Analysis on Evaluation of Ecological Security Based on Remote Sensing Data

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***Abstract*—The eco-security of Dongjiang watershed was evaluated in 1988, 1998 and 2007 separately after the eco-security index system establishment, which included three first-class indicators and eighteen second-class indicators based on P-S-R model. The eco-security dynamic degree was built to analysis the temporal and spatial variation of the countries and cities. Some guiding ideas and practicing tactics has been put forward to promote the watershed eco-security.**

***Index Terms*—Eco-security; Eco-security dynamic degree; Remote Sensing Data**

I. INTRODUCTION

Watershed is a complex ecosystem, composed by socio-economic system, natural systems and water system components. It has abundant land and water resources, raising the human and supporting the social and economic development. However, with the population explosion and the rapid economic development, natural ecosystems have been destroyed. Environmental pollution and resource shortage increase seriously, accompanying ecological damage, such as soil erosion, destruction of vegetation, loss of biodiversity, etc. These factors have seriously affected the ecological security of the system. How to quantitatively evaluate the state of the ecological security is a difficult problem in the subject of regional eco-environmental management and decision-making. So the research of eco-security in watershed is of great scientific significance and practical significance.

II. STUDY AREA AND RESEARCH DATA

The area of this study is Dongjiang watershed，which located from 113° 29′E to 115° 41′E,22° 23′N to 24° 47′N. The area of Dongjiang watershed is 35340 km^2, among it, 90% in Guangdong province. It has the typical subtropical monsoon humid climate, average annual temperature 20℃-22℃, and the precipitation is 1500mm-2400mm.With the rapid economic development in the recent 20 years, ecosystems have been destroyed.

TM images of 1988, 1998 and 2007 were acquired for the study respectively. Moreover, the data of DEM, water quality assessment, statistical yearbook and meteorological record etc. were also been collected.

TABLE I. TABLE TYPE STYLES WEIGHT DISTRIBUTION OF INDEXES FOR ECOLOGICAL SECURITY EVALUATION

Criterion layer (Weight)	Element layer (Weight)	Indicator layer(Weight)	Normalized weight
Eco-security Pressure (0.35)	Resource pressure (0.2)	Farmland areas per person (0.33)	0.023
		land degradation index (0.67)	0.047
	Social pressure (0.3)	population density (0.20)	0.021
		Pressure from residential points (0.40)	0.042
		Pressure from traffic line (0.40)	0.042
	Environmental pressure (0.5)	Intensity of fertilizer application per farmland area (0.33)	0.058
		Influence degree of sand mining (0.53)	0.093
		River water quality (0.14)	0.024
Eco-security State (0.55)	natural conditions (0.5)	Elevation index (0.30)	0.083
		slope index (0.40)	0.110
		Annual average temperature (0.10)	0.028
		Annual rainfall (0.20)	0.055
	resources quantity (0.5)	vegetative cover index (0.38)	0.104
		Rivers density index (0.14)	0.038
		organism abundance index (0.28)	0.077
		soil index (0.20)	0.055
Eco-security Response (0.1)	social response (1)	per capita GDP (0.67)	0.067
		environmental protection (0.33)	0.033

III. RESEARCH METHOD

The index system was established including three first-class indicators and eighteen second-class indicators. The weight of each hierarchy is valued and calculated by the analytical hierarchy process considering the expert's weighted vectors(such as TABLE Ⅰ).

A pixel was taken as the basic evaluation unit. Thematic maps were spatial overlay after standardized processing, using the weight sum method. The index of eco-security in each pixel and the comprehensive index in each country have been calculated by the models, in order to achieve a quantitative evaluation of the regional eco-security.

The models of eco-security index：

$$A_i = \sum_{k=1}^{n} W_k Y_k \qquad \text{(Formula 1)}$$

$$C_i = \frac{\sum A_i \times S_i}{\sum S_i} \qquad \text{(Formula 2)}$$

A_i denotes the eco-security in the ith pixel; W_k denotes the weight of the kth index in the same pixel; Y_k denotes the quantitative value after standardized processing. C_i denotes the comprehensive eco-security of the ith country; S_i denotes the number of A_i in the same country. The result is a value between 0 ~ 10, and the larger the better.

For the purpose of comparison, and according to practical situation, the eco-security was divided into six levels. From level Ⅰ to level Ⅵ, the eco-security is worse and worse.

Borrowed the model of land-use change, the eco-security dynamic degree model has been built. It is the quantity change within a certain period and a certain area, which reflects the changing trend and degree of the eco-security more intuitive and accurate.

$$S = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\% \qquad \text{(Formula 3)}$$

S denotes the eco-security dynamic degree in the studied time period. U_a and U_b denote respectively the eco-security dynamic degree at the beginning of the study period and at the end of the study period. If taken year as the unit, S denotes the annual changing rate of the eco-security dynamic degree. When S is calculated into a positive number, the eco-security is improved, vice versa, worsen. $|S|$ denotes the range of the improved eco-security or the worsen eco-security.

