STUDY ON HARMONIOUS DEVELOPMENT OF POPULATION, ECONOMY, RESOURCES AND ENVIRONMENT IN INNER MONGOLIA, CHINA

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Abstract: Scientific evaluation of the synergistic development capacity of the population, economy, resources and environment of Inner Mongolia has important theoretical value for promoting high-quality development in Inner Mongolia. By constructing an index system that comprehensively assesses the population, economy, resources and environment of Inner Mongolia, analyze the interplay of the three from 2000 to 2021. The results show that: (1) the comprehensive development index is fluctuating and rising, and the comprehensive economic development index is developing ahead of time; (2) the coupling degree and coupling coordination degree show an upward trend, and the coupling coordination degree still has a certain space from the high-quality coupling stage; (3) propose to optimize the industrial structure and enhance the ability of sustainable economic growth; save energy and resources, enhance ecological environment management and protection; Population structure should be optimized, and investment in education and talent recruitment should be strengthened.

Key words: coupling coordination; Population - Economy - Resources and Environment; Inner Mongolia

1. Introduction

The coordinated development of population, economy, resources and environment is an important category to measure the relationship between man and nature and between man and social life [1]. A large number of scholars have carried out a great deal of useful exploration and practice on the coupling and coordinated development of population, economy, resources and environmental systems. The perspective of academic research has gradually changed from the initial qualitative research to quantitative research [2-7], and they all believe that the coordinated development of population, economy, resources and environment is the fundamental path to achieve sustainable development. It is a central and key issue for the regional social economy to achieve high-quality sustainable development. To explore in depth how to regard the regional development process as a complex system composed of population, economy, resources and environment, and to clarify the interactive coupling mechanism and coupling process formed by multiple correlations among the three, so as to effectively promote the coordinated development

of population, economy, resources and environment and achieve more sustainable regional development. This is important for the high-quality development of the country's regional economy.

Inner Mongolia, in the western part of China, is a vast region with stark regional differences. It is a typical research area that comprehensively reflects the characteristics of sustainable development in terms of population, economy, resources and environment. By comprehensively applying multidisciplinary theories and methods, this study makes a quantitative analysis of the coupling and coordinated development of population, economy, resources and environment, expands the research idea of sustainable development, enhances the theoretical significance of population, economy, resources and environment in the context of high-quality development in Inner Mongolia, and enhances the credibility of regional sustainable development in terms of research methods. It provides a theoretical basis for the state to formulate a sustainable development strategy and a regional development plan for Inner Mongolia, as well as a macro-control policy for Inner Mongolia's population, economy, resources and environment. The study on the coordinated development of Inner Mongolia's population, economy, resources and environment will be of great theoretical and practical value in promoting the high-quality economic development of Inner Mongolia Autonomous Region, guiding the construction of a new type of urbanization in the new period of Inner Mongolia's development, and promoting the sustainable development of the region.

2. Research method

2.1 Establishment of index system

By referring to the statistical index system of relevant literature and data in the CNKI database and relevant statistical yearbook data, and in full accordance with the scientific accuracy and accessibility of data acquisition, the evaluation index system was strictly screened through frequency statistics, correlation analysis, expert consultation, and other methods from three dimensions: population, economy, resources and environment. A total of 18 representative indicators were selected to construct a comprehensive system of evaluation indicators for population, economy, resources, and environment.

Table 1. Index system of population-economy-resources and environment comprehensive evaluation

System layer	Index level	Unit	Attribute	Weight
Population system	Total population at year end	People	+	0.1797
	Urbanization rate	%	+	0.2093
	Male to female sex ratio		+	0.1166
	Birth rate	‰	+	0.1081
	Mortality rate	‰	+	0.3001
	Natural rate of population growth	‰	+	0.0861
Economic system	Gross regional product	Yuan	+	0.2095
	Gross domestic product per capita	Yuan	+	0.2111
	The proportion of secondary industry	%	+	0.1081
	The proportion of tertiary industry	%	+	0.1099
	Total retail sales of consumer goods	Yuan	+	0.2023

	Total import and export trade	Yuan	+	0.1592
Resource environment system	Total energy production	Tce	+	0.1625
	Total annual water supply	Ton	-	0.1471
	Total annual electricity consumption	kw • h	-	0.1457
	Domestic garbage removal volume	Ton	+	0.1408
	Per capita public green space	m^2/People	+	0.1915
	Green coverage rate of urban built-up areas	%	+	0.2122

2.2 Indicator data source and processing

The data in this study were all sourced from the China City Statistical Yearbook (2001-2022) and Inner Mongolia Statistical Yearbook (2001-2022), so as to ensure the authenticity and authority of the obtained data.

