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Land Ecological Security Assessment for Bai Autonomous Prefecture of Dali Based Using PSR Model--with Data in 2009 as Case

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Abstract

This paper constructs Bai Autonomous Prefecture of Dali's land ecological security assessment index system based on pressure-state-response model, using entropy method and composite index method to evaluate Dali Prefecture's land ecological security' composite index is 0.60823 in 2009, which is in good security condition. Although the whole prefecture's condition stays comparative security, we should realize the economic disparity and land security status varies from city to city. The difficulty of land exploiting, ecological disasters and the vulnerable land ecosystem are also the reality we should face. So how to maintain the present good trend of land resources development with the rapid development of economy and intensified human activities is what the government and policy makers should consider.

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Keywords: Dali, land ecological security, PSR model, entropy method, composite index

1. Introduction

Land resource is the material base for human being's existence and development. With the aggravation of human being's activity and land resources' using intensity, ecological environment of land resources is severely destroyed. As one important aspect of ecological security, research of the land ecological security is also the frontier of research into sustainable use of resources. At present, the assessment of land ecological security is still at the primary phase. There are a lot of methods to evaluate the security status

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of a certain region, but there is not a mature one. Entropy method and composite index methodology can be used to do quantitative assessment and comparison for land resource in different time, or between different lands. It is very simple and the result it obtains is very reliable and direct. It is a quantitative method that worth popularizing. This paper takes the land state of Bai Autonomous Prefecture of Dali in 2009 as an example to provide the basis for the land management and ecological environment protection by using the PSR model of OECD to build index system, and the composite value to assess the regional land ecological security, both based on the characteristic of local land ecosystem.

2. Materials and Methods

2.1. Date

Date being used in the paper is from “Statistical Yearbook of Dali 2010”, “Statistical Yearbook of China2010” and data supplied by Dali Prefecture Land and Resources Bureau. All the index values are calculated based on the data collected from the above.

2.2. The study site

The Bai Autonomous Prefecture of Dali, located in the middle west of Yunnan province, has a moderate climate and fertile field. It covers an area of 28,316.42 km² with the east-west maximum horizontal distance of 320 km and the north-south maximum vertical distance of 270 km. It is one of the ethnic minority areas that developed earlier than the other areas in the southwest border of China. But with the accelerated economic development in recent years and the growth of population, the population density of the dam area around the Erhai basin has already achieved more than 260 per km² and the per capita cultivated land is only 0.5 acres. The antinomy between cultivated land total supply and demand has become more and more outstanding. So it is an urgent demand to assess and analyze the land ecological security that can provide the basis for the protection and management of Erhai basin.

3. Evaluation methodology

3.1. Pressure-State-Response (PSR) model

The PSR model is based on the concept of causality: human activities exert pressures on the environment and change the quality and quantity of natural resources which lead to responses in human behavior. Three categories of indicators are distinguished. First, eco-environmental pressure indicators describe pressures on the environment by human activities and climate change [1]. Second, eco-environmental state indicators describe the status quo of the natural environment and ecosystem function. Thirdly societal response indicators show the degree to which society responds to eco-environmental changes and concerns. This could be the number and kind of measures taken, the efforts of implementing measures, or the effectiveness of those measures.

3.2. Index selected

The 20 independent indicators, representing principal Dali land eco-security traits, were selected in an adapted PSR framework (table1), the weight of each indicator in each level are also listed in the table. In possess of selecting these indicators, we have considered related methods about ecological security evaluation which used domestic and foreign at present. The indicators have four levels above all. First is target level, namely composite index of ecological security; second is project level, including pressure that result from nature, society and humans, the status of the ecosystem, the responses of human society; and the third is of the factor level, dealing with factors by which the justification criteria is determinate. The specific result is in Table 1[2].

