Ecological Security Evaluation of Cultivated Land in Eastern Liaoning

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Abstract: In order to understand the status of cultivated land ecological security in the counties and districts of Eastern Liaoning, and provide theoretical basis and Countermeasures for the local government to formulate policies to protect cultivated land security, the PSR model was used to construct the index system of cultivated land ecological security, and the multi-factor comprehensive evaluation method was used to evaluate the status of cultivated land ecological security in eastern Liaoning. The results show that from 2005 to 2015, the ecological security index of cultivated land in Tieling, Dashiqiao, Kaiyuan, Fushun and Xifeng is relatively stable, and the ecological environment of cultivated land remains relatively good, while the ecological security index of cultivated land in the two counties of Bayuquan and Ganjingzi has been very low. Most of the counties and cities in eastern Liaoning have improved the ecological security of cultivated land. The security status of eight counties and districts is relatively stable and unchanged. The ecological security of cultivated land in 15 counties and districts has been improved. The ecological security of cultivated land in Ganjingzi has been in an unsafe state, which requires the government to take more effective measures to control it.

1. Introduction

The construction of evaluation index system of cultivated land ecological security is a very important step in the research of cultivated land ecological security evaluation[1,2]. The ecological security of cultivated land is affected by many factors[3]. When constructing the index system of cultivated land ecological security, we should not only consider the impact of climate, topography, vegetation and other factors of resources and environment, but also consider the impact of social and economic factors. In this paper, 33 agricultural counties in Eastern Liaoning Province are selected as the study area, considering the availability and continuity of data such as resources, environment and social economy[4].Relevant data are collected, calculated and processed, and the evaluation index system of cultivated land ecological security in eastern Liaoning Province is constructed according to three levels: target level, criterion level and index level. Among them, the target layer is the ecological security of cultivated land in eastern Liaoning; the criterion layer is divided into three layers: pressure, state and response; and the index layer is composed of specific indicators reflecting the ecological security of cultivated land in eastern Liaoning.

2. Evaluation Index System

Based on the relevant research results at home and abroad[5,6,7], considering the impact of resources, environment and social economy on the ecological security of cultivated land, combined with the characteristics of ecological environment and land use structure in eastern Liaoning Province, this paper uses the pressure-state-response model to construct the index system of cultivated land ecological security in the study area. Pressure (P) reflects the pressure of social and

economic development on the ecological environment, state (S) reflects the state of the ecological environment under such pressure, and response (R) reflects the response of social and economic to the ecological environment under pressure[8].

Based on the pressure-state-response model, 16 evaluation indexes were selected from three aspects of pressure (P), state (S) and response (R) to construct the index system of cultivated land ecological security in eastern Liaoning Province, as shown in Table 1.

Table 1 Evaluation index system of cultivated land ecological security

Target layer	Criterion level	Index code	Index level	Safety trend
Ecological security of cultivated land in eastern Liaoning	P	P1	Fertilizer application rate per unit area	-
		P2	Population density	-
		P3	Natural population growth rate	-
		P4	Urbanization level	-
		P5	Per capita arable land occupancy	+
	S	S1	Average annual temperature	+
		S2	Annual rainfall	+
		S3	The proportion of forest area	+
		S4	Land reclamation rate	+
		S5	Grain yield per unit area	+
		S6	The proportion of primary industry output value to total output value	+
		S7	Per capita net income of farmers	+
	R	R1	Effective irrigation area ratio	+
		R2	Mechanization level of unit cultivated land area	+
		R3	Proportion of Agricultural Financial Expenditure	+
		R4	Per capita food possession	+

3. Survey and Data Sources of Research Areas

3.1 General situation of research area.

The mountainous and hilly area in eastern Liaoning Province is one of the three provincial secondary areas in Liaoning Province, which is located in the eastern part of Liaoning Province[9]. According to the availability of index data, 33 agricultural counties and districts in eastern Liaoning were selected as research areas. By the end of 2015, the total area of land in the study area was 6.98 million hectares, of which 1.44 million hectares were cultivated land. The altitude is 500-800 m, the highest peak is 1300 m, mostly mountainous and hilly, the terrain is complex and diverse. The region is humid and rainy, and has a temperate monsoon climate. The total population is 14.523 million, the agricultural population is 5.681 million, the per capita cultivated land area is 9.9 square kilometers, the urbanization level is 46%, the GDP of the region is 10.23 billion yuan, and the social economy is developed.

