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Study on the Land Ecological Security and early warning in Shenzhen

Meijuan Wang^{1, *}, Yang Li², Yangyang Huai³, and Xin Wang⁴

¹Shandong Women's University, Jinan, China

²Jinan Urban Planning and Design Institute, Jinan, China

³Shandong Women's University, Jinan, China

⁴Shandong Management University, Jinan, China

*Corresponding author e-mail:799471271@qq.com

Abstract. Land is the foundation of human survival and development, and safe land ecological condition is the decisive factor in ensuring security and stability. As the land use intensity continues to deepen and the scope continues to expand, its irrational use has caused a series of ecological security problems. Therefore, studying the relationship between land use and ecological security in the region has become an urgent problem for the current land science. Based on the improved TOPSIS method, this paper constructs a comprehensive evaluation model of urban land ecological security. The results show that land ecological pressure contributes the most to the land ecological security system. The increase of urban population density, the expansion of construction land and the increase of industrial waste emissions will affect the ecological security of the land; since 2004, Shenzhen's land ecological security and development has gone through several stages, from primary ecological coordination to good ecological coordination - ecology Hysteresis type. It is necessary to vigorously establish and improve the land ecosystem. Besides, we need to actively carry out land ecological security warning supervision and promote the maintenance of land ecosystems and the sustainable use of land resources in Shenzhen.

Key words: Land ecological security; TOPSIS model; Shenzhen.

1. Introduction

Land ecological security refers to the fact that the land ecosystem within a specific research area is in a state of health that is less threatened by pollution, while at the same time providing a continuous service function for human beings[1]. With the acceleration of urbanization, the contradiction between economic development and natural resources has become increasingly prominent.

Foreign studies on land ecological security mainly focus on ecological risk assessment and health assessment, which have relatively complete conceptual systems and operation methods[2]; The domestic study focus on the comprehensive evaluation of land ecological security and the construction of ecological security pattern based on land-based changes[3]. The research theory is based on the theory of human and land, landscape ecology and sustainable development; The research area is concentrated in arid zone and lake basin area; Research methods include mathematical models, landscape ecological



models, and digital terrestrial models[4]. There is relatively little research on the relationship between land ecological security and urbanization development and economic development.

Research on the relationship between land ecological security and economic development is very important for Shenzhen, which is representative of rapid urbanization. alleviating human-land contradictions and promoting economic development. Based on the PSR model, this paper constructs a comprehensive index system of land ecological security and economic development, and combines the improved TOPSIS model to quantitatively analyze the coordinated development relationship, providing a basis for the sustainable development of urbanized regional economy and land ecosystem.

2. Materials and methods

2.1. Study Area

Shenzhen, located in the southeastern part of Guangdong Province, is an important growth pole for economic development in the Pearl River Delta region. With the rapid improvement of the economic level, the ecological and environmental problems have become increasingly prominent[5]. How to realize the coordinated development of ecology and economy is a new challenge.

The research data of this paper originated from "Shenzhen Statistical Yearbook", "Shenzhen Environmental Bulletin", "Shenzhen Water Resources Bulletin", "Guangdong Province Statistical Yearbook". The land use data is derived from the land survey data of Shenzhen City over the years.

2.2. Study Method

2.2.1. Index system construction. This paper uses the pressure-state-response (PSR) conceptual model to construct the land ecological security evaluation index system referring to the relevant literature [6]. The following evaluation indicators were selected for research, and the indicators were divided into positive and negative indicators.

Table 1. Evaluation index system of land ecological security in Shenzhen City

| Target layer | Criterion layer | Index layer | Weight | directionality |
|--------------------------|-----------------|--|--------|----------------|
| Land ecological security | pressure | The population density | 0.101 | – |
| | | Wastewater discharge | 0.114 | – |
| | | Solid waste discharge | 0.053 | – |
| | | Soil erosion area | 0.059 | – |
| | | Construction land development intensity | 0.081 | – |
| | | Road network density | 0.133 | – |
| | state | Land reclamation rate | 0.052 | + |
| | | Grain yield per unit area | 0.057 | + |
| | | Forest cover rate | 0.075 | + |
| | | Soil and water coordination | 0.052 | + |
| | | Soil erosion control rate | 0.070 | + |
| | response | Harmless treatment rate of domestic garbage | 0.025 | + |
| | | Comprehensive utilization rate of industrial solid waste | 0.033 | + |
| | | Urban sewage treatment rate | 0.065 | + |
| | | Park green area | 0.031 | + |

