Duolun County Resource and Environmental Carrying Capacity Study

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Abstract: Resources and the environment are the material basis for human survival and development. In the context of building an ecological civilization, the evaluation of the carrying capacity of resources and the environment has become an important basic task in the preparation of the new round of territorial spatial planning. This paper selects the typical ecologically fragile area of Duolun County, Inner Mongolia, as the study area, and utilizes literature, spatial data, socio-economic statistics, and land use secondary classification data to construct a resource and environmental carrying capacity evaluation index system that includes three subsystems: resources, environment, and socio-economy, and analyzes the resource and environmental carrying capacity of Duolun County, Inner Mongolia, in the period from 2005 to 2020, at the temporal and spatial scales for the 65 administrative villages in the Duolun County, Inner Mongolia, and the area of the county.

Keywords: Duo Lun county; Resource and environmental carrying capacity; Administrative village domain

Introduction

Resource and environmental carrying capacity can directly reflect the degree of coordination between human social development, daily life, production and resource environment [1]. The mode and direction of demographic, social and economic development of a region also depend on the carrying capacity of its resources and environment. To realize the sustainable development of regional socio-economics, it is necessary to effectively protect and improve the resource environment [2], so as to realize the coordinated development between various resource elements. As society continues to move forward, limited resources and unlimited demand are important and serious tests for future socio-economic development. Since the reform and opening up of the Inner Mongolia Autonomous Region continued rapid social and economic development, the people's living standards have also been gradually improved, to a certain extent, the resource environment has paid a great price. At the same time on the excessive, disorderly development and utilization of resources and too fast development mode of the region's resources and environment caused serious damage, so how to coordinate the resources and environment and socio-economic development of the contradictions between the promotion of regional sustainable development has become a necessary path to resolve the contradictions, and the resource and environmental carrying capacity to match the various types of resource elements has become an important way to achieve this purpose [3]. Based on the actual situation of Duolun County, Inner Mongolia, the evaluation study of resource and environmental carrying capacity is carried out, which provides suggestions for the future social, economic and ecological construction of Duolun County, and focuses on the reasonable protection and development and utilization of land resources while promoting the urban and rural socio-economic development of Duolun County, improving the quality of the regional ecological environment, realizing the sustainable use of resources, and promoting the coordinated development of the society, the economy and the ecology.

1. Overview of the study area

Duolun County is located in the central part of the Inner Mongolia Autonomous Region, the southeastern part of Xilingol League, between latitude 41 ° 46 ′ - 42 ° 36 ′, longitude 115 ° 51 ′ - 116 ° 54 ′, adjoining five banners, counties, west of Zhenglan Banner as a neighbor, the north and Chifeng City, Keshiketeng Banner, the east and south of the Weichang Manchu Menggu Autonomous County, respectively, with the three counties of Hebei Province, Fengning Manchu Autonomous County, Guyuan County border. Duolun County is located in the south source of the Hunsandak Sandy Land [4], which belongs to a typical agricultural and pastoral intertwined area [5], and is a key area for the construction of the Beijing-Tianjin Wind and Sand Source Project. The total area of the county is 3863km2, with the longest distance from north to south of about 110km, and the longest distance from east to west of about 70km. The county has 3 towns and 2 townships under its jurisdiction, with 65 administrative villages.