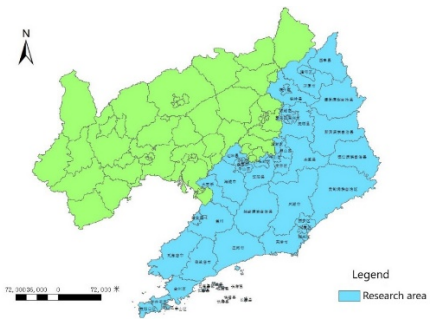

Figure 1 Geographical map of the study area

3.2 Data Sources and Data Processing

3.2.1 Data sources.

The basic data of this paper come from Liaoning Statistical Yearbook in 2005, Liaoning Statistical Yearbook in 2015, Liaoning Statistical Yearbook in 2005 and 2015, and the literature related to the study of cultivated land ecological security.

3.2.2 Data processing.

Firstly, the initial data are processed in dimensionless way. Secondly, in order to reflect the real situation of the indicators and ensure the objectivity and accuracy of the evaluation results, the objective weighting method, namely the entropy method, is used to determine the weight of the indicators[10].

4. Comprehensive Evaluation Process

The multi-factor comprehensive evaluation index method is used to evaluate the ecological security of cultivated land in eastern Liaoning Province, which can objectively reflect the ecological security of cultivated land in the study area by combining the various indicators affecting the ecological security of cultivated land with their weights[11]. The calculation formula is as follows.

$$E = \sum_{i=1}^{m} A_{ij} w_i \tag{1}$$

In the formula E is the comprehensive evaluation value; A_{ij} is the standardized evaluation matrix, i.e. the standardized value of the area j of the index i. i is 1, 2, 3, … , m; m as evaluation index.

5. Determination of Evaluation Criteria

In order to reflect the specific situation of cultivated land ecological security scientifically and reasonably, this paper divides the comprehensive index E of cultivated land ecological security into five intervals, and corresponds to five security levels in turn

Table 2 Evaluation Criteria for Ecological Security of Cultivated Land

E	Grade
0<E≤0.3	Insecurity (I)
0.3<E≤0.35	Safety Sensitivity (II)
0.35<E≤0.45	Safety Criteria (III)
0.45<E≤0.5	Basic Safety (IV)
E>0.5	Safety (V)

6. Result Analysis

6.1 Change analysis of cultivated land ecological security index.

According to the above formulas, the evaluation indices of different places are calculated.

From 2005 to 2015, the comprehensive index of arable land ecological security in 5 counties, such as Jinzhou, Haicheng and Sihu, decreased. The pressure of local cultivated land ecological security increased. The government and the society failed to take effective measures to protect the ecological security of cultivated land.The comprehensive index of cultivated land ecological security in the remaining 28 counties of Qingyuan, Wafangdian City and Changhai increased, and the pressure index, state index and response index all changed.The pressure index, state index and response index of the remaining 22 counties and districts have increased, which shows that the pressure of local population, social economy and resources and environment has been controlled by

the local government under the active control measures, making the cultivated land ecological environment develop in a safer direction.

6.2 Spatial Change Analysis of Agricultural Ecological Security in Counties and Areas.

According to Fig. 2 and Fig. 3, Ganjingzi, Bayuquan, Shuncheng and Pingshan were in unsafe grade in 2005. The Xihu and Mingshan counties and districts are at the safety sensitive level. Nineteen counties and districts, such as Lushunkou, Jinzhou and Wafangdian, are at the critical level of safety. Fushun, Dashiqiao, Liaoyang, Kaiyuan and Xifeng are in the basic safety level. Haicheng, Donggang and Tieling are in the safety level. In 2015, Ganjingzi and the Bayuquan were at the unsafe level. Jinzhou, Shuncheng and Xihu are in the security sensitive grade. Eight counties, such as Lushunkou, Wafangdian and Qingyuan, are in the critical level of safety. Eleven counties and districts, such as Pulandian, Zhuanghe and Changhai, are in the basic safety level. Fushun, Xinbin, Kuandian, Fengcheng, Dashiqiao, Kaiyuan, Xifeng, Donggang and Tieling are in the safety level.