Table 2. Evaluation index system of economic development in Shenzhen City

| Target layer | Criterion layer | Index layer | Weight | directionality |
|----------------------|----------------------|---|--------|----------------|
| Economic development | Economic scale | GDP | 0.099 | -- |
| | | Fixed asset investment in the whole society | 0.105 | + |
| | | Local fiscal revenue | 0.109 | + |
| | Industrial structure | Secondary industry(%) | 0.093 | + |
| | | Number of employees in the secondary industry | 0.040 | + |
| | | Tertiary Industry(%) | 0.084 | + |
| | | Number of employees in the tertiary industry | 0.064 | + |
| | | The total retail sales | 0.104 | + |
| | Economic quality | Per capita disposable income | 0.102 | + |
| | | Engel coefficient | 0.105 | - |
| | | Social employment | 0.094 | + |

2.2.2. Modified TOPSIS model. The TOPSIS [7] model is a multi-attribute decision-making method that gradually approximates the optimal solution order. By calculating the degree to which the target approaches or deviates from the ideal solution, the distance between the evaluation index and the ideal solution is used as the evaluation standard for comprehensive evaluation.

(1) Standardized evaluation matrix

$$V = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1m} \\ v_{21} & v_{22} & \cdots & v_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ v_{n1} & v_{n2} & \cdots & v_{nm} \end{bmatrix} \quad (1)$$

V is the initial evaluation matrix, and V_{ij} is the initial value of the m th indicator;

(2) Index weight determination

In order to make the weight of evaluation indicators more scientific and objective [8], this paper chooses the improved entropy weight method to determine the weight [9].

(3) Building a weight-based evaluation matrix

$$Y = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1m} \\ y_{21} & y_{22} & \cdots & y_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ y_{n1} & y_{n2} & \cdots & y_{nm} \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix} * \begin{bmatrix} r_{11} & 0 & \cdots & 0 \\ 0 & r_{22} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix} \quad (2)$$

(4) Calculate distance closeness

$$D^+ = \sqrt{\sum_{j=1}^m (y_i^+ - y_{ij})^2} \quad D^- = \sqrt{\sum_{j=1}^m (y_i^- - y_{ij})^2} \quad (3)$$

Y_{ij} is the normalized value of the i th index after the j th year. y^+ , y^- is the positive and negative ideal value of the i th index.

(5) Relative closeness

$$R = \frac{D^-}{D^+ + D^-}, 0 \leq R \leq 1 \quad (4)$$

2.2.3. System coupling coordination degree model

(1) Coupling degree [10]

$$C = \left[\frac{f(L) \times f(E)}{\left(\frac{f(L) + f(E)}{2} \right)^2} \right]^{1/2} \quad (5)$$

C is the coupling degree, $0 \leq C \leq 1$; $f(L)$, $f(E)$ is the comprehensive evaluation function of land ecological security and the comprehensive evaluation function of economic development. The higher the degree of coupling, the closer the comprehensive evaluation values of the two systems are, and the smaller the degree of dispersion.

(2) Coupling coordination degree

$$T = \alpha f(L) + \beta f(E) \quad D = \sqrt{C * T} \quad (6)$$

D is the coupling coordination degree and T is the system comprehensive harmonic index. This paper sets $\alpha = \beta = 0.5$ and considers that land ecological security and economic development are equally important.

3. Conclusion and suggestions

3.1. Comprehensive evaluation index analysis

Table 1 shows that road network density (13.28%), wastewater discharge (11.41%), population density (10.07%), construction land development intensity (8.10%) and forest coverage rate (7.46%) on land ecological security level has a high contribution. In general, land ecological pressure and land ecological status are the main factors that affect land ecological security. Table 2 shows that contribution of local fiscal revenue (10.86%), total social fixed assets investment (10.55%), Engel coefficient (10.53%) and total retail sales of social consumer goods (10.42%) is relatively high. It can be seen that the economic scale and economic quality are two main factors in economic development.

