The Urban Intensive Land-use Evaluation in Xi'an, Based on Fuzzy Comprehensive Evaluation

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Abstract. The intensive land-use is the basis of urban "stock optimization", and scientific and reasonable evaluation is the important content of the land-intensive utilization. In this paper, through the survey of Xi'an urban land-use condition, we construct the suitable evaluation index system of Xi'an' intensive land-use, by using Analytic Hierarchy Process (AHP) and Fuzzy Comprehensive Evaluation (FCE) of combination. And through the analysis of the influencing factors of land-intensive utilization, we provide a reference for the future development direction.

1. Introduction
The intensive land-use was the first proposed by classical political economists in rent theory, such as David Ricardo. Its basic meaning is increasing investment in land to get the highest compensation. Many scholars explain and define it from different angles and different scopes [2]. Some scholars hold the opinion that intensive land-use is increasing investment in certain urban land to obtain more output [1]. Some scholars hold the view that add to increase the urban land investment target and led increasing output [3]. Some scholars define intensive land-use from the perspective of land use intensity, and think multi-dimensional utilization of urban space is the urban intensive land-use [4, 5]. All three views are based on intensive use alone, without taking into account the impact of urban layout and land structure [6]. Zhihong Tao considers that reasonable urban layout is the premise of urban’ intensive land-use [7]. Without this premise, it is impossible for the investment to achieve the best efficiency. In addition, all of the scholars have a consensus that urban’ intensive land-use is a dynamic continuous process.

In conclusion, we can assume that intensive land-use refers to the reasonable layout, optimizing the land use structure and sustainable development, by increasing the stock of land investment, improving the operation and management, continuously improving the efficiency of land use, and obtaining higher economic. China's urban development has been transformed from incremental expansion to inventory optimization, which has given new value and significance to the study of intensive land-use [2, 6].

2. Land use survey in the research area
As a central city in northwestern China, Xi'an is one of the first recognized historical and cultural cities in China. It is a research area that has both practical-research significance and academic-research value. According to the land use structure of Xi'an in 2015, the proportion of land occupied by resident and industry is lower than the national standard, and the proportion of land for public administration
and public service, green space and square for the total construction is higher. This is related to the characteristics and functions of Xi'an.

Data source: 2015 urban construction statistics yearbook of Shaanxi province

Table 1. Statistics of land-use structure in 2015 in Xi'an

| Land use types                        | Residential land | Public administration and public service land | Commercial and service facilities | Industrial land | Logistics warehousing | Land for road and transport facilities | Utility land | Land of green space and square | Summation |
|---------------------------------------|-----------------|-----------------------------------------------|----------------------------------|-----------------|-----------------------|--------------------------------------|--------------|-------------------------------|-----------|
| The land area (km²)                   | 246.20          | 106.62                                        | 82.66                            | 129.50          | 23.97                 | 172.47                               | 37.64        | 238.83                        | 1037.89   |
| Proportion (%)                        | 23.72           | 10.27                                         | 7.96                             | 12.47           | 2.31                  | 16.62                                | 3.63         | 23.02                         | 100       |
| National standard (%)                 | 25-40           | 5-8                                           | -                                | 15-30           | -                     | 10-25                                | -            | 10-15                         | -         |

3. Evaluation index system design

3.1. Evaluation index system design
The core of the evaluation work is to establish the evaluation index system. The ministry of land and resources especially issued the ‘Technical plan for the evaluation of urban land intensive utilization potential’. The evaluation put the whole city land utilization condition as evaluation object, with Xi’an’s development direction, function orientation, condition of industrial structure, and land resources combined, select four factors and eight factor-indicators.

Table 2. Evaluation System of Intensive land use Selection

| Index layer factor | The index factor                                                                 |
|--------------------|----------------------------------------------------------------------------------|
| Land investment level | The investment of fixed assets of unit construction land                         |
| Land use intensity   | GDP of unit construction land                                                    |
|                     | Per capita traffic land area                                                     |
| Land yield benefit   | The second and third industry added value of unit construction land              |
|                     | Per capita industrial value of unit industrial land                              |
| Land bearing capacity| The industrial production value of unit industrial land                          |
|                     | Per capita construction land                                                     |
|                     | Urban construction land per capita                                              |
|                     | Per capita construction land for rural residentsal spot                           |

3.2. Evaluation factor classification
The evaluation factors of division are low utilization, moderate utilization, intensive utilization and overuse.

3.3. Index weight determination
According to the actual situation of Xi’an, choose the Analytic Hierarchy Process (AHP) to determine weights of evaluation indexes. In this paper, Delphy is used to invite relevant experts to grade the evaluation indexes. See the table below:
Table 3. Evaluation Index Weight of Intensive land-use of Xi’an

| Target layer A | Criterion layer B | Scheme layer C | The weight |
|----------------|-------------------|----------------|------------|
| Intensive land-use of Xi’an | Land investment level B₁ | The investment of fixed assets of unit construction land C₁ | 0.08 |
| | Land use intensity B₂ | GDP of unit construction land C₂ | 0.22 |
| | | Per capita traffic land area C₃ | 0.12 |
| | Land yield benefit B₃ | The second and third industry added value of unit construction land C₄ | 0.18 |
| | | The industrial production value of unit industrial land C₅ | 0.09 |
| | Land bearing capacity B₄ | Per capita construction land C₆ | 0.52 |
| | | Urban construction land per capita C₇ | 0.16 |
| | | Per capita construction land for rural residential spot C₈ | 0.20 |

4. Intensive land-use evaluation in Xi’an

The degree of land use is difficult to have clear boundaries, and the degree of intensive, extensive or excessive is even more ambiguous. The FCE method is to use the principle of fuzzy transformation and the principle of maximum membership, to consider the multi-objective and multi-level factors related to the evaluation of things, and to evaluate the comprehensive evaluation of it. In this paper, a three-level comprehensive evaluation index system is established to evaluate the degree of intensive land-use in Xi’an.

