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Evaluation of Ecological Carrying Capacity of Resource-Based Cities——A Case Study of Huaibei City

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ABSTRACT. *Urban ecological carrying capacity is an important criterion for measuring the ecological sustainable development capacity of cities. Taking Huaibei City, Anhui Province as an example, this article selects 10 indicators of ecological carrying capacity, support capacity, and pressure to construct a comprehensive evaluation index system of ecological carrying capacity. The entropy method weights the evaluation indicators, and then evaluates the ecological carrying capacity of Huaibei from the aspects of resources, environment, society, and economy. The empirical results show that the ecological carrying capacity index of Huaibei has a rising trend, rising from 0.3452 to 0.6547, indicating that the ecological carrying capacity of Huaibei City has a good development trend, but the resource consumption, environmental pollution and other problems caused by the over-reliance on the development model of coal mining still restrict the composite of "nature, economy, society"*

KEYWORDS: *resource-based city, Huaibei city, ecological carrying capacity*

1. Introduction

A resource-based city is a type of city whose natural resources are extracted and processed in the region. Its development is unitary and cyclical [1]. When the resource development enters the late or late stage, the development is in a depleted state and a resource-exhausted city is formed. The predatory mining mode brings great pressure on the ecological environment and restricts regional economic and social coordination and sustainable development.

The report of the Nineteenth National Congress clearly stated that "The modernization we want to build is a requirement of a modern country in which people and nature coexist in harmony" [2]. With the continuous acceleration of the urbanization process, the traditional pillar industries of resource-based cities are becoming an important bottleneck that restricts the high-quality and healthy development of their economies, and will undoubtedly have a negative impact on

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the regional ecological carrying capacity, thereby limiting the regional Development potential. A single economic development model that relies too much on natural resources severely hinders the high-quality development of resource-based cities. The sustainable development of the ecological environment is closely related to social development. Therefore, a scientific assessment of its urban ecological carrying capacity is an ecological measure of such cities. It is also the basis for regional industrial structure adjustment.

Huaibei is a typical coal-depleted city [3]. As a result, ecological support and pressure are also the solution to the coordinated development of Huaibei's resources, environment, economy, and society, and the prospect of the impact of the destruction of the ecological environment. Row.

2. Literature review

The level of urban ecological carrying capacity is an important basis for measuring the sustainable development capacity of a city. However, due to the complexity of urban pollution, the change of urban ecological environment is non-linear, which has brought extremely extremes to the calculation of urban ecological carrying capacity.

In 1921, Park and Burgess defined the ecological carrying capacity as: the maximum number of a certain body under certain environmental conditions [4]. Odum (1953) published the world's first ecological textbook, which systematically introduced the meaning and application of carrying capacity. Ecological carrying capacity has officially become an important area of ecological research [5].

Jin Yue et al. (2015) used the comprehensive evaluation method to study the trend of ecological carrying capacity in Tangshan City from 2001 to 2010, and the results showed that the overall ecological carrying capacity increased in a curve during the decade [6] .Liu Shaohua (2018) evaluated the comprehensive ecological productivity of Ningxia Hui Autonomous Region based on the state space method [7]. Ren Caifeng et al. (2019) evaluated and analyzed the ecological carrying capacity of Huaibei City from 2010 to 2016 by using the mean squared decision method, and concluded that the ecological elasticity has a clear upward trend [8]. Cui Haotian et al. (2020) based on the pressure (p) -state (s) -response (r) model to construct an evaluation index system for the comprehensive ecological carrying capacity of the coastal zone. Force shows a rising trend [9] .Huo Wenmin et al. (2020) used the ecological footprint model to analyze the coupling relationship between industrial development and ecological carrying capacity in Ordos City, a resource development zone, and the results showed that the ecological carrying capacity in the area did not match the industrial development in Chengdu [10].

The ecological carrying capacity evaluation method is continuously improved and innovated in the process of social practice. Among them, the ecological footprint method [11], state space method [12], System Dynamics Method [13], comprehensive evaluation method [14], Evaluation Method of Net Primary Productivity of Natural Vegetation [15] and life cycle methods [16] is a more

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common method used by scholars from various countries to quantify and analyze regional ecological carrying capacity.

