Analysis and Evaluation of Urban Land Use

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Keywords: Land use; Analysis; Evaluation.

Abstract. During the rapid urban development, the scientific assessment of urban land use status played an important role in the rational planning, development and utilization of land resources. From the aspect of land utilization and its impact on society, economy and ecology, we designed 12 index systems for evaluating index formation, complete the model quantification according to AHP, calculated the comprehensive evaluation value, and formed the quantitative evaluation results.

Introduction

Eric F Lambin [1] studied the issue of intensive land use. Grimaud A [2] studied how land use promotes regional economic growth. C. He [4] and C. E. Shannon [5] applied mathematical methods to study the impact of different factors on land use efficiency. K. Morris [6] studied land use efficiency from a theoretical perspective. Liu Jiyuan [3] evaluated the land use efficiency of Jiangning District in Nanjing, China.

Multi-index evaluation is a method of completing the evaluation of urban land by choosing a variety of indicators and calculating the index by a certain mathematical model. Common index calculation methods include comprehensive index method, fuzzy comprehensive evaluation method, ideal value correction method, artificial neural network method [7]. This papchose the comprehensive index method for land use analysis and evaluation.

Evaluation index system

Land evaluation needed to take into consideration the above three attributes at the same time and pay attention to the unity of the three attributes. Furthermore, according to the idea of   "the sum of the whole was greater than the sum of the parts", we should pay attention to the optimization of the overall land use structure and the intensification of the single land use, and made the measurement of the rationality of the urban land structure an important part of the evaluation. In addition, the intensive use of urban land is more the dynamic process of unceasing development of land use potential, and there was no static ideal state. Therefore, the land evaluation involved in this paper would focus more on the quality of evolutionary process.

In order to scientifically evaluate the quality of urban land use, by making full use of the existing land use survey data, the following indicators were established:

The evaluation index system had a pyramid structure. The top layer was the target layer, which characterized the quality of urban land use. The second layer was the standard layer, belonging to the target layer, including four independent first-level indicators. These first-level indicators reflected the general indicators of land-use quality in the process of urban expansion and evolution, including land use patterns, social benefits, economic benefits and ecological benefits, from different aspects. The lowest level was the indicator level, and it contained a number of second level indicators, each of which was subordinate to a first level indicator in the guideline level. The second-level index was an indicator that directly reflects the specific quality of land use in the development and evolution of urban land and can be quantitatively evaluated.

Among the above indicators, the indicators of land use were mainly from the analysis of the evolution of patches, especially the patches of construction land. The secondary indicators under the land use pattern were shown in Table 1.

Table 1 Instructions of the second level indicators of land use patterns

Second level indicators	Indicator description
Expansion velocity index	It reflected the expansion ratio and speed of construction land.
Expansion and evolution of population elasticity coefficient	It reflected the dependence of population growth on the growth of construction land.
Patch area index	It reflected the changes of average size of construction land.
Patch shape index	It reflected the changes of average compactness of construction land.
Mixed utilization index	It reflected the changes of degree of mixed use of land during the evolution of urban land use.

The social benefit was utilized to assess the extent to which the current limited resources could meet the growing material and cultural needs of the whole society. The second-level indicators and descriptions of social benefits were shown inTable 2.

Table 2 Instructions of the second level indicators of social benefits

Second level indicators	Indicator description
Population density change rate	It reflected the rate of population density changes in the same period in the study area.
Traffic density index	It reflected the number of roads per unit area of land, indicating the development degree of local traffic.

Economic benefits played an important role in the development of land resources in view of the value of products and services that could be produced in the limited land. The second level indicators which were subordinate to the economic benefits were described in Table 3.

Table 3 Instructions of the second level indicators of economic benefits

Second level indicators	Indicator description
GDP density	It reflected the GDP per unit area.
GDP elastic coefficient with extended evolution	It reflected the dependence of the growth rate of GDP on the growth rate of expansion of construction land.

Ecological benefits mainly evaluate the ecological level of land. Good ecological quality of land was of great significance to the excavation of land potential and the promotion of land value. The second level indicators which were subordinate to the ecological benefits were described in Table 4.