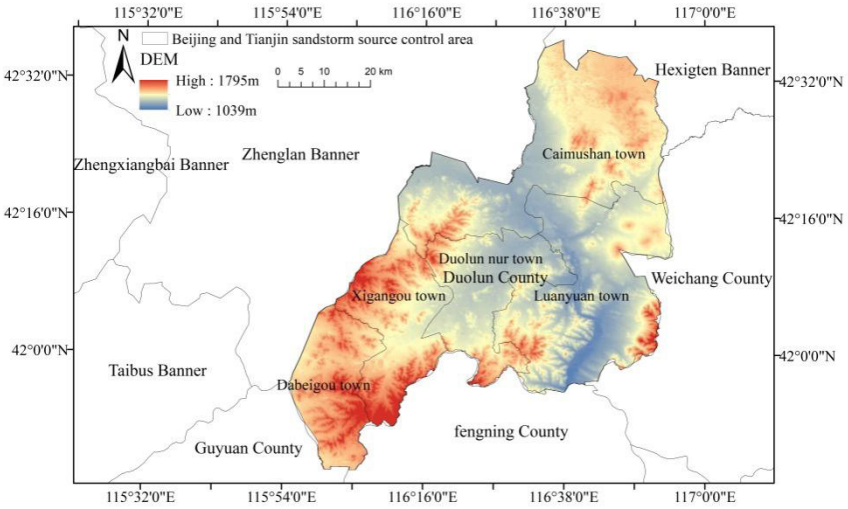

Figure 1 Overview map of the study area

2. Research Methodology

2.1 Entropy value method

Data standardization

Since different indicators have different units and cannot be compared, all indicators need to be quantitatively toughened to eliminate the effects of different quantitative outlines and to make the data comparable. In this study, the extreme value method was selected as the dimensionless processing method for the indexes of the study of resource and environmental carrying capacity of Duolun County, Inner Mongolia, which is characterized by transforming all the values of the indexes within the interval of 0-1, with a minimum of 0 and a maximum of 1. In addition, considering the later data processing, the dimensionless indicator can be shifted by one minimum unit value all the time. In order to meet the arithmetic requirements. The formula of the extreme value method is as follows:

For positive indicators the treatment formula:

$$X_{ij} = \frac{X - X_{min}}{X_{max} - X_{min}}$$

For negative indicators the treatment formula:

$$X_{ij} = \frac{X_{max} - X}{X_{max} - X_{min}}$$

Where: mj is the maximum value of Xij and m is the minimum value of Xij.

(2) Dimensionless processing

Indicators are categorized into positive and negative indicators, moderate indicators, and interval indicators, depending on their own attributes. Larger values for positive indicators indicate better indicator performance. A smaller value for a negative indicator means that the indicator is performing better. The raw data are dimensionless to eliminate the effect of physical quantities to calculate the characteristic weight or contribution of the ith administrative village under the jth indicator.

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}}$$

(3) Calculate the entropy value of the jth indicator.

$$e_j = -\frac{1}{\ln n}\sum_{i=1}^{n} p_{ij}\ln(p_{ij}), 0 \le e_j \le 1$$

(4) Calculation of the coefficient of variation

$$g_j = 1 - e_j$$

(5) Calculation of evaluation indicator weights wj

$$w_j = \frac{g_j}{\sum_{i=1}^{m} g_j}, j = 1,2,3.....m$$

2.2 Carrying capacity evaluation model

Based on the statistical analysis model for the standardization of data on carrying capacity indicators and their weights, the carrying capacity of administrative villages in Duolun County, Inner Mongolia, was measured using the weighted summation method, with the following formulas.

$$U = \sum_{i}^{n}(\sum_{j}^{m} X_{ij} \times W_{ij}) \times W_i$$

Where: Xij is the standardized value of the jth indicator in the ith subsystem, Wij is the weight of the jth indicator in the ith subsystem, and Wi is the weight of the subsystem. u is the comprehensive carrying capacity of the resources and environment, and the larger value of u indicates the higher quality.

3. Results and analysis

3.1 Construction of evaluation index system of resource and environmental carrying capacity

As an open, dynamic and sustainable comprehensive system, the resource and environmental carrying capacity can reflect the coordinated development of human activities in the study area among different influencing factors, and in the process of selecting evaluation indicators and constructing the evaluation indicator system, it is necessary to show scientific rationality and objectivity to ensure the smooth progress of the evaluation and the accuracy of the results. Therefore, the following principles are followed when constructing the resource and environmental carrying capacity evaluation index system.

(1) Principle of science；

The evaluation indicators selected must be scientific, objective and comprehensive to reflect the state of development and evolution of the system under study, and can fully reflect the internal mechanism of resource and environmental carrying capacity, the evaluation of resource and environmental carrying capacity is a scientific and reasonable quantitative analysis combined with the process of qualitative analysis, and the selection of indicators should fully demonstrate the principle of science.