According to the literature review, it is found that the current research results on ecological carrying capacity are already abundant, but the targeted research on urban ecological carrying capacity is not enough, and some key elements have been ignored. The focus of future research should be based on existing theories and methods. Gradually improve the research on the relevant connotation and representation methods of urban ecological carrying capacity, comprehensively consider the natural resource elements and human living factors, reduce the uncertainty of the model, and carry out dynamic evaluation and prediction research of urban ecological carrying capacity in combination with the special conditions of different regions. Find weak links for urban ecological construction. Previous studies on the "natural, economic, and social" complex system in Huaibei mostly used the ecological footprint method to carry out quantitative analysis of the time series of carrying capacity, with ecological bias and missing estimates. This study will qualitatively analyze the ecological carrying capacity from the four aspects of resources, environment, society, and economy by constructing an evaluation index system of ecological carrying capacity in Huaibei City, which will make up for the social and economic impact of human activities missing from the ecological footprint model. Implementation of research results into the formulation of urban planning policies and sustainable development strategies in HuaibeiMake the research results both theoretically meaningful

3. Determination of research methods and evaluation indicators

3.1 Construction of evaluation index system

The resource-based urban ecosystem is a "resource-environment-social-economic" ecosystem. The ecological carrying capacity is mainly analyzed from the ecological support system and the ecological pressure system. Among them, the factors studied in the ecological support system and the ecological pressure system the variables are opposite. Therefore, according to the connotation of the three aspects of ecological carrying capacity, this article mainly discusses the socio-economic balance and the energy resources.

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Table 1 Comprehensive evaluation index system of ecological carrying capacity of resource-based cities

Target layer	Constraint layer	Feature layer	Indicator layer	Indicator properties
Ecological carrying capacity	Support system	Ecological elasticity	p1 Excellent air quality rate /%	Forward
			p2 Annual mean value of precipitation ph	Negative
		Resource supply	p3 Education investment / 100 million yuan	Forward
		Environmental governance	p4 Urban construction area / m^2	Forward
	Pressure system	population growth	p5 Natural population growth rate /%	Forward
		Economic Growth	p6 disposable income per capita / yuan	Forward
			p7 Industrial added value / 100 million yuan	Forward
		Resource consumption	p8 steel cement usage / 10,000 tons	Forward
		Environmental pollution	P9 SO2 emissions / t	Negative
			p10 acoustic environment	Negative

It is concluded from Table 1 that the index attributes of resource-based cities in terms of ecological resilience and environmental pollution are negative, mainly because it has a negative impact on the development of the city, while other indicators of resource supply, governance of environmental problems, high pressure The indicators of economic growth and population growth in the economy are showing a positive development trend. Therefore, the relevant indicators of the support system have a positive impact on the development and construction of resource-based cities.

3.2 Data source

This study selected various data of Huaibei City from 2014 to 2018.The data mainly come from Huaibei Statistical Yearbook, Anhui Statistical Yearbook, China City Statistical Yearbook, and Huaibei Environmental Status Bulletin.

Table 2 Index data of Huaibei City

Indicator layer	Year 2014	2015 year	2016 year	2017 year	2018 year
p1 Excellent air quality rate /%	87.4	67.1	66.1	52.1	58.9
p6 disposable income per capita / yuan	23787	25690	27248	27450	31959
p7 Industrial added value / 100 million yuan	465.5	488.4	347.8	364.6	356.1
p8 steel cement usage / 10,000 tons	973	865	868.4	971.1	930.7
p9 so2 annual average / mg / m^3	0.028	0.02	0.019	0.018	0.015

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p10 Acoustic environment / dB	53	52.4	52.9	51.95	51.7

According to the data analysis of the comprehensive evaluation indicators of the ecological carrying capacity of Huaibei City from 2014 to 2018 in Table 2, it can be known that the excellent air quality rate is decreasing year by year, and exhaust gas emissions and arbitrary deforestation and other behaviors have led to a decline in the excellent air quality rate. The reason is that the degree of change in the annual average value of precipitation ph is basically horizontal; the investment in education first increases and then decreases, and it generally shows an upward trend, which shows the importance of government students' education. Its basic performance is that education facilities and education levels have been greatly improved. The natural population growth rate showed an overall trend of rising first and then falling. The opening of the second child policy was the main reason for the significant increase in population growth rate; per capita disposable income showed a steady upward trend in general; industrial added value increased from 46.55 billion yuan in 2014 It fell to 35.61 billion yuan in 2018.The root cause of the decline is that the state has issued policies prohibiting the mining of various small coal mines; the overall use of steel and cement has shown a downward trend, fully demonstrating that the city's economic situation is not optimistic; the so2 annual average is steadily decreasing, and greening The increase in area has a significant correlation; the acoustic environment shows a slight downward trend, all within the standard range.