3.2. Comprehensive evaluation of land ecological security and economic development

The comprehensive level of land ecological security in Shenzhen showed a trend of decreasing first and then increasing, from 0.51 in 2004 to 0.34 in 2007, and then fluctuated to 0.52 in 2014. The land ecological pressure continues to increase, mainly due to the increase in pollutant emissions and the rapid expansion of construction land, resulting in large areas of soil erosion and soil pollution; In general, the comprehensive level of land ecological security in Shenzhen is at a medium level of safety, indicating that the structure of the land ecosystem is relatively complete, but there is still the possibility of being vulnerable to disasters and human disturbance.

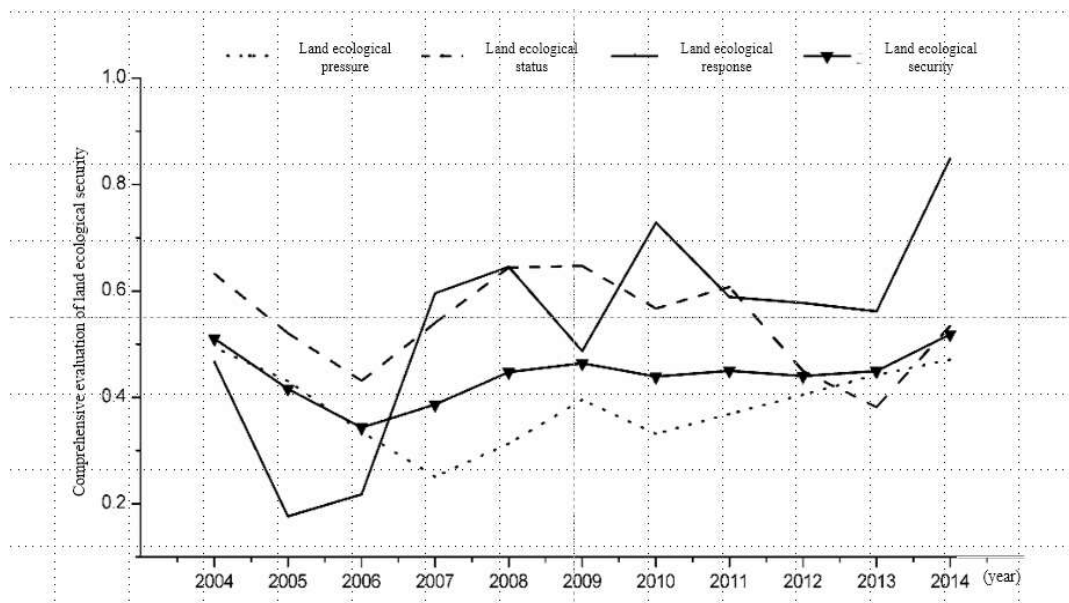


Fig 1. Comprehensive evaluation of land ecological security

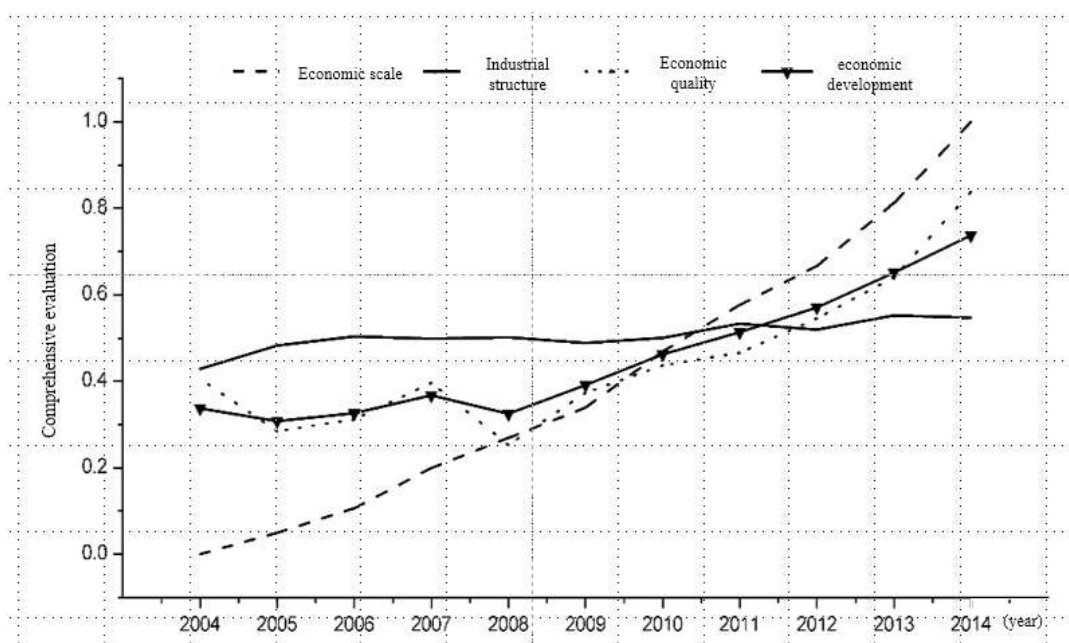


Fig 2. Comprehensive evaluation of economic system in Shenzhen City

