Research on Carrying Capacity of Land Resources in Guyang County, Inner Mongolia

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Abstract: Land resources are important factors of production for human survival and development, and also important basic resources for social and economic development. The carrying capacity of land has a direct impact on regional social and economic development. This paper analyzes the carrying capacity of land resources in six townships of Guyang county, Inner Mongolia from the perspectives of agriculture, construction, population and ecological environment. The results show that: From 2005 to 2020, the overall increase of land resource carrying capacity in Guyang county accounted for the majority. The land carrying capacity index increased by 0.0044 in Jinshan Town, 0.1822 in Xiashihao Town, 0.0244 in Huaishuo Town and 0.1789 in Xingshunxi Town.Silver Town fell 0.1026. In terms of spatial distribution, Jinshan Town in the southwest of Guyang county and Xidoupu Town and Xingshunxi Town in the northwest of Guyang county have a high level of land resource carrying capacity, while Xiashihao Town and Yinhao Town in the southeast and Huaishuo Town in the northwest of Guyang county have a low level of land resource carrying capacity. On the whole, the carrying capacity of land resources in Guyang county is higher in the west and lower in the east.

Keywords: Land Resources; Carrying Capacity; Guyang County

1. Introduction

As the most basic guarantee for human beings to carry out life and production activities, land has not only natural value but also high economic and social value, and is an irreplaceable resource for today's social development[1]. The development process of human society is accelerating, but with the increase of population, the lack of order in land development and use, and the lack of scientific guidance in land resource management, people are facing more and more serious land environmental problems, such as soil erosion, the decline of cultivated land quality, and the degradation of land functions[2]. The development of human society has increased the demand for resources, while the available resources are constantly reduced and still destroyed. In order to achieve the sustainable development of human society, it is necessary to control the intensity of human activities within the scope of the carrying capacity of the land. Therefore, the evaluation and analysis of the carrying capacity of the land has gradually become the focus of modern research.

Based on the principles of science, regional particularity and simplicity and operability, this study selects the evaluation index of land resource carrying capacity of Guyang County, calculates the evaluation value of land resource carrying capacity of Guyang County, and understands the current changes of land resource carrying capacity of the county. On this basis, the spatial and temporal pattern of Guyang County's land carrying capacity was explored to provide reference for its future development direction and rational allocation of land resources.

2. Overview and data sources of the study area

2.1 Overview of the study area

Guyang county, located in Baotou city, Inner Mongolia, has a long history and beautiful products. The climate is dry and rainless, with four distinct seasons and an average altitude of 1300 meters. The total area of the county is 5,025km^2, with jurisdiction over 6 townships, 6 communities, 73 administrative villages, 923 natural villages, and 1 autonomous region-level industrial park. The total registered population is 194,100, of which 168,900 agricultural population, accounting for 87.01% of the total population, composed of 31 ethnic groups such as Han, Mongolian, Hui and Manchu.

2.2 Data sources

The data collected in this paper are based on township level administrative areas. The social and economic statistical data used are from *Guyang County Statistical Yearbook*. The land use data is from the *Data Center for Resources, Environment and Sciences, Chinese Academy of Sciences.* The precipitation data came from the platform of the *National Tibetan Plateau Scientific Data Center*.DEM data comes from *Geospatial Data Cloud* platform.

3. Research methods

3.1 Index system construction

Evaluation of regional land resource carrying capacity is inseparable from the construction of evaluation index system[3]. According to the actual situation of the research area and the scientific principle, the principle of operability, the principle of comprehensibility, the principle of hierarchy and the principle of regional particularity, 17 evaluation indexes were selected from the four criterion levels of agricultural land carrying capacity, construction land carrying capacity, population carrying capacity and ecological environment carrying capacity, and the evaluation index system of land resources carrying capacity in Guyang County, Inner Mongolia was established(Table 1).