(2) Principle of accessibility；

As a comprehensive evaluation object, the research data of resource and environmental carrying capacity involves many related departments, so the principle of accessibility means that when selecting evaluation indicators, not only the research significance of the indicator should be considered, but also the difficulty of obtaining the indicator.

(3) Systemic principle

The evaluation of resource and environmental carrying capacity of Duolun County is a systematic evaluation, the selection of indicators should systematically reflect the study area “resource supply profile - environmental factors profile - socio-economic profile” of the situation, this paper in the establishment of the indicator system is divided into the resource and environmental carrying capacity of the overall objectives, sub-systems, indicators, layers, layers of advancement, so that sub-systems and the target layer of interaction and integration.

(4) Principle of Integration

Evaluation indicator system as a whole can be comprehensive, objective reflection of the target level, must select a sufficient number of evaluation indicators, in order to comprehensively reflect the degree of interconnectedness of the various factors in the research system, the more systematic information carried by the indicators to reflect the indicator system is more comprehensive.

(5) Principle of dynamism

Resource and environmental carrying capacity is characterized by dynamic changes, which will change with the resource supply profile, ecological profile, topography, and the impact of various human activities and socio-economic profile of the study area.

3.1.1 Resource and Environmental Carrying Capacity Evaluation Methods and Systems

(1) Literature analysis method

Literature analysis method is to collect, organize and screen all kinds of literature, the literature through the study, the formation of scientific understanding of the facts of the method. A very effective and economical information collection method, but also the most often used a primitive information processing methods, this paper through the research and collection of related papers, books, journals, web pages, etc., the use of a variety of database tools, a more comprehensive collection of literature on the theory of the carrying capacity of the resources and environment and evaluation of the system of standards and other literature.

(2) Hierarchical analysis

AHP is a practical multi-option or multi-objective decision-making method. This method is suitable for describing problems or decision analysis in which there are many indicators with different criteria, expressing in quantitative form problems that are difficult to study quantitatively. Its biggest feature is the quantification of qualitative problems, the mathematization of thinking judgments, and after hierarchical analysis, it can describe the differences in the degree of importance of each explanatory index, which is conducive to the formation of the final judgment. At present, it is widely used in various fuzzy evaluations.

(3) Comprehensive Evaluation Method

The comprehensive evaluation method is the main research method used in this paper. The comprehensive evaluation method constructs multiple indicators from the whole to evaluate multiple evaluation samples, also known as the multivariate comprehensive evaluation method, and the construction of evaluation indicators is similar to the hierarchical analysis method of evaluation indicator grading. By setting the weights of the indicators, the comprehensive score of each sample is given, and finally the sample scores continue to be ranked, so as to find the optimal sample or the optimal program.

(4) GIS spatial analysis method

Apply GIS technology to geographic information data, spatial data for overlay analysis, spatial query and other analytical processing.

3.1.2 Methodology for the selection of evaluation indicators

(1) Expert opinion method

The biggest advantage of the expert opinion method is a good control of the selection of priority screening selection, and has a relatively strong operability, experts generally have a relatively rich experience and party, the use of a number of experts combined with the views can effectively control the selection of indicators, as well as initial purification of the indicators, but this type of method has a strong subjectivity, and the cost of indicator selection is relatively high, the time to control does not have the stability of the use of the process should be flexibly utilized.

(2) Typical indicator screening methods

Complex integrated system in the selection of indicators, usually indicators will be more, but in the specific implementation, the selection of indicators can not be selected comprehensively, this is generally used in the selection of indicators of the cluster analysis, and then select a number of more representative of the significance of the indicators, which is typical of the method of selection of indicators.

(3) Explanatory Structural Modeling

ISM explains the structural type method to analyze, and the ten key influencing factors discover the logical relationship between them to draw the final conclusion. Qualitative analysis can make the article more comprehensive and systematic, of course, quantitative analysis also has its advantages, through the calculation of real data, the conclusion is more convincing.

