater level and other water pools on land surface to form many big and small lakes. The relief in this county mainly includes: sand hill land, salt bottom land, flood plain land and marshland with lakes and bubbles.

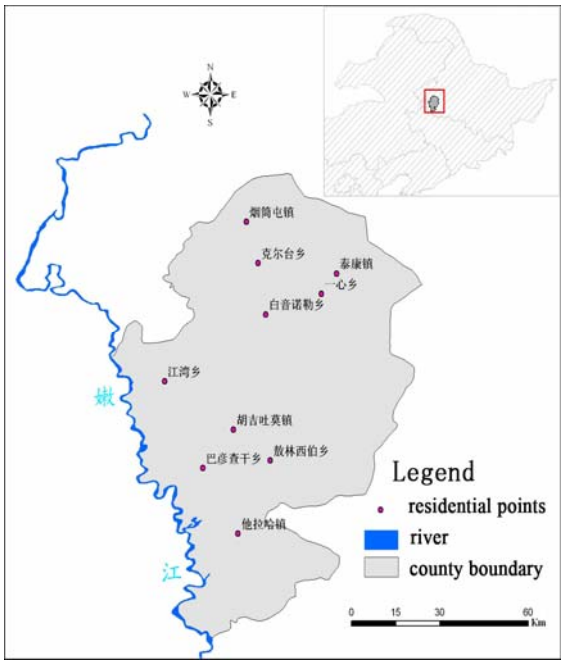


Figure1 The geographical location of Duerbote County

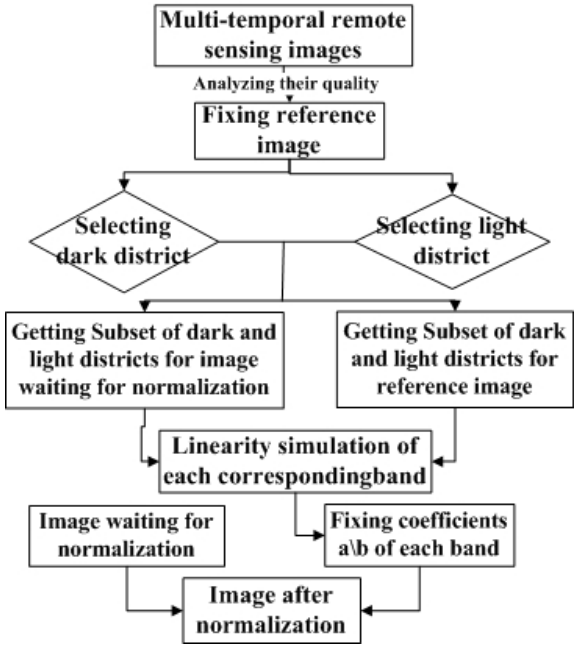


Figure2 The flow of relative radiometric normalization

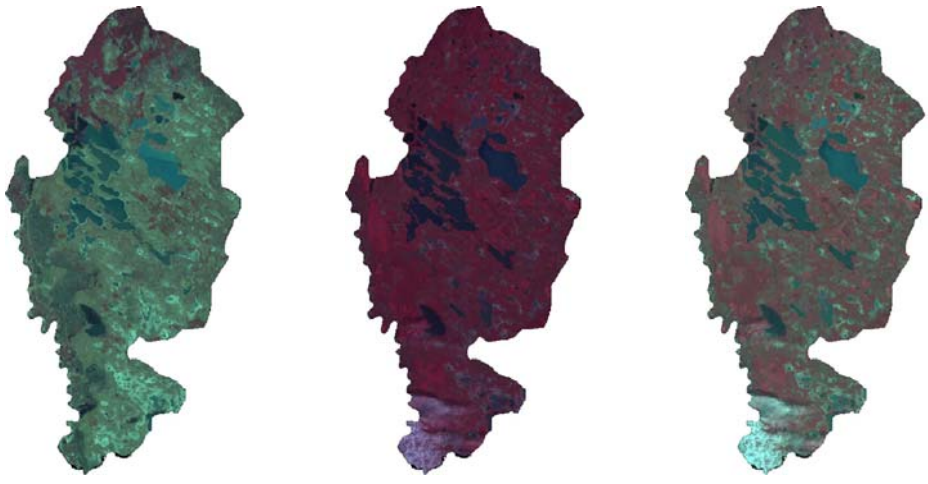
3. DATA SOURCE AND REMOTE SENSING IMAGE PROCESSING

