EVOLUTION TREND AND INFLUENCE FACTORS OF HUMAN-LAND RELATIONSHIP IN THE YELLOW RIVER BASIN OF INNER MONGOLIA: A CASE STUDY OF HOHHOT, CHINA

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Abstract：Taking Hohhot, a central city in the Yellow River basin of Inner Mongolia, as the case study, this paper constructs a theoretical human-land system coupled with an evaluation system to explore evolutionary trends and influence factors in human-land relations. The results show that: (1) the regional development intensity index and resource and environment level index show a fluctuating upward trend from 2000 to 2022, and the land development intensity is ahead of the resource and environment carrying capacity after 2014; (2) the coupling degree of the human-land system is rapidly improved, and the coupling degree has achieved high-quality coupling since 2003, and the coupling coordination degree has shown a slow rising trend and the high-quality coordination achieved in 2020; (3) The main obstacle factors are total annual electricity consumption, total water supply, total industrial waste gas emission, and natural population growth rate; (4) Accelerate the building of ecological civilization, enhance the carrying capacity of resources and the environment, and optimize the spatial structure of the interaction between human activities and the geographical environment.

Keywords： Human-land relationship; Obstacle factors; Yellow River Basin; Inner Mongolia; Hohhot

The human-land relationship is the interaction between human social activities and the natural geographical environment and is a pair of basic relations accompanied by human development and evolution [1]. Human-land relationship is one of the core issues of geographical research and the eternal theme of human geography [1-3]. In the context of the growing trend of economic globalization and the growing prominence of global environmental issues, the human-land relation territorial system, as the core soul and theoretical cornerstone of geographical research, is an important law for the implementation of global sustainable development strategies and circular economic strategies. The optimal regulation of human-land relationships directly determines the success or failure of global and regional sustainable development [4-8]. With the growing contradictions between humans and land, the search for coordinated development of humans and land in different regions has gradually become a central goal in the study of human-land relations. With the help of models such as DFSR, VSD, PRED, and EF, scholars have constructed two-way index systems and quantified human-land relations with the aim of exploring the degree of

coordination and regulation of human-land contradictions in regional human-land relations. Evolutionary trends in human-land relations and their mechanisms of influence have received increasing attention from interdisciplinary disciplines such as geography, environmental science, economics, and management. It is an important strategic direction for the future development of Chinese geographical science to strengthen the study of the evolution of human-land relations in typical regions.

Located in the middle and upper reaches of the Yellow River, the Yellow River basin of Inner Mongolia is an arid and semi-arid region with a typically fragile ecological environment. It is also the core area of the northward open area, the Yellow River basin Economic Belt and the Yellow River basin Ecological Protection Belt, and the core area of the "One Belt, One Road" strategy, the China-Russia-Mongolia Economic Corridor, and the construction of the ecological barrier in northern China. The Yellow River basin of Inner Mongolia is one of the most prominent and complex areas in the fragile ecological environment of western China due to the severe imbalance between social and economic development and natural hydrological and ecosystem processes. The scientific understanding of the interaction relationship between human activities and regional systems is an important basis for the coordinated development of the human-land relationship in the Yellow River basin of Inner Mongolia. Therefore, under the strategic guidance of ecological environment protection and high-quality development in the Yellow River Basin, this paper constructed a comprehensive evaluation index system for the coupled evolution trend of human-land systems in the Yellow River Basin of Inner Mongolia, explored the coupled evolution trend of human-land systems, and used the diagnosis model of barrier factors to identify the main influencing factors in order to alleviate the contra To offer a theoretical framework for encouraging green development and ecological civilization in the region.

2. Research methods and data sources

2.1 Construction of index system

The human-land relationship is the interaction between human activities and the geographical environment. This paper fully combines the previous research basis [6-8] and the natural geographical environment characteristics of the Yellow River Basin of Inner Mongolia and is based on the systematic, dynamic, and operational principles of index selection, starting from the internal relationship between the two subsystems of land development intensity and resource and environment carrying capacity in the human-land system of the basin. A comprehensive system of evaluation indicators for the coupled evolution trends of the human-land system in the Yellow River basin of Inner Mongolia has been constructed; namely, 14 indicators have been selected to reflect the intensity of land development in three subsystems: population scale expansion, economic development, and land development intensity. From the three aspects of resource utilization level, ecological environment pressure, and ecological environment governance, 16 indicators were selected to reflect the resource and environment carrying capacity subsystem (Table 1).