Table 1. Indicators Index system of Dali land ecological security evaluation

Target layer	Project layer	Factor	Index layer	Index weight
Land ecological security	Land ecological pressure	Population pressure	D1 population density	0.0151
			D2 natural population growth rate	0.0187
		Land pressure	D3 per capita cultivated land	0.0165
			D4 mean annual precipitation	0.0206
			D5 yield per unit area under crops	0.0471
			D6 annual forestland production value per unit	0.0400
			D7 annual agricultural land production value per unit	0.0517
		Socio-Economic pressure	D8 economic density	0.1191
			D9 urbanization level	0.1228
	Land ecological state	Land quality	D10 proportion of non-irrigated farmland	0.0247
			D11 agrochemical application rate (calculated by pure consumption)	0.0155
		Land use structure	D12 land resource backup rate	0.0350
			D13 proportion of cultivated land	0.0339
			D14 proportion of grassland	0.1688
			D15 proportion of forestland	0.0297
	Land ecological response	Socio-Economic response	D16 proportion of tertiary industry in GDP	0.0256
			D17 per capita GDP	0.0914
			D18 growth rate of total social investment in fixed assets	0.0223
			D19 rural per capita net income	0.0528
			D20 farming mechanization	0.0486

3.3. Standardization of Index

As different indexes have no comparability due to the fact that they differ completely in dimensions, it's necessary to convert original data to dimensionless form. The evaluating indicators can be divided into the positive term target and the negative term target. The model takes the following two forms.

1) Standardization of positive effect indexes: for some indexes, the higher their values are, the greater the positive effect they will bring to land ecological security, which means this kind of indexes has much less risk to ecological security. Their standardization method is:

$$P_i = \frac{x_i - x_{\min}}{x_{\max} - x_{\min}} \qquad (1)$$

2) Standardization of negative effect indexes: for other indexes, the higher their values are, the greater the negative effect they will bring to land ecological security, which means this kind of indexes has much more risk to ecological security. Their standardization method is:

$$P_i = \frac{x_{\max} - x_i}{x_{\max} - x_{\min}} \quad (2)$$

In the formula, P_i is the i th standardized value of each index included in the assessment; x_i is the i th actual value; $x_{\max}$ is biggest value of this index, and $x_{\min}$ is the minimum value of this index.

3.4. Determination of weights value

During the process of land ecological security assessment, the importance of each evaluation factor to target ranges, the value determined by their proportion in the evaluation according to the importance of indicators is the weight value [5]. Assign weights to each factor is another basic issue influencing eco-security. The correctness of the weight value not only affects the efficiency of evaluation, but also affects the precision of evaluation results. As a user-friendly and practical tool based on simple principles, the entropy method is applicable to problem arising in uncertain environments in which multiple evaluation criteria exist. The entropy is an appropriate method for deriving the weight assigned to each indicator, and been applied widely in environment evaluation and sustainable management. This paper adopts entropy to determine the evaluation indicator weights, and the specific process is as follows:

Information entropy represents the uncertainties of things and issues, which can measure effective information the data provided, the entropy and entropy weight decrease with the reduction of information amount, and vice versa[3]. The computation of entropy and entropy weight is as following [4]:

$$e_j = -K\sum_{i=1}^{m}(f_{ij} Inf_{ij}) \quad (3)$$

Where, e_j is entropy of j index, $f_{ij} = \frac{P_{ij}}{\sum_{i=1}^{m} P_{ij}}$, $k = \frac{1}{Inm}$.

Suppose W_j is entropy weight of j index, then

$$W_j = \frac{1 + K\sum_{i=1}^{m}(f_{ij} Inf_{ij})}{\sum_{i=1}^{n}(1 + K\sum_{i=1}^{m}(f_{ij} Inf_{ij}))}, \quad 0 \le W_j \le 1, \quad \sum_{i=1}^{n} W_j = 1 \quad (4)$$

3.5. Integrated evaluation index value

In order to quantitatively assess the security status of a region ecosystem composite index (T) needed to be developed. A scale from 0 to 1 was chosen as a basis for ranking where T of zero indicates the worst possible health state and one of 1 the best possible health state. In order to facilitate verbal descriptions of health status, the T was further divided into five groups with ranges as: 0-0.3, 0.3-0.5, 0.5-0.6, 0.6-0.8, 0.8-1 corresponding to five health states, “Worst”, “Bad”, “Middle”, “Good” and “Best”, respectively.