Figure 2 shows Shenzhen's economic development has risen rapidly. The economic quality showed a rapid development trend after 2008, indicating that the scale of Shenzhen's economy is developing rapidly and the people's living standards are rising steadily.

Figure 3 shows that during the study period, there was a lag in the development of land ecological security and economic development. The first stage economic development evaluation index is significantly lower than the land ecological security evaluation index, and the second stage is the opposite, indicating that the development pace between Shenzhen's land ecology and economy is inconsistent.

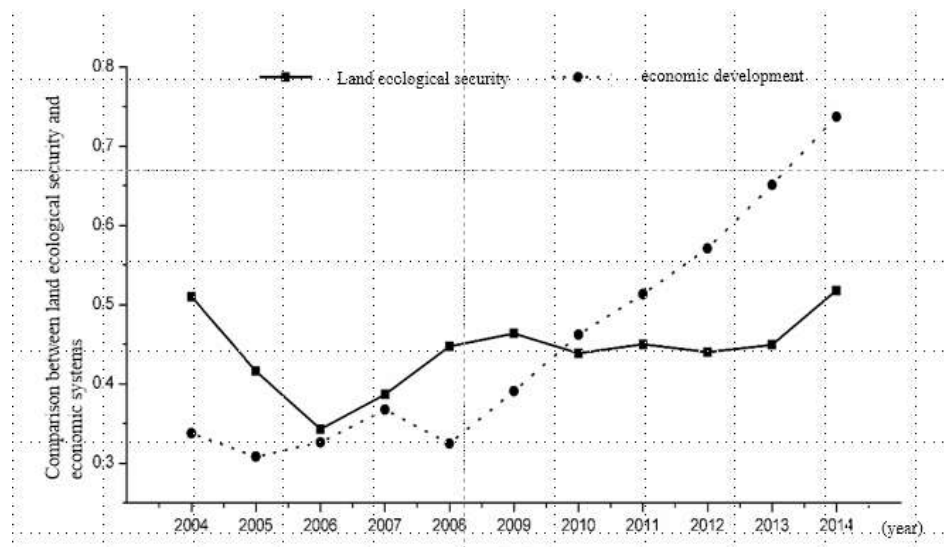


Fig 3. Comparison between land ecological security and economic systems

3.3. System coordination development analysis

In 2004-2014, the coupling degree of Shenzhen City fluctuated between 0.97-1.00, which was in line with the development model of inverted U-shaped curve, indicating that the level of land ecological security and economic development level have been at a high level of coupling stage.

