Research on the Space Classification and Function Evaluation System of "Sansheng Space" Based on the Land Space Data of Chongqing

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Abstract. In order to promote the balanced and sustainable development of Chongqing's land space, we propose an evaluation method for the coordinated development of production, life and ecology in view of Chongqing's special geographical location, and propose corresponding development strategies. Firstly, use the land use map of Chongqing's production, life and ecology to design reasonable functional evaluation indicators; secondly, use the functional evaluation indicators to build a functional evaluation system to realize the functional evaluation of the three; finally, analyze the future of Chongqing in the three areas through data analysis. The development focus of living space will provide decision-making basis for the follow-up sustainable development of Chongqing.

Keywords: Chongqing City · Sansheng Space · functional Evaluation · new Barrel Theory

1 Introduction

In recent years, relying on the "One Belt, One Road" strategy, Chongqing has achieved rapid economic development in Chongqing, from a relatively closed mountain city to the frontier of opening up to the outside world. However, the problem of land use inconsistency is still becoming more and more serious, which limits the balanced development of spatial regions. It will lead to a decline in regional development competitiveness. In addition, a series of social problems such as affecting the ecological environment, production environment and human settlement environment have also emerged. How to use Chongqing's land and space data to realize the analysis of the spatial-temporal pattern of land use in the three areas, and to conduct quantitative evaluation of functions is a problem worthy of our in-depth consideration to solve the current development dilemma. Therefore, the research on the spatial-temporal pattern of Chongqing's "Sansheng Space" is helpful to the optimization of Chongqing's land space, and has certain guiding significance for the sustainable development of Chongqing.

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At present, the research methods of using land spatial data to realize the spatial function evaluation of life, living and living can be summarized into two categories [5]. One is to qualitatively identify the three-life space, that is, to classify and merge land use data; the other is to conduct a certain quantitative evaluation of the spatial evaluation unit. In the literature [1], the author analyzed the three aspects of land function, ecosystem service and landscape function by using the method of vertical and horizontal comparison, and constructed a corresponding functional classification system. In literature [2], the author selects the national standard of land use classification and comprehensively analyzes the relationship between land use function and type, so as to build a classification and function evaluation system model. In the literature [3], the author formulated the criteria for the division of three-life land use, and proposed a three-life use land extraction method based on the census of geographic national conditions, so as to realize the rapid and effective extraction of "Sansheng Space" use land.

Most of the existing studies mainly use qualitative analysis, and quantitative analysis is rarely used. This paper proposes a mixed mode analysis and evaluation method. First, starting from the main functions of the land, we use the spatial analysis method in the geographic information system to select appropriate classification indicators and construct a classification system; secondly, use the new barrel theory method and the analytic hierarchy process [10] to analyze the changes in the spatio-temporal pattern, Construct a quantitative evaluation model, dig out the balance points and existing problems among production, life, and ecology, and propose corresponding improvement measures, so as to make the development of the three-life space in Chongqing more balanced, and also contribute to the sustainable development of Chongqing in the future. provide an important basis for decision-making. In-depth research on the evolution of the space-time pattern of the three-life space in Chongqing.

2 Materials and Methods

2.1 Overview of the Study Area

Chongqing City is geographically located between 105°11'–110°11' east longitude and 28°10'–32°13' north latitude. There are 38 districts and counties in total, with a total area of 82,400 km^2 and a permanent population of 32.1243 million. There are many hills and mountains, and it is an important economic and financial center in the upper reaches of the Yangtze River. It is also an important strategic fulcrum for the development of the western region, and an important link between the "Belt and Road" and the Yangtze River Economic Belt [8].

2.2 Data Source and Processing

The data used in this paper come from the Resource and Environment Science Data Center of the Chinese Academy of Sciences (https://www.resdc.cn/), and the data of natural resources and economic statistics come from the Chongqing Statistical Yearbook (http://tjj.cq.gov.cn/).

2.3 Research Methods

Classification system

Based on the dominant function of land, we take the main function of land as the basis for the division of "Sansheng Space", establish the connection between land use data and "Sansheng Space", and construct the three-life space classification system (Table 1) [6]. The production space is the place where agricultural products and industrial products are provided. Living space is a space that provides people's life and activities with life services and life guarantees, that is, a place for living, consumption and entertainment. Ecological space mainly refers to the land with the function of regulating, maintaining and guaranteeing ecological security, including green vegetation space (woodland, grassland) and other ecological spaces (water area, unused land, etc.).