Table 1. Comprehensive evaluation index system of the evolution trend of human-land

system coupling

Target layer	System layer	Indicator layer
Land development intensity	Population expansion	Total population, urbanization rate, natural population growth rate, proportion of employment in secondary and tertiary industries at the end of the year
	Economic development Intensity	Gross regional product, per capita gross regional product, fixed asset investment, proportion of secondary and tertiary industry output value, total import and export volume of foreign trade
	Land development intensity	Population density of urban built-up area, total power of agricultural machinery, effective irrigation area, actual paved road area at the end of the year, per capita road area
Resource and environment carrying capacity	Resource utilization level	Total sown area of crops, total grain output, number of livestock stocks at the end of the year, green coverage rate of built-up areas, per capita park green space
	Ecological environmental pressure	Total annual water supply, total annual electricity consumption, industrial wastewater emissions, industrial sulfur dioxide emissions, industrial particulate emissions, industrial waste gas emissions
	Ecological environment management	Afforestation area, urban sewage treatment rate, harmless treatment rate of household garbage, comprehensive utilization rate of industrial solid waste, green land rate of built-up areas

2.2 Research Methods

Based on existing literature [6-8], this paper comprehensively uses coupling degree and coupling coordination degree models to study the coupling evolution trend and influencing factors of the human-land system in the Yellow River Basin of Inner Mongolia during 2000–2022. The index data of the human-land system are all from the Hohhot Statistical Yearbook (2001-2023) and Inner Mongolia Statistical Yearbook (2001-2023). Due to the fact that raw indicators typically have different dimensions and orders of magnitude, extreme value methods were first used to normalize raw data to reduce the interference of random factors and facilitate mathematical statistical analysis. The entropy approach is then used to give objective weights to subsystems and indicators, which are subsequently employed by the integrated linear weighting method to compute the integrated development level of land development intensity as well as resource and environmental carrying capacity. Coupling degree and coupling coordination degree models have been used to identify trends in the coupling evolution of terrestrial systems, and obstacle factor diagnostic models have been used to identify factors affecting the coupling interactions of terrestrial systems in the Hohhot.

3. Result analysis

3.1 Comprehensive evaluation of man-land system

The composite assessment index for land development intensity showed a continuous upward trend, rising rapidly from 0.0219 in 2000 to 0.9414 in 2022, representing an annual growth rate of 3.9980%. The intensity of land development has continued to increase, and population size expansion has shown a significant downward trend since 2020 due to the continued decline in natural population growth rate. The intensity of economic development has long lagged behind the intensity of land development and the expansion of population size, and the gap between the two has narrowed year-on-year since 2020, indicating a well-developed trend.The comprehensive evaluation index of resource and environment carrying capacity showed a fluctuating upward trend, with an annual growth rate of 2.6891%. The level of utilization of resources and energy and the protection of the ecological environment have slowly improved. The resources supported by territorial spatial planning have been efficiently utilized, ecological environment construction and protection have been continuously promoted, and the discharge of various pollutants has been effectively controlled. The pressure of the ecological environment shows a fluctuating downward trend. The comprehensive assessment index for the human-land system shows a fluctuating and continuous upward trend, from 0.01908 in 2000 to 0.8895 in 2022, which comprehensively reflects that the intensity of land development and the carrying capacity of the resources and environment of Hohhot are on a well-co-operative development trend.

3.2 Comprehensive analysis of the degree of coupling in the Human-land system

The time evolution trend of coupling degree showed a change trend of rapid rise, slight fluctuation, and stable development, and the coupling degree increased rapidly from 0.4647 in 2000 to 0.9907 in 2005, and the annual growth rate of coupling degree from 2000 to 2005 reached 8.766%, showed a rapid growth characteristic. From 2005 to 2011, there is a slight upward-downward fluctuation process, and from 2011 to 2022, it remains around 1. Coupling degree evolution process experience: The three stages of antagonism (2000) - high-level coupling (2001-2002) - high-quality coupling (2003-2022), it indicate that Hohhot has continuously strengthened resource and environmental management, changed the mode of economic development, optimized the industrial structure, strengthened the construction of the ecological civilization system, and improved the resource and environmental carrying capacity. The mutual repulsion between the strength of territorial space development and the carrying capacity of resources and environment is small, and the development of coordination and interaction is essentially achieved. Human-land relations are becoming more interconnected, and comprehensive, coordinated, and sustainable development of the region is being promoted.