In this paper, the Landsat-7 ETM+ ortho-rectification image acquired on August 11 2001 and Beijing-1 small satellite multi-spectral image acquired on August 30 2007 were used as the main data sources. Meanwhile we also used Beijing-1 small satellite panchromatic image acquired on September 21 2007 as ancillary data.

3.1 Geometric Correction

Using ETM+ ortho-rectification images as reference data, make geometric correction of Beijing-1 small satellite multi-spectral image. Taking one view as correction units, using quadric polynomial for correction model and using cubic convolution as resample method, the multi-spectral image was corrected and the correction error was limited in one pixel in plain areas. The images used in this paper are Universal Transverse Mercator Projection, and belong to North Zone 51.

3.2 Relative Radiometric Normalization



2001.08.11_ETM+ 2007.08.30_BJ-1(Before Normalization) 2007.08.30_BJ-1(After Normalization)

Figure 3 The pictures of images before and after relative radiometric normalization

In the acquiring of Remote sensing images, the images will be affected by the sensor, sun elevation angle,

atmosphere, terrain and so on, as a result, the spectral differences of the same target in multi-temporal images is very big which affects the abstraction of land use and its change information (Zhang You-shui *et al*., 2006). Therefore, before using ETM+ image and Beijing-1 small satellite multi-spectral image to extract wetlands, the relative radiometric normalization must be done. In this paper, the statistical regression method was used that is the dark water body and light sand land or salina land were chosen as the normalization sample points those are PIFs, the ETM+ image of 2001 was selected as reference image to make relative radiometric normalization. The normalization flow is seen in Figure 2 and the normalization results are seen in Figure 3.

4. METHOD

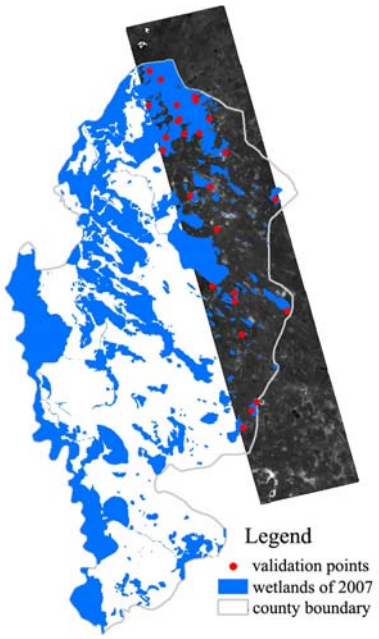


Figure 4 The diagraph of validating wetlands information extraction

4.1 Classification Standard and Wetlands Extraction Method

Combined with the definition of wetlands and the remote sensing data scale, the study by Niu Zhen-guo *et al.* (2009) consulted, the wetlands in Duerbote County was divided into Natural Wetlands and False Wetlands. Natural Wetlands includes River Wetlands, Lake Wetlands, Marsh Wetlands, Flooding Wetlands. False Wetlands includes Paddy Field and Other Artificial Wetlands. As for Lake Wetlands and River Wetlands, the object-oriented classification method (Zhou Hui-zhen *et al*., 2010) was mainly used and as for other type of wetlands artificial visual interpretation was used. Meanwhile, we used Beijing-1 small satellite panchromatic 4m resolution image acquired on September 21 2007 to validate the classification results of 2007. In the validation process (Figure 4), 26 random validation points was chosen and there were 3 misjudgment points, whose validation precision is about 90%.

4.2 Landscape Pattern Index Choosing and Calculating Method

Landscape pattern indices are some quantitative ones which can condense the landscape pattern information and can reflect its frame and spatial distribution. Through landscape pattern indices we can make quantitative study of the composing, spatial distribution, its dynamic change and so on. According to the characteristic of the study area, the landscape pattern indices listed in Table 1. were chosen for the analysis of landscape pattern and its dynamic change in Duerbote County. Then the software Fragstats 3.0 and ArcGIS were used for calculation.