Table 4 Instructions of the second level indicators of ecological benefits

Second level indicators	Indicator description
Open space impact index	It reflected natural space occupancy derived from the expansion of land, including mountain farmland, rivers and lakes, all kinds of green space, etc.
Per capita green space index	It reflected the change of green area per capita under the background of urban expansion.
Regional Shannon diversity index	It reflected the changes of diversity of regional landscape.

Determination of weight

The relative weights that passed the consistency test could be applied as the weights of the first-level and second-level indexes in this evaluation system. Weight represented the relative importance of each indicator at the same level, and its rational allocation was an important step in quantitative evaluation and analysis, which directly affected the result of evaluation.

In this paper, first of all, spatial data in experimental area were analyzed and calculated based on geographic information system and landscape analysis platform, and then experienced experts were invited to judge the importance of each indicator. According to the judgment of relative importance, the weight of each second-level index was acquired based on the AHP method. Table 5 showed the criterion and factor layer weights:

Table 5 Weigths of first level and second level

First level indicators	Weights of first level indicators	Second level indicators	Weights of second level indicators
Land use patterns	0.25	Expansion velocity index	0.0714
		Expansion and evolution of population elasticity coefficient	0.1429
		Patch area index	0.2143
		Patch shape index	0.2143
		Mixed utilization index	0.3571
Social benefits	0.25	Traffic density index	0.6
		Population density change rate	0.4
Economic benefits	0.25	GDP elastic coefficient with extended evolution	0.4
		GDP density	0.6
Ecological benefits	0.25	Open space impact index	0.2857
		Per capita green space index	0.4286
		Regional Shannon diversity index	0.2857

Calculation results

The obtained evaluation index values were normalized. According to the set weights, the multi-index comprehensive evaluation formula was used to evaluate the urban land surface evolution quality of street scale. Calculated as follows:

$$A = \sum w_i a_i \qquad (1)$$

In formula 1, A was the total score of evaluation, w_i was the weight value of the index of i, and a_i was the index value for completing the index with the trend and the dimensionless.

In order to visualize the evaluation results, the street index values were ranked according to the natural discontinuous point classification provided by ArcGIS. Divided into four levels, the first level indicators ranged from 0.330380-0.407999, the second level was 0.408000-0.440174, the third level was 0.440175-0.470174, and the fourth level was 0.473732-0.549201.

According to this grading standard and the grading result of evaluation, it was rendered as shown in Figure 1.
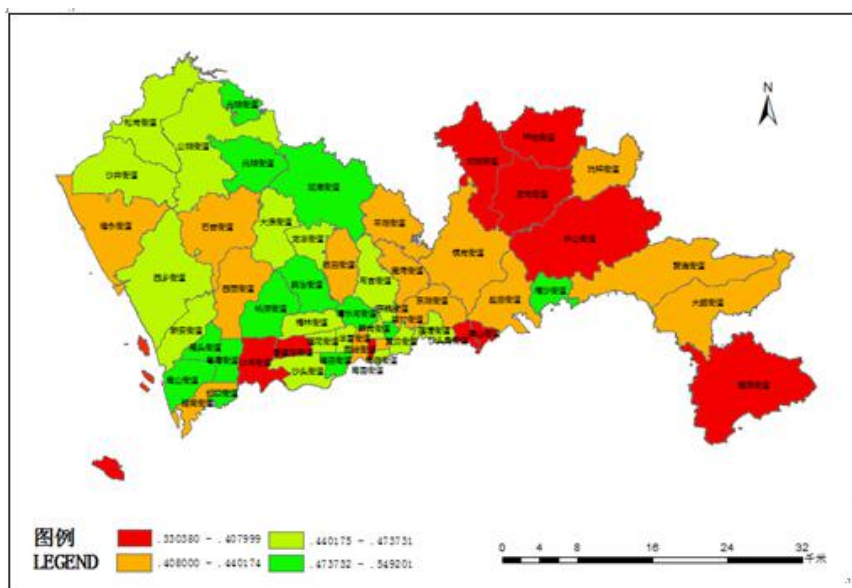
Figure 1. Urban land use quality evaluation results

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