Table 1. Spatial classification system

Three-life space	Class of land	Land function	Dominant function	Description
Production space	Mining area	Production master-life secondary	Production	Land space for the production of primary industries such as agriculture, forestry, animal husbandry, by-products, and fishery, and land space for the provision of industrial products and services
	Industrial land			
	Dry land	Production master-Ecological-side- life secondary		
	Paddy field			
Living space	Land for transportation	Life master- Production secondary	Living	The land space that carries people's living and living

(*continued*)

Table 1. (*continued*)

Three-life space	Class of land	Land function	Dominant function	Description
	Residential land	Living master		
Ecospace	Meadow Grass Herb space Paramo Evergreen broad-leaf forest Broad leaved deciduous forest Evergreen needleleaved forest Deciduous coniferous forest Mixed broadleaf-conifer forest Lake River Unused land	Eco-logical master-Production-side-life secondary Eco-logical master-life secondary	Ecology	Adjust, maintain, and guarantee ecological functions and safe land use space

New Cask Theory

The new barrel theory [10] is to change the traditional barrel theory's single thinking of making up for shortcomings into paying attention to both the shortest plank and the longest plank, and at the same time paying attention to the difference between the long and short planks. The New Barrel Theory is a new, complementary, and collaborative whole that can achieve a more balanced state. In order to better evaluate the "Sansheng Space" in Chongqing, this paper adopts the evaluation model of the new wooden barrel theory, which can directly reflect whether the state of Chongqing's "Sansheng Space" is balanced.

Index normalization

The evaluation index values of the "Sansheng Space" functions have different dimensions and orders of magnitude. In order to ensure the reliability of the evaluation results, we standardized the original values of each index system to avoid the impact of units and orders of magnitude on the evaluation results. The unification formula is as follows:

$$y_{ij} = \frac{x_{ij}}{\sum_{j=1}^{n} x_{ij}}$$

Indicator weight determination

Since the AHP determines the index weight through the expert scoring method, the operability is not strong. In this paper, we use the AHP in the subjective weighting method to determine the index weight.

First, build a hierarchical model. We decompose the relevant evaluation factors into the highest level, the middle level and the bottom level according to different attributes. The factors of one level have corresponding influences on the factors of the upper level, and it also affects the factors of the lower level play a certain role (Fig. 1) [7].

Second, construct a judgment matrix. We determined the appropriate scale through pairwise comparisons among the factors. After establishing the hierarchical structure, it is necessary to compare the proportions of the factors and the subordinate indicators. To realize the transformation from qualitative to quantitative, a quantitative scale is required. Combined with expert scoring, the final judgment matrix is obtained:

$$K = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nn} \end{bmatrix}$$

where x_{ij} denotes the relative importance of x_i to x_j.

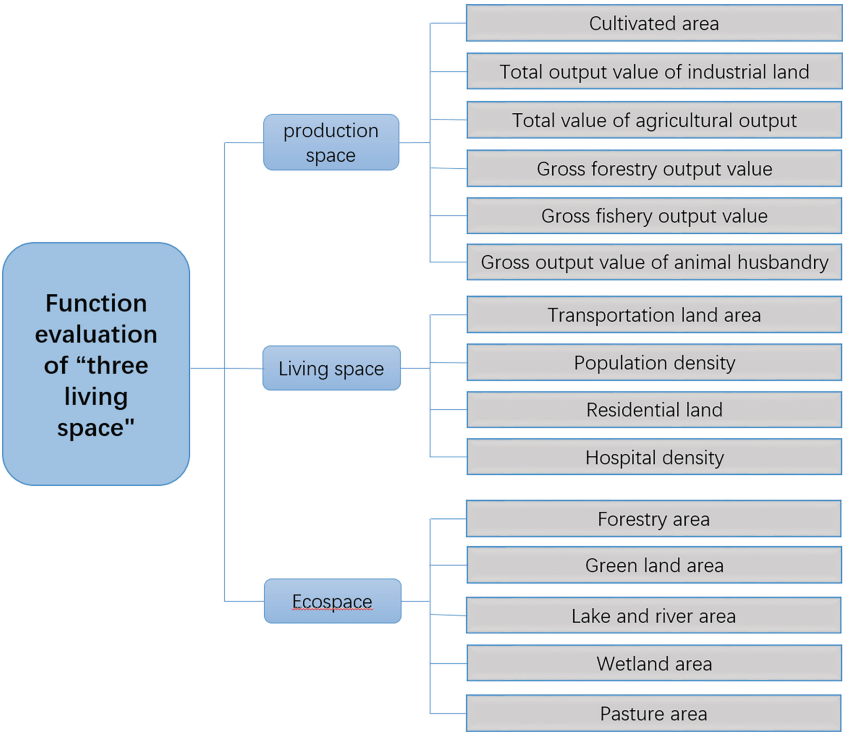

Fig. 1. Evaluation index grading

Finally, the consistency test. By calculating the consistency index

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

In the above formula, λ_{max} is the maximum eigenvalue of the judgment matrix, and n is the order of the judgment matrix. The consistency ratio can be calculated as follows: $CR = \frac{CI}{RI}$, which RI can be obtained by querying the AHP index table. If $CR < 0.1$, it is considered that the consistency of the judgment matrix is acceptable.

3 Functional Evaluation

3.1 Functional Evaluation Index System

The differences in the spatial structure of life, living and living in Chongqing are relatively obvious, showing the main characteristics of large-scale dispersion of production space and ecological space and small-scale concentration of living space (Fig. 2). The area of ecological space accounts for the largest proportion, followed by production space and the least living space. In order to better evaluate the "Sansheng Space" in Chongqing, based on the production function, living function and ecological function, combined with the actual development of Chongqing's "Sansheng Space", and drawing on relevant research results, the construction of Chongqing's "Sansheng Space" The functional evaluation index system of "Sansheng Space" includes a total of 13 evaluation factors (I_1–I_{13}) (Table 2).