3.3 Calculation of evaluation indicators

In order to objectively calculate the index weight of each indicator, the article weights based on the entropy method, the steps are as follows:

Normalize the data. Because the values and unit sizes are different, we will normalize the data.

$$X_{ij} = (Y_{ij} - Y_{jmin})/(Y_{jmax} - Y_{jmin)} \quad (1)$$

$$X_{ij} = (Y_{jmax} - Y_{ij})/(Y_{jmax} - Y_{jmin}) \quad (2)$$

Among them, X_{ij} Normalized data for the original data, Y_{ij} For the raw data corresponding to various indicators in different years, Y_{jmin}, Y_{jmax} Respectively j The minimum and maximum data for the item indicator. (1) Formula is a formula for calculating the data that is positive in each indicator in Table 1; Formula (2) is a formula for calculating the data that is negative in each indicator in Table 1.

Calculate thejIndexiAnnual indicator share P_{ij}

$$p_{ij} = X_{ij}/\sum_{i=2014}^{2018} X_{ij} \quad (3)$$

Calculating entropy e_j

$$e_j = -\left(\frac{1}{\ln 5}\right)\sum_{2014}^{2018} p_{ij} \bullet \ln p_{ij} \quad (4)$$

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Calculate indicator weight w_j

$$w_j = (1 - e_j) / \sum_{j=1}^{10} (1 - e_j) \quad (5)$$

3.4 Determination of weights of ecological carrying capacity evaluation indicators

This article uses the entropy weight method to normalize the original data of Huaibei city, and then calculates the index proportion of each index layer in each year of 2014-2018, and then calculates the entropy value and index weight in turn, and finally obtains the relevant data table 3. Through the following table of ecological carrying capacity evaluation index weights, household results show that the four indicators of p1, p2, p3, and p4 in Huaibei City have higher weights, indicating that the pressure on social carrying capacity is greater.

Table 3 Evaluation index weight of ecological carrying capacity

Support system indicator weight	P1	P2	P3	P4
Huaibei	0.1556	0.0923	0.0778	0.0921
Stress system index weights	P5	P6	P7	P8
Huaibei	0.1242	0.0838	0.1872	0.1806

4. Comprehensive evaluation and analysis

The pressure index, bearing index and bearing pressure index are used to determine the bearing level of the ecological carrying capacity of these resource-based cities. The pressure index refers to the pollution or consumption of the environment and resources in the process of economic and social development, mainly in economic development In terms of population growth, environmental pollution and other factors; the carrying index refers to the objective carrying capacity of the ecological city system, which mainly includes the supply of resources, environmental governance, and ecological elasticity. The corresponding formula is shown in Table 4.

Table 4 Index calculation formula

Ecosystem pressure index p	$P=\sum_{j=5}^{6} \mathbf{x_{ij} * w_j}$,P,$\mathbf{x_{ij}}$,$\mathbf{w_j}$They are the pressure index, the standardized value of the data, and the corresponding weight of the pressure index.
Ecosystem carrying index s	$S=\sum_{J=1}^{4} \mathbf{x_{ij} * w_j}$,S,$\mathbf{X_{ij}}$,$\mathbf{w_j}$They are the bearing index, the standardized value of the data, and the corresponding weight of the support index.
Bearing pressure index d	D=P/S

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The level of ecological carrying capacity of resource-based cities in the article is based on the range of index values.This article divides the pressure index, support capacity index, and bearing strength index into intervals according to the index value, which is divided into five levels.

Table 5 Graded evaluation criteria for ecological carrying capacity

Index value	0-0.20	0.21-0.40	0.41-0.60	0.61-0.80	>0.80
Stress system review	weak	low	medium	Higher	Strong
Systematic reviews of support	weak	low	medium	Higher	high
Systematic evaluation of bearing capacity	weak	low	medium	Higher	high

At present, the ecological support, pressure and bearing capacity index of this resource-based city in Huaibei will be evaluated based on the original data

The indicators are calculated and then classified according to the grading evaluation criteria.

Table 6 Huaibei Index Evaluation in 2014-2018

	2014	2015	2016	2017	2018
Support Index	0.5347	0.7453	0.8764	0.6532	0.8121
Grading	Medium support	Higher support	High support	Higher support	High support
Stress index	0.401	0.6124	0.4997	0.3129	0.2677
Grading	Medium pressure	Higher pressure	Medium pressure	Medium pressure	Low pressure
Bearing capacity index	0.3452	0.4271	0.5896	0.4682	0.6547
Grading	Carrying high load	balance	Low load	Low load	Low load

According to the calculation results in Table 6, the year is used as the abscissa, and the ecological support, pressure and ecological carrying capacity index are used as the ordinate to draw a dynamic change trend graph.