Table 1 Landscape pattern indices and their meanings

Model	Meaning
Patch number、Area(a)、Perimeter (P)	The basic data for analysis of landscape pattern
P_k 、 m 、 A、$A1$	the ratio of the landscape k are to the total areas； total number of landscape type； total landscapes' areas； the biggest patch area of this landscape
Shape index—Fractal Dimension（ FD ）： $FD = 2\lg(P/4)/\lg(a)$	the bigger the FD value of the patch，the more complex the edge of the patch，the more little they are affected。
Landscape Diversity Index（ H ）： $H = -\sum_{k=1}^{m}(P_k)\log 2(P_k)$	the bigger the H value，the more complex the landscape composing
Dominance Index（ D ）： $D = H_{\max} + \sum_{k=1}^{m}(P_k)\log_2(P_k)$ $H_{\max} = \ln(m)$	Describing the dominance degree of one or some landscape types of the landscape pattern
Internal Habitat Fragmentation Index（ FI ）： $FI = 1 - A1/A$	The bigger the FI value，the more complex the fragmentation degree of the landscape

5. RESULTS AND ANALYSIS

5.1Total Characteristic of Wetlands Landscape Pattern

Table 2 listed the wetlands landscape indices of each wetland type in 2001 and 2007 in Duerbote County. Seen from it, the wetlands landscape includes 6 wetlands landscape types, there were 459 patches in 2001 and 574 patches in 2007. In 2001, the mean patch area of Flooding Wetlands is the biggest, and then that of Paddy Field and then that of Marsh Wetlands and River Wetlands. In 2007, the mean patch area of Paddy Field is the biggest, and then that of Flooding Wetlands and River Wetlands. The main wetlands landscape types in Duerbote County are March Wetlands and Lake Wetlands. The natural wetlands occupy the most part of the wetlands landscape in this county.

Table2 Different landscape pattern indices in each type of wetlands landscape

wetlands type / index value/year		Natural Wetlands				False Wetlands	
		River	Lake	Marsh	Flooding	Paddy Field	other
patch number	2001	11	203	178	32	21	14
	2007	17	257	182	71	34	13
Mean patch area ($*10^6$)	2001	5.602	3.366	5.730	8.700	6.215	1.489
	2007	2.067	2.875	5.387	3.988	6.142	1.586
Area Percent	2001	2.79	31.14	46.48	12.69	5.95	0.95
	2007	1.55	32.59	43.25	12.49	9.21	0.91
FD	2001	1.1849	1.2327	1.3831	1.2290	1.2970	2.3063
	2007	1.5522	1.2207	1.3730	1.1669	1.1816	2.2947
FI	2001	0.7600	0.7918	0.7773	0.6349	0.5516	0.6030
	2007	0.8330	0.8075	0.7684	0.6754	0.7197	0.5988

Seen from the spatial distribution (Figure 5), the wetlands are widely distributed in Duerbote County. Marsh

Wetlands are mainly located in the northern part of the county, which belongs to Zhalong Wetland. Lake Wetlands are mainly distributed in the middle area of the county. River Wetlands and Flooding Wetlands are located in the southwestern edge of the county, where the Nenjiang River runs. The False wetlands area is relative smaller, among which Paddy Field is distributed relatively concentrative, almost located along the Nenjiang River. Seen from the distribution of wetlands from 2001 to 2007, the distributed area of each wetland landscape type is relatively fixed. Through area calculation, the wetlands area of this county occupies 37% of the total county area in 2001 and 38% in 2007.