The T is then calculated according to the following equation:

$$T = \sum_{i=1}^{n} (Y_i \times W_i) \tag{5}$$

Where T is a synthetic ecosystem security index, Y_i the i th sub-ecosystem security index for the i th indicator, n the number of indicators considered in assessment, and W_i the weighting factor for the i th indicator.

It can be seen from Eq. (5) that the synthetic T depends on the various Y_i and the weighting factors for each indicator.

4. Results and analysis

According to the assessment method raised above, the ecological security results of Dali in 2009 are reveling in table 2:

Table 2: Results of Dali Prefecture land ecological security evaluation

City/County name	pressure	state	response	composite value	rank	status
Whole Prefecture	0.30796	0.11050	0.18977	0.60823		Good
Dali city	0.38049	0.116	0.22909	0.72558	1	Good
Yangbi County	0.2289	0.10813	0.1484	0.48543	10	Bad
Xiangyun County	0.32979	0.12388	0.1831	0.63677	3	Good
Binchuan County	0.30487	0.16304	0.18913	0.65704	2	Good
Midu County	0.27826	0.09487	0.14253	0.51566	6	Middle
Nanjian County	0.25506	0.11246	0.138	0.50552	7	Middle
Weishan County	0.26685	0.10233	0.13577	0.50495	8	Middle
Yongping County	0.24545	0.11175	0.14661	0.50381	9	Middle
Yunlong County	0.19997	0.11106	0.13158	0.44262	12	Bad
Eryuan County	0.26439	0.12112	0.15701	0.54252	4	Middle
Jianchuan County	0.21747	0.12783	0.13178	0.47707	11	Bad
Heqing County	0.25432	0.12704	0.14748	0.52884	5	Middle

It can be seen from table 2 that the higher the composite value of land ecological security, the greater the degree of land ecological security. The land ecological security composite value of Dali Bai Autonomous Prefecture in 2009 is 0.60823, the security level is "good" and the ecological security status is that the land ecological environment is good, the structure of ecosystem and the service function of land ecosystem are basically sound. The ecosystem can recover by itself if it is mildly disturbed, and the chance of ecological disasters is very small. Meanwhile, the land ecological security levels of Dali City, Xiangyun County and Binchuan County are also "good". These three places located in the dam area, and the levels of land utilization and economic development in these places are relatively high. There are six counties that are in the levels of "middle". The economies of these places are relatively underdeveloped compared with Dali City. It is hard to exploit land there because the terrain is largely mountainous. Land ecological function is weak, and ecological disasters happen sometimes. The land ecological security levels of Yangbi, Yunlong and Jianchuan County are in the level of "bad". These three counties are in the remote area of the prefecture. The economy of these regions is underdeveloped and the level of agricultural production is comparatively low. Taking Yunlong County as an example, the security index of farming mechanization is 0.01623, the level of farming mechanization is 2.4393 KW/hm^2 much lower than that of national average value which is 20 KW/hm^2. It results in extensive farming method, misuse and ecological insecurity of land resources. According to the analysis above, the results of the analysis model is consistent with the actual situation.

5. Conclusion

According to the results of the land ecological security assessment of Dali prefecture, the security status of the region in 2009 is pretty good. However, it is noteworthy that the economic disparity among different cities in the prefecture and the land security level varies from city to city. The difficulty of land exploiting, ecological disasters and the vulnerable land ecosystem are also the inevitable reality people should face. So how to maintain the present good trend of land resources with the rapid development of economy and intensified human activities is what the government and policy makers should consider.

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