Figure 1. The steps of FCE

(1) Establish an evaluation factor set U.

\[ U = \{u₁, u₂, \cdots, uₙ\} \]

Factor refers to the various properties or performance evaluation object. Find out the factor sets which is put forward from the object associated with the recognition of the characteristics. \( U = \{U₁(\text{land investment level}), U₂(\text{land use intensity}), U₃(\text{land yield benefit}), U₄(\text{land bearing} \)
membership principle. We determined the evaluation set of \( V = \{ \text{Low utilization}, \text{Moderate utilization}, \text{Intensive utilization}, \text{Overuse}\} = (V_1, V_2, V_3, V_4) \).

(3) Determine the weight vector \( A \) of the evaluation.

\[
A = (0.08, 0.22, 0.18, 0.52) \quad A_1 = (0.08) \quad A_2 = (0.12, 0.10) \quad A_3 = (0.09, 0.09)
\]

\[
A_4 = (0.16, 0.20, 0.16)
\]

(4) Establish a fuzzy comprehensive evaluation matrix \( R \).

For the single factor evaluation: \( r_i = (r_{i1}, r_{i2}, \cdots, r_{im}) \); The relationship between the factor theory domain \( U \) and the evaluation domain \( V \) is represented by \( R = U \times V \).

\[
R = \begin{pmatrix}
    r_{11} & r_{12} & \cdots & r_{1m} \\
    r_{21} & r_{22} & \cdots & r_{2m} \\
    \vdots & \vdots & \ddots & \vdots \\
    r_{n1} & r_{n2} & \cdots & r_{nm}
\end{pmatrix}
\]

\[
R_1 = \begin{pmatrix}
0.15 & 0.35 & 0.40 & 0.10
\end{pmatrix}
\]

In the matrix, \( r_{ij} \in [0, 1] \) \( (i=1, 2, \cdots, n; j=1, 2, \cdots, m) \), the factor \( U \), which is rated as the fuzzy membership of \( V \). The row \( i \) in the matrix \( R = (r_{i1}, r_{i2}, r_{i3}, \cdots, r_{im}) \) is single factor of evaluation factor \( U \). We get the results of \( R_1, R_2, R_3 \) and \( R_4 \) in sequence.

(5) Comprehensive evaluation.

Use fuzzy set computation to solve \( B \), and determine the degree of influence based on maximum membership principle.

\[
B_1 = A_1 \times R_1 = (0.08) \times (0.15, 0.35, 0.40, 0.10) = (0.012, 0.028, 0.032, 0.008)
\]

Calculate the \( B_1, B_2, B_3, B_4 \) in turn, draw \( R \):

\[
R = \begin{pmatrix}
0.0120 & 0.0280 & 0.0320 & 0.0080 \\
0.0380 & 0.0830 & 0.0720 & 0.0270 \\
0.0225 & 0.0765 & 0.0630 & 0.0180 \\
0.1040 & 0.1740 & 0.1720 & 0.0700
\end{pmatrix}
\]

\[
B = A \times R = (0.08, 0.22, 0.18, 0.52)
\]
According to maximum membership principle, corresponding set of comments \( V = \text{(Low utilization, Moderate utilization, Intensive utilization, Overuse)} \). We can draw the conclusion that the level of intensive land-use in Xi’an is moderate.

5. Evaluation Result Analysis
The evaluation above can be concluded that the intensive land-use level in urban areas of Xi’an is not high. Its’ influencing factors are as follows:

(1) Economic factors. Land location, purpose and price will affect intensive utilization. Generally speaking, the land location conditions are superior, the intensive land-use price will be higher, and the input and output of commercial land are much higher than industrial land and residential land.

(2) Institutional factors. In the 1980s, under the planned economy system, the role of market was completely excluded, resulting in the lack of efficiency and low intensive land-use. After economic system reform, the market economic system gradually established. Xi’an shall practice a system of paid for the use and transfer of land, urban land value and location advantages to embody, directly affect the land-use.

(3) Ecological factors. Urban environmental bearing capacity determines the maximum intensity of urban intensive land-use, which means urban ecological environment is an important limiting factor of intensive land-use.

(4) Historical and cultural protection factors. Due to the demand of protect historic city, architectural style in old city is given priority to with continuation of traditional style and features. Thus, the building height, the Plot Ratio and the land revenue will be limited and reduce. Some old land’s Plot Ratio can reach 3 or 4 (now is 1.8), the net income can be doubled (which is hard to be achieved now).

6. Conclusion
Intensive land-use has become an important trend in China. Xi’an’ land-use expansion has been accelerated in recent years, and the lack of economic and available land becomes increasingly prominent. Relatively speaking, the urban land-use structure is still not reasonable, and the intensive land-use potential is not fully utilized. This requests us practice strict way of scientific land-use intensification in the future, make reasonable land-use planning, optimize the structure of land-use, improve the market allocation mechanism, strengthen environmental protection and management, adjust measures to local conditions, formulate the overall implementation plan of the intensive land-use, become incremental expansion for inventory optimization mode of land-use, and improve the land use intensive degree and comprehensive benefit.

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