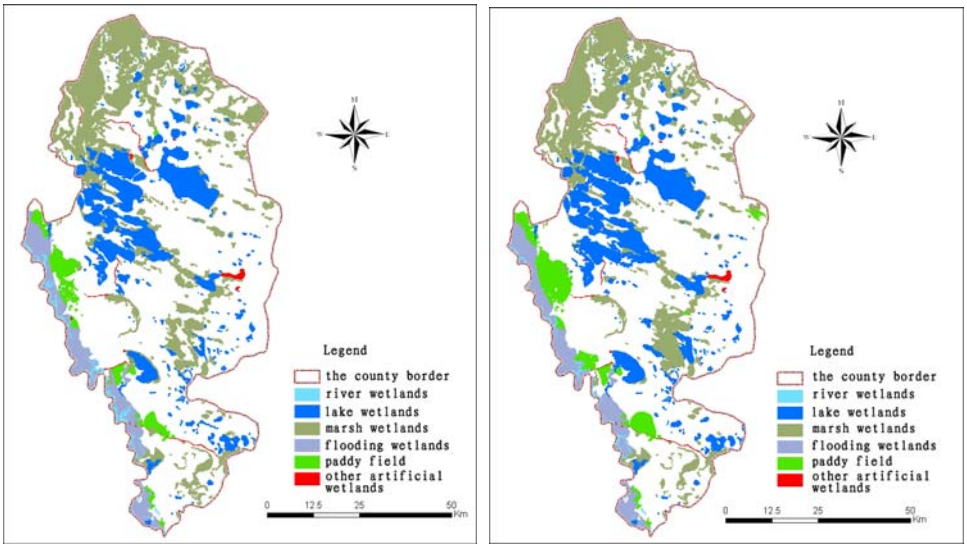


Figure5 The spatial distribution of wetlands in Duerbote County (a. 2001 b.2007)

5.2 Wetlands Landscape Indices Analysis

Table 2 and Table 3 listed the wetlands landscape indices of Duerbote County in different scale in 2001 and in 2007. The FD value of nearly all types of wetlands except for River Wetlands took on decreasing trend which is more recent to 1. The total FD value of wetlands landscape also took on decreasing trend, which were 1.3636 in 2001 and 1.3557 in 2007. Those indicated that the geometric shape of the wetlands landscape in this county turn more simple and the influence on the wetlands by human activities is bigger. The H value of the wetlands landscape is increasing from 1.2933 in 2001 to 1.3147 in 2007 while the D value is descending from 0.4985 in 2001 to 0.4771 in 2007, which showed that affected by human activity, the area difference of each type of wetlands is turning smaller and the complexity is increasing. Seen from every type of wetlands landscape, the FI values of River Wetlands, Lake Wetlands, Flooding Wetlands and Paddy Field are all increasing from 2001 to 2007 while those of Marsh Wetlands and Other Artificial Wetlands are descending, which indicated the stability of the former four types of wetlands is descending and the human activities are increasing. The reason for the change of the FI values are including two sides, one is that the increasing of the air temperature leading to the water body area and water amounts of rivers and lakes are descending, as a result the mean area of paddy field area turn smaller. The other reason is that the human activities increase leading to the increasing of False Wetlands area and the descending of water preservation of wetlands. Generally, the wetlands landscape in Duerbote County from 2001 to 2007 turns more complex.

Table 3 Landscape pattern indices in different periods in Duerbote County

year	patch number	FD	H	D
2001	459	1.3636	1.2933	0.4985
2007	574	1.3557	1.3147	0.4771

6. CONCLUSION

In this paper, we used ETM+ image and Beijing-1 small satellite data and used objected-oriented classification and artificial visual interpretation to extract wetlands information and then make study of the wetlands landscape pattern characteristic and its dynamic change in Duerbote County with some landscape pattern indices. The conclusions are as follows:

(1) It is necessary to make relative radiometric normalization before using multi-temporal images to extract wetlands information, and we can use statistical regression method to realize this process and then the wetlands information abstraction precision can be about 90%.
(2) In Duerbote County, The wetlands landscape area occupies about 40% of the total county area and Marsh Wetlands and Lake Wetlands are the main wetlands types.
(3) From 2001 to 2007, the spatial distributions of every type of wetlands are relatively fixed. The values of *H* and *FI* ascend while the values of *FD* and *D* descend, which demonstrates the wetlands landscape pattern in this County turns more complex.

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