Postprint: A Study on the Coupling and Coordinated Development of New-type Urbanization and Ecological Security in Zhangye City

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Abstract

Zhangye City in Gansu Province is located in the arid region of northwestern China. The region belongs to inland river basin oasis cities with extremely fragile ecological environments, making the study of coupled and coordinated development between new-type urbanization and ecological security particularly important. This paper draws on existing domestic and international research findings on the coupled and coordinated development of urbanization and ecological environment, establishes a comprehensive evaluation index system based on statistical data of Zhangye City from 2005 to 2017, employs the entropy weight method to determine index weights, constructs a coupling coordination degree model, and calculates the comprehensive index of coupled and coordinated development between new-type urbanization and ecological security to characterize the coupling relationship in this region. The results indicate that over the 13-year period, the system evolved from low-level coupling coordination through an antagonistic period and a running-in stage to high-level coupling development. The development level of new-type urbanization maintained a basically steady upward trend, while the comprehensive ecological environment level, despite an overall positive trend, fluctuated significantly with 2011 as the inflection point. The coupling coordination degree between new-type urbanization and ecological security continued to improve, reaching a peak in 2012 and thereafter remaining at an extremely high level greater than 0.9. Finally, policy recommendations are proposed to promote the coupled and coordinated development of new-type urbanization and ecological security in this city.

Full Text

Abstract

Considering the oasis city Zhangye, Gansu Province, in the arid region of Northwest China, as the object of study, and constructing new-type urbanization and index systems of ecological environment, this research analyzes coordinated development between new types of urbanization and ecological environment. We used the case of Zhangye between 2005 and 2017 and employed the entropy research method to calculate weight values. According to the feedback at different stages, we were able to give detailed descriptions of changing processes in the system, for example, coupling coordination at low levels, antagonism periods, and running-in periods to high level coupling. Our results indicate that new types of urbanization developed steadily in Zhangye between 2005 and 2017. Although comprehensive development of the ecological environment presents a better trend on the whole, it shows fluctuations in time alignment, decreasing to its lowest point (0.397) in 2011, before maintaining a steady rising trend from 2011 until 2017. The results also show that the degree of coupling between new types of urbanization and ecological security in Zhangye rose from 0.457 in 2005 to 1.000 in 2012. Thereafter, the degree of coupling coordination remained at a very high level above 0.9. The conclusions made by this study are as follows: according to the coupling calculated for the studied period, the degree of environmental pollution in Zhangye is shown to be comparatively smaller when urbanization develops at a lower speed. When urbanization develops more rapidly, the pollution of the ecological environment increases and negative feedbacks become more obvious. However, with the implementation of sustainable development and circular economy strategies, it is planned to improve urban and rural ecological environment protection and make more effort to manage the ecological environment in order to release positive feedbacks. Towards this goal, the coupling between new types of urbanization and the ecological environment in Zhangye is able to develop step by step. New types of urbanization and ecological environment change and develop alternately, such that the coupling coordination presents a general trend of gradual strengthening. At present, the trend for coupling the development of new types of urbanization and ecological security in Zhangye is such that new urbanization develops more prominently than the ecological environment. Therefore, in order to promote a better interaction, it is essential to strengthen the protection and management of ecological environment when advancing new urbanization. It is therefore necessary to constantly regulate the coordinated development of new types of urbanization alongside the ecological environment.

Keywords: new urbanization; ecological security; coupling coordination; Zhangye

3.2 Entropy Method for Weight Calculation

The entropy method was employed to determine objective weights for each indicator. This approach avoids subjective bias in weight assignment by measuring the information content provided by each indicator' s variation. The calculation process involves two main steps: data normalization and entropy weight computation.

For indicator normalization, we apply different formulas based on the indicator' s orientation. For positive indicators where higher values represent better performance, the normalization formula is:

$$x'_{ij} = \frac{x_{ij} - \min(x_{1j} \ldots x_{mj})}{\max(x_{1j} \ldots x_{mj}) - \min(x_{1j} \ldots x_{mj})}$$

For negative indicators where lower values represent better performance, the normalization formula is:

$$x'_{ij} = \frac{\max(x_{1j} \ldots x_{mj}) - x_{ij}}{\max(x_{1j} \ldots x_{mj}) - \min(x_{1j} \ldots x_{mj})}$$

where x_{ij} represents the original value of indicator j in year i, and x'_{ij} represents the normalized value.

Following normalization, we calculate the entropy value e_j and information utility value d_j for each indicator. The weight w_j is then determined by the degree of variation in each indicator across the study period. The entropy method ensures that indicators with greater variation and higher information content receive larger weights, reflecting their greater contribution to distinguishing between different years.