In order to eliminate the effect of the differences in the dimensionality of each index within the subsystems and among the main influence factors on the results of the calculations, and to ensure a scientifically rigorous evaluation of the results, the original data was normalized using range normalization in this study.

2.3 Calculation of weight

In order to eliminate subjective arbitrariness in the process of index weighting as much as possible and overcome the shortcomings of the single objective weighting method, this paper adopts the entropy method and the coefficient of variation method in the objective weighting method to respectively assign weights to the original indicators. Finally, the arithmetic mean of the two methods is used as the combined weight to improve the realism and accuracy of the quantitative analysis of the calculated results.

2.4 Construction of coupling model

$$c = \left\{ \frac{f(x) \cdot g(y) \cdot h(z)}{\left[\frac{f(x) + g(y) + h(z)}{3} \right]^3} \right\}^{\frac{1}{3}} ; \quad D = \sqrt{C \times T} ; \quad T = \alpha f(\mathrm{x}) + \beta \mathrm{g(y)} + \chi(\mathrm{z})$$

Based on the relevant research results of the coupling model, ***T*** is the comprehensive development index of population ***f(x)***, economy ***g(y)***, resources and environment ***h(z)***; ***D*** is the degree of coupling coordination, reflecting the level of system development; ***C*** is the degree of coupling, the strength of the interaction between the reacting systems; α, β, χ is the undetermined weight, which is proposed as α = β = χ =1/3 in this study.

3. Results and analysis

3.1 Comprehensive horizontal time series analysis

The integrated development index for population and the development index for resources and environment in Inner Mongolia showed a relatively clear upward trend. In particular, the integrated development index for resources and environment showed a clear fluctuating feature from 2000 to 2012 and a steady trend after 2013 due to the optimization of resource and energy structures and the transformation and upgrading of industrial structures. The integrated population development index has shown a slow growth trend in recent years due to declining

birth rates and natural population growth rates. The Economic Development Index has been showing a trend of rapid and sustained growth, rising from 0.0278 in 2000 to 0.9336 in 2021, representing a growth rate of 0.9058 and an annual growth rate of 0.0412. The Economic Composite Development Index has shown advanced development since 2015. Moreover, the gap between the total population development index and the integrated development index for resources and the environment is growing year by year. Further optimizing the population structure, improving the utilization efficiency of natural resources, and strengthening the governance and protection of the ecological environment are central and key to improving the coordinated development capacity of the system.

3.2 Coupling degree timing analysis

From 2000 to 2021, the coupling degree of population, economy, resources and environment system in Inner Mongolia experienced three stages, namely run-in (2000) - high-level coupling (2001-2003) - high-quality coupling (2004–2021). The high-level coupling stage was realized in 2001 and the high-quality coupling stage in 2004. The long-term steady development trend of high-quality coupling continued into 2021, with the degree of coupling increasing from 0.6361 in 2000 to 0.9782 in 2021, with a growth rate of 0.3421 and an annual growth rate of 0.0156. The trend of the change in the degree of coupling coordination shows a continuous rise towards a steady trend. Through the above coupled evolutionary process, the population, economy, resources and environmental systems of Inner Mongolia have always been able to integrate with each other and develop cooperatively, as reflected in the overall picture. The advantages of rich natural resources and ecological environments have played a positive role in accelerating urbanization, promoting population development, and fostering sustainable economic growth. In the process of rapid urbanization, the industrial structure is optimized and upgraded, the urban infrastructure is constantly improved, the social medical, health, education, and other public utilities are improved year by year, and the overall economic and social environment is constantly optimized, thus achieving a high-quality coupling stage of long-term synergistic interaction between population, economy, resources and environmental systems.