Table.1 Evaluation index system of land resources carrying capacity in Guyang County, Inner Mongolia

Target layer	Criterion layer	Index level	Unit	Index type	Index weight
Carrying capacity of land resources	Agricultural land carrying capacity	Arable land per capita	hm/ people	+	0.0829
		Grain yield per unit area	t/hm	+	0.0568
		Per capita forest and grassland area	hm/ people	+	0.0493
		Forest coverage rate	%	+	0.0767
		Utilization rate of cultivated land	%	+	0.0249
	Construction land carrying capacity	Proportion of construction land	%	+	0.0356
		Highway density	km/100 km^2	-	0.0634
		Urbanization level	%	+	0.0503
		Proportion of secondary and tertiary industries	%	+	0.0031
		Per capita GDP	yuan/ people	+	0.0693
	Population carrying capacity	Total employment rate	%	+	0.0509
		Population density	people /km^2	-	0.0603
		Economic density	yuan /km^2	+	0.1163
	Ecological environmental carrying capacity	Average annual rainfall	mm	+	0.1280
		Relief of relief	m	-	0.0427
		Topographic roughness	μm	-	0.0841
		Utilization rate of land development	%	+	0.0055

3.2 Construction of entropy weight-topsis evaluation model

3.2.1 Determine the weight based on entropy weight method

Entropy weight method is a method of assigning value by using objective information. The original data must be standardized before calculation. In this study, the method of step difference transformation will be used to process and calculate the original data of each index[4]. Its calculation formula is as follows:

$$\text{Forward indicator：}\ A_i = \frac{(B_i - B_{i\min})}{(B_{i\max} - B_{i\min})} \quad (1)$$

$$\text{Negative indicator：}\ A_i = \frac{(B_{i\max} - B_i)}{(B_{i\max} - B_{i\min})} \quad (2)$$

Where, A_i represents the value after standardizing the *i th* indicator; B_i represents the value before the standardization of the *i th* indicator; B_{imax} and B_{imin} are respectively the maximum and minimum values before standardization.

After data standardization, the entropy of the *i th* index obtained is defined as:

$$E_i = -k\sum_{j=1}^{n} z_{ij}\ln z_{ij}, (1 \le i \le m) \quad (3)$$

Among,$k=\frac{1}{\ln n}$, And when $Z_{ij}=0$, $z_{ij}lnz_{ij} = 0; z_{ij} = \frac{P_{ij}}{\sum_{j=1}^{n} p_{ij}}$

Where P_{ij} represents the standard value of the *j th* evaluation object on the *i* index.

On the basis of defining the entropy value of the *i th* indicator, its entropy weight is defined as:

$$w_i^n = \frac{1-E_i m}{m-\sum_{i=1}^{m} E_I}, 0 \le w_i^n \le 1 \quad (4)$$

3.2.2 Evaluation matrix construction process based on entropy weight

The entropy weight W_i is used to construct the weighted normalized evaluation matrix *Z*, and the specific calculation formula is as follows:

$$Z = \begin{pmatrix} Z_{11} & \cdots & Z_{1n} \\ \vdots & \ddots & \vdots \\ Z_{m1} & \cdots & Z_{mn} \end{pmatrix} = \begin{pmatrix} r_{11} \cdot W_1 & \cdots & T_{1n} \cdot W_1 \\ \vdots & \ddots & \vdots \\ r_{m1} \cdot W_m & \cdots & T_{mn} \cdot W_m \end{pmatrix} \quad (5)$$

Where *r* is the result after standardization and *W* is the weight.

3.2.3 Determine positive ideal values and negative ideal values

Let z^+ be the positive ideal value, which is the maximum value of the *i th* index in the evaluation data in the *j* year; z^- is a negative ideal value and is the minimum value of the *i* index in the evaluation data in the *j th* year.The specific calculation formula is:

$$z^+ = \left\{ \max_{1\le i\le m} y_{ij} \middle| i = 1,2,\cdots,m \right\} = \{z_1^+, z_2^+, \cdots, z_m^+\} \quad (6)$$

$$z^- = \left\{ \max_{1\le i\le m} y_{ij} \middle| i = 1,2,\cdots,m \right\} = \{z_1^-, z_2^-, \cdots, z_m^-\} \quad (7)$$