IV. RESULT AND DISUSSIONS

In 1988, the mean value of the eco-security in Dongjiang watershed is 6.55, Fig. 1 and Fig. 2 reveal there were three，six and five cities in level Ⅰ, level Ⅱ and level Ⅲ separately. Shenzhen internal had the lowest the eco-security. There was no city in level Ⅴ or level Ⅵ.

In 1998， The eco-security range of each city was from 5.18 to 7.14. Compare with 1988,the cities lie in level Ⅰ had no changes, while the cities number of level Ⅱ increase to eight; and level Ⅲ reduce to three. It is worth to say that the eco-security of Dongguan had been improved a little, which located level Ⅳ in 1988 and level Ⅲ in 1998; while Huicheng was exactly the opposite. Tough the eco-security of 1998 is better than that of 1988 on the surface , the actual eco-security was only 6.48 in 1998,which was reduced by 1.1%; because the eco-security of Shenzhen internal and external all had fell into level Ⅴ from level Ⅳ.There was no city in level Ⅵ.

In 2007 , the eco-security of was not optimistic, with the mean eco-security value only 6.18, which reduced by 4.83% compare with 1998. The city in level Ⅵ appeared, Shenzhen

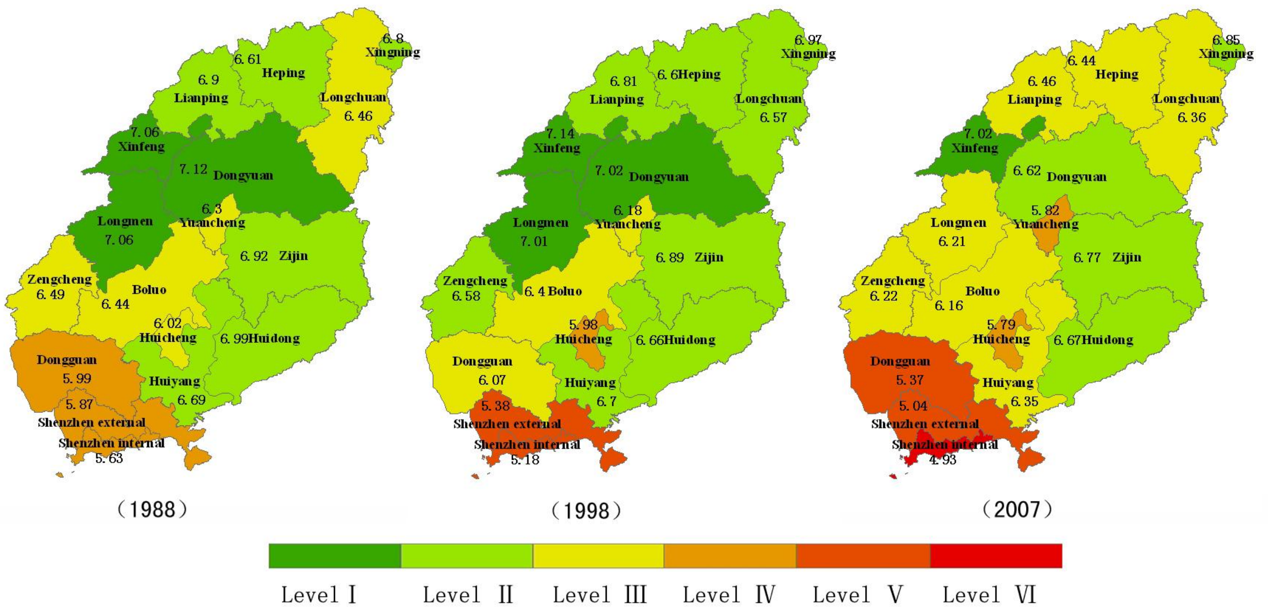

Fig.1 Eco-security evaluation result in different cities

internal, with the eco-security just 4.93. Among all the city eco-security values, the best was 7.02, which was lower than that in 1998. The total number of cities in level Ⅰ, level Ⅱ and level Ⅲ was reduced to twelve. There was only Xinfeng keeping very safety state. Yuancheng was fell into level Ⅳ from level Ⅲ and Dongguan was fell into level Ⅴ from level Ⅲ.

The eco-security changes in every county and town can be seem clearly from Fig.3 and TABLE Ⅱ. In the early 10 years, the changes were not obvious, except Shenzhen, whose eco-security was getting worse and worse. But a phenomenon that the eco-security was a slightly better also appeared in some county and town. In the last 9 years, the whole eco-security was seriously deteriorated, with every county and town had different degrees of decline in the quality of the eco-security.