3.3 Timing analysis of coupling coordination degree

From 2000 to 2021, the coupling of population, economy, resources and environmental systems in Inner Mongolia continued to increase, from 0.3696 in 2000 to 0.8420 in 2021, an annual increase of 0.6526 and 0.0215, respectively. The trend of the degree of coupling coordination shows a steady and continuous rise (Figure 2). The coupling coordination type has experienced coupling coordination processes such as mild disadjustment (2000-2002), moderate coordination (2003-2009), and good coordination (2010-2021), and has been in a good coordination evolution stage for a long time, and has shown a good development trend. It comprehensively reflects that the type of coupling coordination degree of population, economy, resources and environment system in Inner Mongolia has experienced continuous optimization and adjustment in the past 22 years, and the overall coupling coordination degree has a trend of continuous improvement, but there is still a certain gap between reaching high-quality and high-quality coordination. In addition, through the comparative analysis of the comprehensive index of population, economy, resources and environment systems from 2000 to 2021, it was found that the advanced coupling and coordination type of resources and environment is more dominant, which can also reflect that good resources and environmental advantages are an important

engine to continuously promote the sustainable development of the regional economy in Inner Mongolia. Capacity for sustainable regional economic growth and improved economic well-being are the main limiting factors that constrain the development of coupling and coordination in the system.

4. Conclusion and suggestion

4.1 Conclusion

This paper reviews relevant studies on the coordinated development of population, economy, resources and environment in Inner Mongolia, constructs a comprehensive evaluation index system of population, economy, resources and environment in Inner Mongolia, uses the coupling degree model to study the comprehensive development level and interactive coupling relationship of the three systems of population, economy, resources and environment in Inner Mongolia from 2000 to 2021, and draws the following conclusions:

(1) From the perspective of the comprehensive development level of the system, the comprehensive development index showed a continued slow rise, the comprehensive economic development index continued to grow prominently, the comprehensive resource and environment development index dominated from 2000 to 2014, the comprehensive economic development index advanced from 2015 to 2021, and the comprehensive population development index fluctuated;

(2) From the perspective of the coupling degree evolution process, the coupling evolution process consists of three stages: running-in (2000), high-level coupling (2001-2003) and high-quality coupling (2004–2021). After 2004, the coupling process was in the midst of a long period of high-level and high-quality coupling, reflecting a long period of well-coordinated development of population, economy, resources and environment.

(3) From the perspective of the evolution process of coupling coordination degree, the coupling coordination type experienced three coupling coordination stages, namely mild discoordination (2000-2002), moderate discoordination (2003-2009), and good coordination (2010-2021). Although the phase of good coordination was reached in 2010 and will continue until 2021, there is still a large gap from the phase of high-quality coordination.

4.2 Suggestion

(1) Optimize the industrial structure and enhance the capacity for sustained economic growth.

Continue to implement the innovation-driven strategy and the action of "rejuvenating Mongolia through science and technology", optimize and upgrade our energy and strategic resource bases, enhance our ability to support scientific and technological innovation, transform traditional industries and enterprises with high and new technologies and advanced and applicable technologies, and expand and extend chains to make them more high-end, intelligent and green. Promote high-quality and efficient transformation of agricultural and livestock production bases, foster strategic emerging industries, transform and upgrade traditional industries, and accelerate the establishment of a modern industrial system with green features and advantages.

(2) Save energy and resources, and strengthen ecological and environmental governance

and protection.

Coordinate the use of energy and resources and the distribution of industries to build a global model of ecological security. We should establish a new concept of ecological development, increase investment in science and technology, increase the application of science and technology in production, accelerate the green development of industries and the circular development of resource-based industries, optimize the efficiency of resource allocation, improve the utilization rate of energy and resources, and realize the circular use of resources. Upgrade the regional industrial base and modernize the industrial chain, raise the level of scientific and technological innovation in the region, and enhance regional innovation and development capabilities.

(3) Optimize the population structure, strengthen education investment and talent introduction

Further policy incentives to have a second child and increase the birth rate of the newborn population. Strengthen the development of higher education and vocational and technical education and expand the pool of innovative personnel who can meet the demands of transformation and development. Invest more in higher education, focus on personnel training, increase the proportion of higher-level talent, and provide intellectual support for industrial restructuring and economic development. Enhance vocational and technical training, improve the overall technical level and professional quality of corporate personnel, and provide adequate human capital for transformation and development.

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