3.1.3 Selection of evaluation indicators

Resource and environmental carrying capacity is the result of the interaction between the resource supply profile, environmental profile, socio-economic profile and human activities, and fully reflects the capacity of the study area to carry the population and the corresponding socio-economic total. The construction of Duolun County resource and environmental carrying capacity evaluation index system should start from the actual profile of Duolun County, as far as possible, the impact factors affecting the resource and environmental carrying capacity will be taken into account, taking into account the profile of Duolun County as a whole as well as the administrative villages. By referring to the relevant results of the study of resource and environmental carrying capacity, following the above basis for the selection of indicators and the principles of indicator system construction, and combining the actual situation of Duolun County and the difficulty of obtaining data, we constructed the evaluation index system of resource and environmental carrying capacity of Duolun County, which contains resource subsystem, environmental subsystem, and socio-economic subsystem, with a total of 20 indexes.

3.2 Characterization of spatial and temporal changes in the carrying capacity of resources and environment

The spatial distribution of the resource and environmental carrying capacity of Dorian County from 2005 to 2020 is all characterized by the northeast being higher than the southwest area. In 2005, the high carrying capacity areas were located in the central region of the County, in the Village of North, and in the northern region, in the Village of Green Dragon's Back, and accounted for 11 percent of the total land area. The higher carrying capacity areas are located in the southern, central and northern parts of the county, accounting for 22% of the total land area. The Central Carrying Capacity Area is located in the central, southwestern, and northern portions of the County. It accounts for 40% of the total land area. The lower carrying capacity and lower carrying capacity are distributed in the central, northern, and southern parts of the county, showing spatial aggregation and distribution, and accounting for 28% of the total land area. 2005-2010, the high carrying capacity areas showed no significant change in space, and the higher carrying capacity areas were spatially dispersed in the eastern and central parts of the county by 2010, showing aggregation and distribution, accounting for 21% of the total land area. The 2010 Medium Carrying Capacity Area is clustered in the central and eastern portions of the county, accounting for 41 percent of the total land area. The lower carrying capacity areas are mostly clustered in the southern and southwestern portions of the county, with a few scattered in the northern and central portions of the county, accounting for 25 percent of the total land area. The smaller low carrying capacity areas account for only a fraction of the total land area. The Medium Carrying Capacity Area is found in the southwestern region and central part of the County, accounting for 16 percent of the total land area. The lower carrying capacity areas are in the southwestern region of the County and are dispersed in the southern and eastern regions, comprising 19 percent of the total land area. The low carrying capacity areas are located in the southwestern portion of the County and comprise 6% of the total land area.The high carrying capacity areas in 2020 are located in the northern portion of the County and the central portion of the County and comprise 12% of the total land area.The higher carrying capacity areas are dispersed in the northern portion of the County and the southern and eastern portions of the County comprise 30% of the total land area.The high carrying capacity areas are located in the northern portion of the County and in the eastern portion of the County. The Medium Carrying Capacity Area is located in the southern, southwestern, eastern, and central portions of the County and comprises 33% of the total land area. The lower carrying capacity areas are located in the central, southwestern, and northern portions of the County and comprise 22% of the total land area. The Low Carrying Capacity Area is located in the southern portion of the County and comprises only 3% of the total land area.

The comprehensive carrying capacity of resources and environment from 2005 to 2020 shows the spatial characteristics that villages in the northeastern region are higher than those in the southwestern region, and villages with high carrying capacity values are mainly distributed in the northeastern region of Duolun County, with a small number of villages distributed in the central region of Duolun County. Villages with low carrying capacity values are mainly distributed in the southwestern part of Duolun County and villages in the central part of the county.