3.3 Analysis of human-land system coupling coordination degree

The time-varying trend of the coupling coordination degree showed a steady and continuous upward evolution, with the coupling coordination degree rapidly

increasing from 0.2978 in 2000 to 0.9423 in 2022, reaching an annual growth rate of 2.8022%. The evolution of coupling coordination degree has undergone five evolution processes: severe coordination (2000), mild coordination (2001-2003), moderate coordination (2004-2007), good coordination (2008-2019), high-quality coordination (2020-2022), showed a spiral development trend. This is closely related to the fact that in recent years, the Yellow River Basin in Inner Mongolia has always adhered to the five development concepts of innovation, coordination, green, open, and sharing, gradually transformed the economic and social development model to green development, and continuously promoted the human-land coordination policies and measures of new-type urbanization, rural revitalization, and high-quality development. However, at present, the Yellow River Basin in Inner Mongolia is still at the primary coupling level of the high-quality human-land system coupling stage, and it is still necessary to continuously improve the resource and environmental carrying capacity, strengthen the construction and protection of the ecological environment, maintain the coupling and coordinated development of the human-land relationship, and promote the orderly evolution of the human-land system to achieve regional sustainable development.

3.4Analysis of influencing factors of human-land system

By using the diagnostic model of obstacle factors, the main obstacle subsystems gradually change from the level of resource utilization, land development intensity, and population expansion to ecological environmental pressure and ecological environmental governance. From 2000 to 2007, the relatively slow process of urbanization produced little pressure on the ecological environment. From 2008 to 2022, as the pace of industrial urbanization continues to accelerate and the pressure of social and economic development on the ecological environment continues to increase, the protection and governance of the ecological environment have lagged behind. Strengthening the construction and protection of the ecological environment will always be a key path to promote the optimal management and regulation of human-land systems.

From the analysis of barrier factors at the factor level of the human-land system, it can be seen that in recent years, among the main barrier factors affecting the coupling coordination degree of the human-land relationship system in Hohhot, the top three obstacle factors in the land development intensity system are: natural population growth rate, fixed asset investment, and total import and export volume of foreign trade; the top 3 barrier factors to resource and environmental carrying capacity are: total annual electricity consumption, total annual water consumption, and total industrial waste gas emissions.

4. Conclusions and Suggestions

4. Conclusion

By constructing a comprehensive evaluation index system for the coupled

evolution trend of the human-land systems in the Yellow River Basin of Inner Mongolia and by means of coupling degree models, coupling coordination degree models, and obstacle factor diagnosis models, this paper makes an empirical analysis of the evolution trend of human-land relationships and its influencing factors in Hohhot from 2000 to 2022 and draws the following conclusions: The intensity of land development and the carrying capacity of resources and environment show a trend of synergistic development, showing a continuous and stable synergistic positive influence. The coupling degree is rapidly increasing and has been in a steady development phase of high-quality coupling for a long time; the degree of coupling coordination undergoes five evolutionary stages, including severe coordination, mild coordination, moderate coordination, good coordination, high-quality coordination. The main barriers are total annual electricity consumption, total water supply, total industrial waste gas emissions, and natural population growth rate.

4.2 Suggestions

Scientific and technological innovation is central and key to driving high-quality human-land coordination development in the Yellow River Basin of Inner Mongolia. Accelerate the construction of ecological civilization, promote green and low-carbon development, practice the concept of green development, promote green and low-carbon lifestyle, accelerate the modernization of harmonious coexistence between human-land, and build a beautiful China with harmonious coexistence between human-land; relying on science and technology to strengthen resource conservation and intensive, using the establishment of a systematic system of biodiversity compensation and balance to promote the construction of a beautiful China, ecological restoration as a new economic growth point to promote the construction of ecological civilization, and improve the carrying capacity of resources and environment; to establish a spatial structure for sustainable development, to form a reasonable spatial development pattern, to speed up the construction of an ecological civilization system, to coordinate ecological and environmental relations between regions, to promote coordinated and sustainable regional development, and to optimize the spatial structure for the interaction of human activities with the geographical environment.

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