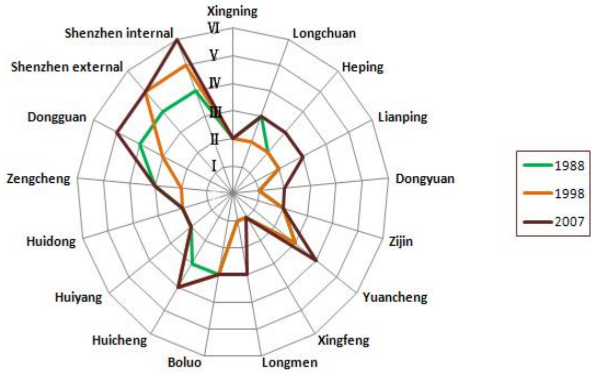

Fig.2 Eco-security evaluation level in different cities

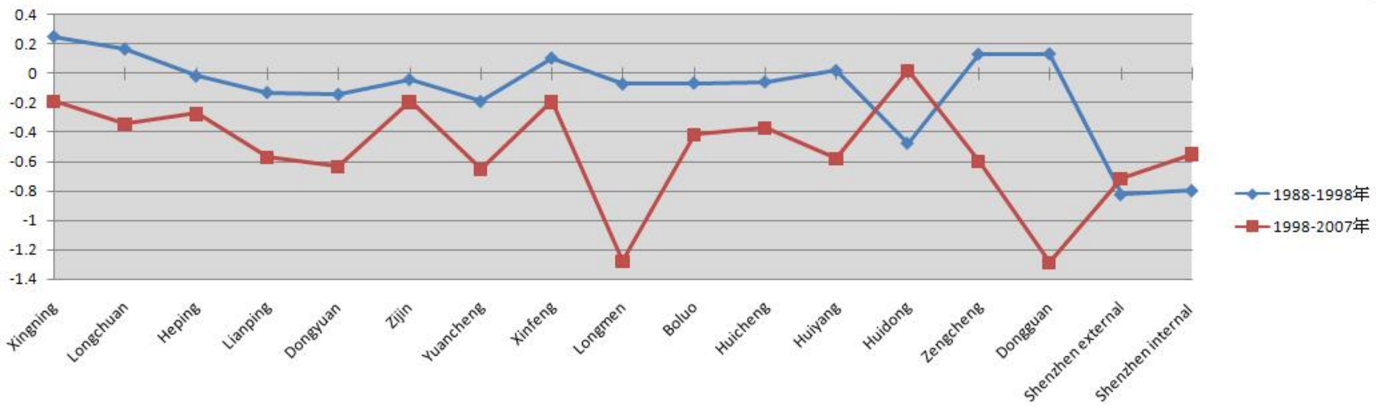

Fig.3 Eco-security dynamic degree in different cities in different periods

TABLE II. TABLE OF ECO-SECURITY DYNAMIC DEGREE

	Xinning	Longchuan	Heping	Lianping
1988-1998	0.25%	0.17%	-0.02%	-0.13%
1998-2007	-0.19%	-0.35%	-0.27%	-0.57%
	Dongyuan	Zijin	Yuancheng	Xinfeng
1988-1998	-0.14%	-0.04%	-0.19%	0.11%
1998-2007	-0.63%	-0.19%	-0.65%	-0.19%
	Longmen	Boluo	Huicheng	Huiyang
1988-1998	-0.07%	-0.06%	-0.06%	0.02%
1998-2007	-1.28%	-0.42%	-0.37%	-0.58%
	Huidong	Zengcheng	Dongguan	
1988-1998	-0.47%	0.13%	0.13%	
1998-2007	0.02%	-0.60%	-1.28%	
	Shenzhen external		Shenzhen internal	
1988-1998	-0.82%		-0.79%	
1998-2007	-0.71%		-0.55%	

From 1988 to 1998, the eco-security of 6 cities had been improved. They are Xingning、Longchuan、Xinfeng、Huiyang、Zengcheng and Dongguan. The largest improvement range is 0.25%, belonging to Xingning, which lies in upstream. In addition to these 6 cities, others had different degrees of decline in the quality of the eco-security, and the largest deterioration range was 0.82%, belonging to Shenzhen external, next come Shenzhen internal and Huidong, with the deterioration range 0.8% and 0.47%.

From 1998 to 2007, except Huidong, there was no improved city. The deterioration range of Lianping、Dongyuan、Yuancheng、Huiyang、Zengcheng、Longmen、Dongguan and Shenzhen external were more than 0.55%, worse still, Longmen and Dongguan reached to1.28%.

V. SUMMARY

Based on the Dongjiang current situation of the eco-security, the paper addresses some guiding ideas and practicing tactics in order to promote the watershed ecological steady development as follows: pollutant sources controlling and water quality protection; illegal sand mining regulation and mining environment conservation; pure eucalyptus forest transformation and species diversity enriching; water compensation mechanism perfecting and the economic development coordinating in different cities; "Digital Basin" building and ecological management informationization; watershed ecological monitoring, assessment and early warning systems establishing and information-sharing mechanisms creating.

ACKNOWLEDGMENT

This work was supported by Guangdong NSF (10151007003000002) and Comprehensive strategic cooperation project of the Chinese academy of sciences and Guangdong province (2011B090300048)

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