3.2.4 Calculating distance

In this paper, Euclidean distance calculation formula is selected to calculate the distance, so that G_j^+ is the distance between the i th index and z_i^+, and G_j^- is the distance between the i th index and z_i^-, the specific calculation formula is as follows:

$$G_j^+ = \sqrt{\sum_{i=1}^{m} (z_i^+ - z_i)_j^2} \quad (8)$$

$$G_j^- = \sqrt{\sum_{i=1}^{m} (z_i^- - z_i)_j^2} \quad (9)$$

Where: z_{ij} is the weighted normalized value of the *i* index in the *j th* year; z_i^+ and z_i^- are positive ideal values and negative ideal values of the *i th* index in the *n* year respectively.

3.2.5 Calculate the closeness between the evaluation object and the ideal value

E_i is the degree to which the land bearing capacity in year *j* is close to the optimal bearing capacity, often referred to as proximity, the value range is between [0,1], and the greater E_i is, the closer the carrying capacity of the land in that year is to the optimal level of carrying capacity. When E_i=1, the land carrying capacity is the highest; When E_i=0, the land carrying capacity is the worst. This paper reflects the level of land resource carrying capacity in the study area according to the size of the development progress.The calculation formula is as follows:

$$E_i = \frac{G_j^-}{G_j^+ - G_j^-} \quad (10)$$

3.3 Grading of land resource carrying capacity

In this study, the land resource carrying capacity of Guyang County in Inner Mongolia in 2005, 2010, 2015 and 2020 was classified by ArcGIS natural break (Jenks)point classification method, and the land resource carrying capacity was divided into four levels, namely weak bearing area, low bearing area, intermediate bearing area and high bearing area.

4. Results and analysis

4.1 Analysis of temporal characteristics of land resource carrying capacity in Guyang County

Table 2 Changes in carrying capacity of land resources in Guyang County, Inner Mongolia

Towns	2005Year	2010 Year	2015 Year	2020 Year
Jinshan Town	0.578816	0.578287	0.593632	0.583197
Xidoupu Town	0.379606	0.336131	0.38253	0.561788
Xiashihao Town	0.30412	0.241006	0.235311	0.328546
Silver Town	0.448781	0.454801	0.424613	0.346216
Huaishuo Town	0.299915	0.305677	0.250665	0.30896
Xingshunxi Town	0.392699	0.374084	0.318801	0.571549

Through Table 2, it can be seen exactly the change of the carrying capacity of land resources in Guyang County, Inner Mongolia. From 2005 to 2020, the overall increase of the carrying capacity of land resources in Guyang county accounted for the majority, including Jinshan Town, Xidoupu town, Xiashihao town, Huaishuo town and Xingshunxi town. During the study period, the land carrying capacity index increased by 0.0044 in Jinshan Town, 0.1822 in Xiashihao Town, 0.0244 in Huaishuo Town and 0.1789 in Xingshunxi Town.Silver Town fell 0.1026.