Table 2. Evaluation index system

Objective level	Index	No.
production function	cultivated area	I_1
	total value of agricultural output	I_2
	gross forestry output value	I_3
	total output value of fishery and animal husbandry	I_4
	total output value of industrial land	I_5
vital function	population density	I_6
	density of road network	I_7
	density of primary and secondary schools	I_8
	number of beds in health institutions per capita	I_9
	urbanization level	I_{10}
ecological functions	forest coverage rate	I_{11}
	green area	I_{12}
	water area coverage	I_{13}

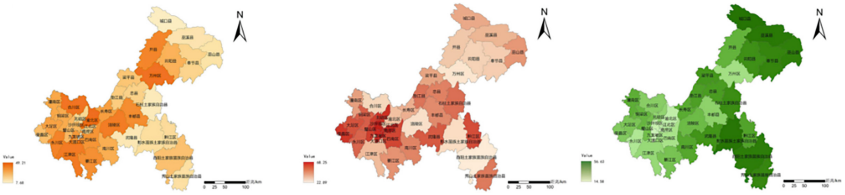

Fig. 2. Percentage expression diagram of Sansheng functions (from left to right: production, living and ecology)

Table 3. Function evaluation index and weight values

Index	Weights
I_1	0.023
I_2	0.026
I_3	0.026
I_4	0.023
I_5	0.046
I_6	0.151
I_7	0.129
I_8	0.135
I_9	0.029
I_{10}	0.037
I_{11}	0.0121
I_{12}	0.0327
I_{13}	0.0649

3.2 Weight Calculation

Using the analytic hierarchy process, according to the importance of each evaluation index relative to the evaluation index of the previous layer, its weight in the evaluation is determined, so as to obtain the weight value of each index of the "Sansheng Space" function evaluation (Table 3).

3.3 Model Establishment

Based on the new wooden barrel theory, we quantitatively evaluate the function of "Sansheng Space" in Chongqing, reflecting the development status of Chongqing in space.

Quantification of the construction level of "Sansheng Space": $T = \frac{1}{3}\sum_{i=1}^{n} r_i$, where T represents the total amount and r_i represents various parameter values.

Quantification of the development space of the three-life space $L = \max\{A, B, C\}$, $M = \min\{A, B, C\}$, $Y = L - M$, Y represents the quantitative value of the development space, and the larger the value, the greater the development potential. In this article, $A = \{I_1, I_2, I_3, I_4, I_5\}$, $B = \{I_6, I_7, I_8, I_9, I_{10}\}$, $C = \{I_{11}, I_{12}, I_{13}\}$.

3.4 Evaluation Results

In order to study the gaps between the various spaces in the "Sansheng Space" of Chongqing, and compare the development potential of the worst space construction compared with the best space construction, we select the highest parameter value and the lowest parameter value of the "Sansheng Space". The parameter value is analyzed, and the quantitative value of the development space of the "Sansheng Space" is obtained by using the new barrel theory. Any space promotes the overall development. The more time and energy Chongqing can allocate from the good parameters of space construction to the poor parameters of space construction, the construction of poor parameters can be strengthened, and its room for improvement will gradually decrease [9].

Using the "Sansheng Space" function evaluation index system and model to calculate the quantitative value of Chongqing's "Sansheng Space" construction level $T = 0.41$, we take 1 as the equilibrium value, it can be seen that the development of Chongqing's "Sansheng Space" is not balanced. We also calculated by the consistency test $CR = 0.037 < 0.1$, indicating that the proposed model is acceptable. In addition, we also give the evaluation results of "Sansheng Space" functions, as shown in Table 4. It can be seen from Table 4 that the ecological space (0.15) is the short board in the development process of the three spaces, indicating that the ecological space in Chongqing needs to be adjusted in the future and has the greatest development potential; secondly, according to the new wooden barrel theory, the living space in Chongqing (0.32) is in the middle of the three, which is not a short board for development, but there is a large gap with the production space and needs to be adjusted; finally, the value of the production space is 0.61, which shows that the production space of Chongqing is more developed than the other two spaces. The fastest, reflecting the development gap among the three. In addition to the development of production space, the development focus of Chongqing in the future should also focus on the development of ecological space and living space in order to achieve a balanced development of "Sansheng Space".

Table 4. Results of functional evaluation of Sansheng Space

Type	Evaluation result
production space	0.61
living space	0.32
ecospace	0.15

4 Conclusion

This thesis mainly researches the classification and function evaluation model of "Sansheng Space" in Chongqing, adopts the new wooden barrel theory, establishes the corresponding mathematical model, and realizes the classification and function evaluation of "Sansheng Space" in Chongqing. Through the consistency test, the proposed model is scientific and feasible. In addition, through the quantification of the three spaces of production, life and ecology, it provides guidance for the specific implementation of balanced development and construction in Chongqing.

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