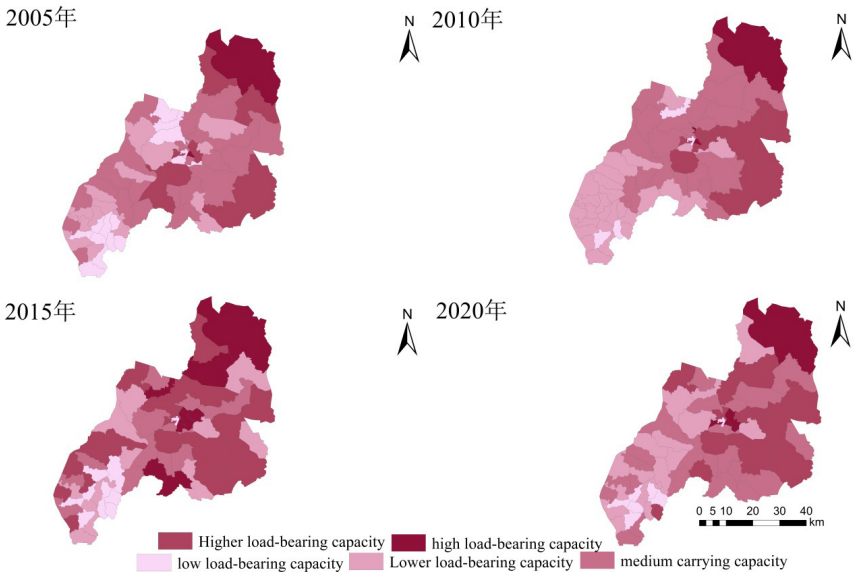

Figure 2 Spatial and temporal distribution of resource and environmental carrying capacity of Duolun County, Inner Mongolia, 2005-2020

4. Conclusion and outlook

4.1 Conclusion

Taking the typical ecologically fragile area of Duolun County in Inner Mongolia as the study area, and the administrative village domain as the evaluation unit, using digital elevation data, remote sensing image data, meteorological data, land use data, soil data, and socio-economic statistical data to fully consider the land resources, climatic resources, location resources, ecological and environmental factors, topographical and geomorphological factors, and socio-economic influences, to construct the indicator system of the resource and environmental carrying capacity based on the carrying capacity of the resource sub-systems, the carrying capacity of the environment sub-systems, and the carrying capacity of the socio-economic sub-systems with three dimensions, and to analyze the temporal and spatial characteristics of the resource and environmental carrying capacity in the period from 2005 to 2020.

The comprehensive carrying capacity of resources and environment from 2005 to 2020 shows the spatial characteristics that villages in the northeastern region are higher than those in the southwestern region, and villages with high carrying capacity values are mainly distributed in the northeastern region of Duolun County, with a small number of villages distributed in the central region of Duolun County. Villages with low carrying capacity values are mainly distributed in the southwestern part of Duolun County and villages in the central part of the county. The center of gravity of the high carrying capacity in the comprehensive carrying capacity of resources and environment shows the migration characteristics of southwest-northeast pattern. The higher carrying capacity shows the migration characteristics of the center of gravity in the southeast-northwest-northeast pattern. The center of gravity of medium carrying capacity shows the migration characteristics of northeast-southwest-southeast pattern. Lower carrying capacity presents migration characteristics of the center of gravity in a southwest-northeast-southwest pattern. The low carrying capacity center of gravity exhibits migration characteristics in a northeast-southwest pattern.

4.2 Outlook

Due to the construction of the evaluation index system and the selection of indicators in this paper, the lack of relevant data and the slight difficulty in obtaining some of the indicators lead to the evaluation index system is not comprehensive enough. As a result, the evaluation results of the resource and environmental carrying capacity of this paper are subjective, and the analysis of the results is a little shallow. Therefore, the depth of research on the resource and environmental carrying capacity of the study area needs to be further improved. It is hoped that in the future, we can collect data from various sources, conduct more field surveys, fully understand the resources, environment

and socio-economic status of the study area, and establish a more complete and comprehensive evaluation index system. Although this paper adopts the entropy value method, comprehensive index model, and research on the existing level and historical changes of the resource and environmental carrying capacity of Duolun County, the future development trend of the resource and environmental carrying capacity of Duolun County in Inner Mongolia is not predicted, and it is hoped that effective research methods can be considered in future research to predict and analyze the resource and environmental carrying capacity of Duolun County in Inner Mongolia.

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