3.3 Coupling Coordination Model

The coupling coordination model was applied to quantitatively assess the interaction between new-type urbanization and ecological security systems. This model, based on systems theory, measures both the coupling degree (interaction strength) and coordination degree (harmonious development level) between the two subsystems.

The comprehensive evaluation functions for the urbanization system $U(x)$ and ecological security system $E(y)$ are constructed as follows:

$$U(x) = \sum_{i=1}^{m} w_i x_i$$

$$E(y) = \sum_{j=1}^{n} w_j y_j$$

where x_i and y_j represent the normalized values of urbanization and ecological security indicators, respectively, and w_i and w_j are the corresponding weights determined by the entropy method.

The coupling degree C is calculated to measure the interaction intensity between the two systems:

$$C = \left\{ \frac{U(x) \times E(y)}{[(U(x) + E(y))/2]^2} \right\}^k$$

where k is the adjustment coefficient, typically set to 2 for two-system coupling.

The coordination degree T represents the overall development level of the combined system:

$$T = \alpha U(x) + \beta E(y)$$

where α and β are undetermined coefficients reflecting the relative importance of each subsystem, with $\alpha + \beta = 1$.

Finally, the coupling coordination degree D is obtained by:

$$D = \sqrt{C \times T}$$

This integrated index simultaneously reflects both the coupling strength and the coordinated development level, providing a comprehensive measure of the relationship between new-type urbanization and ecological security.

[Figure 1: see original paper]

References

[1] Qian Xuesen, Yu Jingyuan, Dai Ruwei. A new discipline of science: The study of open complex giant system and its methodology[J]. Chinese Journal of Nature, 1990, (1): 3-10.

[2] Yang Ting, Tang Zhiqiang. Factor analysis of new urbanization construction and urban residents' life satisfaction[J]. Productivity Study, 2016, (8): 67-69.

[3] Yue Li, Yu Cui, Gao Xincai. Quantitative evaluation of resource environmental stress in the urbanization process of Hexi Corridor[J]. Arid Land Geography, 2017, 40(4): 860-865.

[4] Dang Jianhua, Halik Wahafo, Zhang Yuping, et al. Coupling coordinated development of population, economic and ecological system in the Turpan area of China[J]. Journal of Desert Research, 2015, 35(1): 260-266.

[5] Liu Yaobin, Chen Fei, Li Rendong. Regional urbanization and ecological environment coupling development simulation and regulation strategy: Take Jiangsu Province as an example[J]. Geography Study, 2007, 26(1): 187-195.

[6] Tang Zhiqiang. Evaluation of the relationship between urbanization and resources and environment of Hexi Corridor based on the coordination degree of dispersion coefficient[J]. Northern Economy, 2017, 32(1): 75-77.

[7] Cai Zhenrao, Li Yuhong, Li Xudong. Study on the coupling of urbanization and ecological environment in Guiyang City[J]. Ecological Science, 2017, 36(5): 196-203.

[8] Qiao Biao, Fang Chuanglin. Dynamic coupling model of coordinated development between urbanization and ecological environment and its application in arid areas[J]. Journal of Ecology, 2005, (11): 211-217.

[9] Man Qiang. Research on the coordinated development of urbanization and ecological environment in Changchun[D]. Changchun: Northeast Normal University, 2007.

[10] Zhang Xiuhong. Evaluation and analysis of the status quo of ecological city construction in Harbin[J]. Journal of Suihua University, 2007, (1): 15-18.

[11] Liang Chongbin. Quantitative judgment and classification system for coordinated development of environment and economy: A study of the city group in the Pearl River Delta[J]. Tropical Geography, 1999, 19(2): 171-177.

[12] Shi Guiqin, Tang Zhiqiang, Guo Yumei. Evaluation of ecological city construction in Zhangye City based on entropy method[J]. Journal of the HeXi University, 2014, 30(5): 1-9.

[13] Tang Zhiqiang. Coupling development of new-type urbanization and ecological security in Zhangye City[J]. Arid Land Geography, 2017, 40(4): 860-865.

[14] Hou Pei, Li Chao, Yang Qingyuan. Analysis of the coordination degree between urbanization and Eco-environment of Chongqing City in recent 12 years[J]. Research of Soil and Water Conservation, 2015, 22(5): 240-252.

[15] Tang Zhiqiang. Interaction between urbanization and eco-environment in arid area of northwest China with constrained water resources: A case of Zhangye City[J]. Arid Land Geography, 2014, 37(5): 520-531.

Note: Figure translations are in progress. See original paper for figures.