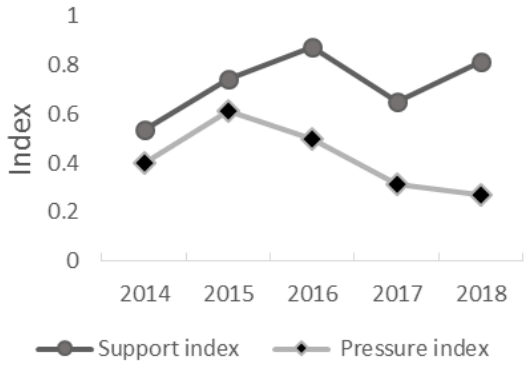

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Figure. 1 Dynamic trend of ecological support and pressure index in Huaibei City

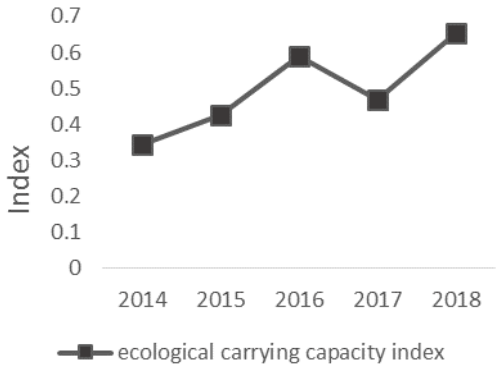

Figure. 2 Dynamic trend of ecological capacity in Huaibei city

4.1 Ecological support index

From the change trend chart 1, Huaibei's ecological support index showed a volatile upward trend from 2014 to 2018. It is because the Huaibei municipal government proposed to develop strategic emerging industries such as carbon-based, silicon-based, and aluminum-based new materials, while vigorously promoting the food industry is becoming bigger and stronger. The traditional resource-based enterprises 'ability to deal with pollutants such as the three wastes has continued to increase, which has led to a continuous improvement of the comprehensive index of environmental protection. The continuous rise in the per capita income of residents has driven the rise of the ecological support index. The average value decreased by 46.4% during the five-year period from 2014 to 2018. Overall, Huaibei has a relatively good ecological recovery from 2014 to 2018, but due to location and historical factors, Huaibei's urban appeal to talents and funds is still limited.

4.2 Ecological stress index

Because the larger the pressure index of the bearing object is, the smaller the actual pressure brought by the bearing object is. Therefore, the change of the pressure of the bearing object during the study period is exactly the opposite of the change trend of the pressure index. From the analysis of the change trend, Figure 1, the The pressure fluctuates greatly, from 2014 to 2015, the pressure showed a downward trend, and it continued to rise from 2015 to 2018. From the analysis of the indicator layer, Huaibei City, as a typical coal resource-based city, puts a lot of pressure on the ecosystem. The contradiction of the industrial structure has been it severely restricts the sustainable development of Huaibei's economy, and how to

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adjust its own industrial structure in the wave of economic integration in the Yangtze River Delta is still an urgent issue for Huaibei.

4.3 Ecological carrying capacity

From the change trend chart 2, it can be seen that the ecological carrying capacity index of Huaibei City fluctuates from 2014 to 2018. It can be seen from the comprehensive charts 1 and 2 that the change trend of the supporting capacity index is roughly the same as the annual change curve of the ecological carrying capacity index. In recent years, the environmental pollution caused by a single development model mainly based on the development of coal resources has limited the improvement of the ecological carrying capacity of Huaibei City. To this end, Huaibei City has further promoted the construction of an ecologically civilized city, and actively built ecological parks in the city to enable a compound ecological environment. The resources, environment, society and economy of the system are coordinated in four aspects, and all efforts are made to reduce the pressure of socio-economic development on the ecosystem. On the whole, the carrying capacity of the ecosystem in Huaibei City has been continuously improved.

5. Conclusions and recommendations

In summary, the carrying capacity of the ecosystem in Huaibei City has been continuously improved, which has effectively promoted the high-quality development of the regional economy. However, as a typical resource-dependent city, Huaibei City is a contradiction in the economic development model at the cost of environmental damage and resource exhaustion. Increasing sexuality. With the proposal of the Beautiful China Strategy, the coal pillar industry that is driving the economic growth of Huaibei has begun to show signs of decline. Therefore, in the future development, Huaibei must vigorously promote cleaner production, create a green economy, and improve nature. Landscape to improve ecological resilience, so as to enhance the ability of ecosystems to regulate and restore; with a view to increasing the supporting capacity of ecosystems by strengthening cultural construction, adjusting industrial structure, and improving resource utilization; thereby better exerting resource and economic benefits Promote the integration of Huaibei faster and more fully into the economic radiation circle of the Yangtze River Delta.

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