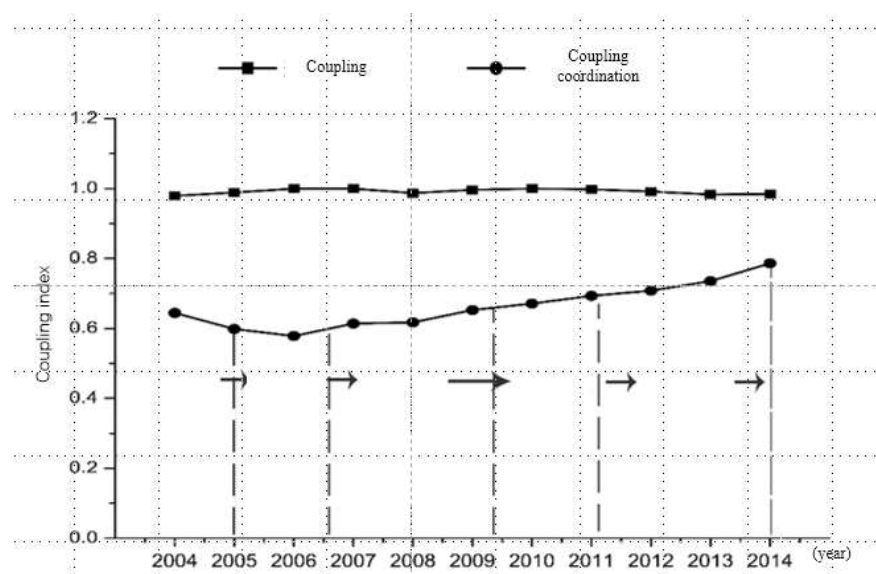


Fig 4. Coordinated coupling degree of land ecological security and economic development in Shenzhen City

Table 3. Evaluation grade standards of coordinated development degree

| coordinated development index | subtype | $\Delta = f(L) - f(E)$ | synchronization |
|-------------------------------|---------------------------|------------------------|-------------------------|
| $0 \leq D < 0.1$ | On the verge of Disorder | $\Delta < -0.1$ | Ecological lag |
| $0.2 \leq D < 0.4$ | Reluctant coordination | $\Delta = 0$ | Synchronous development |
| $0.4 \leq D < 0.6$ | Primary coordination | $0.1 < \Delta$ | Economic lag |
| $0.6 \leq D < 0.7$ | Intermediate coordination | | |
| $0.7 \leq D \leq 0.8$ | Good coordination | | |
| $0.8 \leq D \leq 1.0$ | Advanced coordination | | |

The degree of coupling coordination showed a downward trend in 2004 and 2006, from “intermediate coordination – economic lag” to “primary coordination”. The level of land ecological security at this stage is higher than the level of economic development. The level of land ecological security has dropped from 0.51 to 0.36, while the level of economic development has remained at around 0.33. During this period, the accelerated development of the economy drove a sharp increase in construction land, industrial pollution wastewater discharge, and land ecological security continued to decline due to economic growth. It is the “intermediate coordination – economic lag” from 2007 to 2009, and the coordinated coupling degree of land ecological security and economic development increased steadily. The level of land ecological security has improved since the "Eco-city Construction Plan". From 2010 to 2012, the coupling and coordination degree between land ecological security and economic development continued to increase, and the level of land ecological security and economic development level were improved. However, the growth rate of economic development level is higher than the level of land ecological security, which restricts the overall level of coordinated development. The growth rate of the coordination between the two has been further enhanced, and it has gradually approached the high level of coordination since 2012.

4. Conclusion and discussion

This paper analyzes the dynamic changes of urban land ecological security status and economic development level by constructing a coupling coordination model of land ecological security and economic development. The coupling and coordination of land ecological security level and economic development in Shenzhen developed from the “economic lag type” to the “ecological lag coordination type” with good coordination level, and it is close to the advanced coordination type, which is consistent with the S-type change. It shows that Shenzhen is experiencing a transition from transition to coordinated development. While developing the urban economy, it also takes into account the sustainable development of land ecology. For the further development of the city, it is recommended that the government control the speed of construction, and improve the efficiency of land intensive conservation and utilization, and strengthen the protection of ecological land. Besides, we should pay attention to adjusting and optimizing the industrial structure, vigorously developing strategic emerging industries, and transforming the mode of economic growth. Thus we can achieve sustainable development.

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