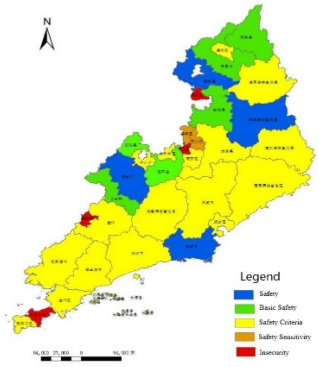

Figure 2 Grade map of cultivated land ecological security in eastern Liaoning in 2005

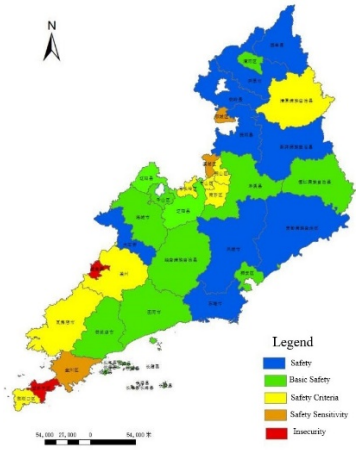

Figure 3 Grade map of cultivated land ecological security in eastern Liaoning in 2015

6.3 Time variation of cultivated land ecological security in counties and districts.

According to the changes of cultivated land ecological security index value and security grade in 2005 and 2015 in each county, the changes of ecological security in each county were analyzed and summarized. 33 counties in eastern Liaoning were divided into three categories, i.e. safe and stable area, safety deterioration area and safety improvement area. The ecological security grade of cultivated land in 12 counties such as Ganjingzi, Bayuquan and Xihu has not changed, which is a safe and stable area. Shuncheng, Pingshan, Mingshan and other 18 counties and districts have been upgraded to safety improvement zones. The security level of Jinzhou and Haicheng counties and districts declined, which was a deteriorating area.

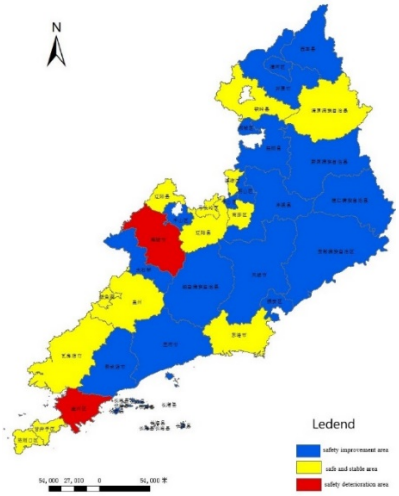

Figure 4 Time-varying chart of cultivated land ecological security grade in different areas

7. Conclusion

(1) In 2005, Tieling, Donggang, Haicheng and other places in eastern Liaoning Province had higher ecological security index of cultivated land, while Shuncheng, Pingshan and Bayuquan had lower ecological security index. In 2015, Tieling, Xifeng, Kaiyuan and other places had higher ecological security index of cultivated land, while Jinzhou, Ganjingzi and Bayuquan had lower ecological security index. The ecological environment of cultivated land in Tieling, Donggang, Dashiqiao and other places remained relatively good. However, the ecological security index of cultivated land in the two counties of Bayuquan and Ganjingzi has been very low. The governments of the two counties should strengthen the management of cultivated land ecosystem and take more effective measures to ensure the ecological security of cultivated land.

(2) The evaluation of cultivated land ecological security in Liaodong in 2005 and 2015 shows that most areas of cultivated land ecological security in Liaodong counties have been improved. In the 33 agricultural counties, the ecological security level of arable land decreased except for two counties in Jinzhou and Haicheng, and the ecological security status of cultivated land in 12 counties such as Ganjingzi, Bayuquan and Xihu was relatively stable. The ecological security of cultivated land in 19 other counties and districts has improved to some extent. It shows that the pressure of resources, environment and social economy on the ecological security of cultivated land has been effectively controlled in 2015 compared with 2005. The local government has also paid more attention to the ecological security of cultivated land, increased the financial expenditure on agriculture, and adopted more positive and beneficial measures to protect cultivated land.

(3) For Ganjingzi and Bayuquan area, the ecological security of cultivated land is always unsafe. The local government should focus on the factors that affect the ecological security of cultivated land, such as population density, urbanization level, etc. At the same time, we should increase financial expenditure and technical investment in agriculture to ensure the ecological security and stability of cultivated land in the region, and finally achieve the result of improving the level of security. Although the ecological security of cultivated land in other areas has remained stable or improved, it is still necessary to control the pressure within a reasonable range, and at the same time continue to strictly implement the policy of protecting cultivated land, stabilize the security situation and improve food production.

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