4.2 Analysis of spatial-temporal evolution of land resource carrying capacity in Guyang county

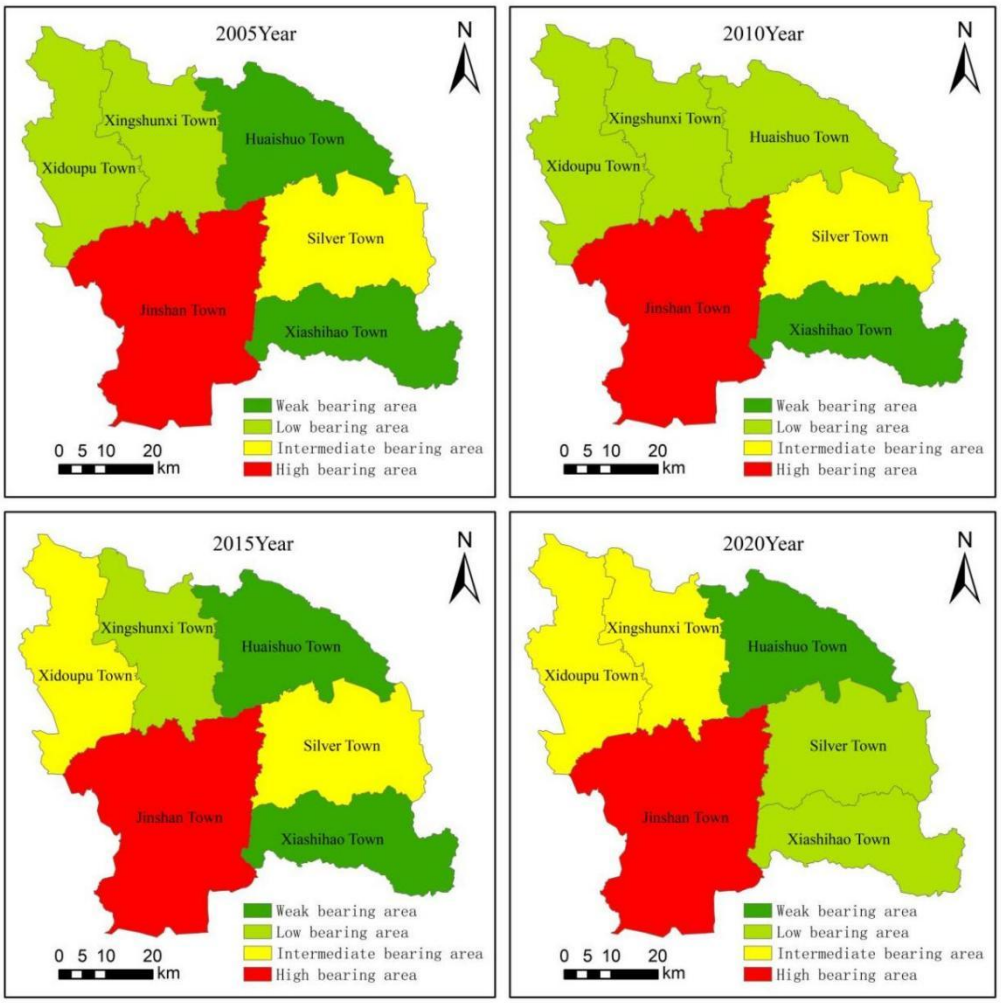

Figure 1 Distribution map of land resources carrying capacity in Guyang County, Inner Mongolia

As can be seen from Figure 1, the changes of the carrying capacity of land resources in Guyang county between 2005 and 2020.The carrying capacity of land resources in Jinshan Town has remained in the high bearing area for 15 years, which is because Jinshan Town is the central urban area of the county, and the county is making every effort to build the comprehensive and high-quality development of Jinshan Town. The carrying capacity of land resources in Xidoupu Town and Xingshunxi Town has steadily increased, from low bearing area in 2005 to medium bearing area in 2020. In terms of spatial distribution, Jinshan Town in the southwest of Guyang county and Xidoupu Town and Xingshunxi Town in the northwest of Guyang county have a high level of land resource carrying capacity, while Xiashihao Town and Silver Town in the southeast and Huaishuo Town in the northwest of Guyang county have a low level of land resource carrying capacity. On the whole, the carrying capacity of land resources in Guyang county is higher in the west and lower in the east.

5. Conclusion

The research on the carrying capacity of land resources in Guyang county shows that the carrying capacity levels of each township are different. By 2020, there will be one township (Jinshan Town) in the high-carrying area, two townships (Xidoupu Town and Xingshunxi Town) in the medium-carrying area, two townships (Xiashihao Town and Silver Town) in

the low-carrying area, and one township (Huaishuo Town) in the low-carrying area. With the change of time, the comprehensive assessment value distribution of land resources in Jinshan Town, Xiashihao Town, Huaishuo Town and Xingshunxi Town increased by 0.0044, 0.1822, 0.0244 and 0.1789. In general, the carrying capacity of land in Guyang county is in the stage of high development. It is believed that the carrying capacity of land resources will be further improved if the land resources can be used scientifically and rationally in the future development.

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