Design of the Urban Land Grading Information System

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1 Introduction

Grading urban land correctly and determining the land price are important basic work to carry out the compensational exploitation and develop the real estate market. The land grading must be built on objective evaluation and scientific evaluation and calculation of land quality. Urban land grading, which is based on the analysis of social, economic and natural attributes of urban land, is a process of synthetic analysis of urban land use value and exploring the regional difference of land use benefits in the inner part of town.

Nowadays, many cities in our country have finished the land grading and evaluation. This is the basic work for the reform of land use systems. Our urban land economic investigators and practitioners have contrived many methods that are fitful for our land use situation and developed many information systems about land grading and evaluation, but many of them are lack of flexibility. So this paper puts forward the land grading system based on GIS technology.

Combining with the “Regulation of Urban Land Grading” promulgated by the Ministry of Land & Resource in 2000, aiming at systematizing the current land management, this paper discusses the design of the urban land grading system, the function of the system and the implementation of the system. Finally, the paper gives an example of the commercial land grading of the urban area of Wuhan City.

2 The method of urban land grading

Multiple factors assessment method has been widely used in urban land grading. And this paper uses it as a primary method.
to grade land. The method generally takes account of as many characteristics of urban land as possible in evaluating urban land area, reveals the differences of the land value or land use value and the spatial distribution in the urban land area, and then assesses the urban land quality grade or income distinction. The urban land is affected by many factors. If the score and weight can be gotten by reasonable methods, we can get the effect value of every land parcel through the score and weight.

Assuming that m factors are chosen in evaluation and each factor includes n attributes. The value of a particular factor in land evaluation parcel is equal to the sum of every attribute score multiplied by its weight.

\[ P_j = \sum_{j=1}^{n} F_j W_j \quad (1) \]

where \( F_j \) is the score of the jth attribute; \( W_j \) is the weight of the jth attribute.

If we assume that \( P \) is the sum of some land evaluation parcel and that \( W_j \) is the weight of attribute \( j \), then the sum of this parcel is

\[ P_j = \sum_{j=1}^{m} F_j W_j \quad (2) \]

then

\[ P = \sum_{j=1}^{m} \sum_{i=1}^{n} F_j W_j \quad (3) \]

In this method, there are two calculations: one is value calculation, and the other is weight calculation.

3 Key points for the designing of urban land grading system

3.1 The purposes of the system

In order to meet the requirement of urban land grade, the system must reach the following purposes:

- interactively choosing the landuse types and factors which affect urban land grading
- automatically calculating the effect value according to factor type
- using many kinds of technical methods to determine the weight of land grading factors interactively
- determining the land grade automatically
- plotting land grading map and the isoline map of effect value of various grade factors
- checking up the land grade
- interactively providing the interface for users to update the grade data.

3.2 Basic functions of the system

Fig. 1 illustrates the functions of the system.

3.3 Data sources of the system

The system acquires data from the following sources:

- the natural data, such as terrain, environment, climate, etc.
- the economic data, such as net of road, economy, population, etc.
3.4 Data organization and data structure

The data involved in urban land grading consists of spatial data and attribute data.

3.4.1 The organization of spatial data

Spatial data is organized by “map-layer-object” (Fig. 2). To meet the requirement of land grading, relative layers are designed.

![Fig. 2 The spatial data organization](image)

3.4.2 The organization of attribute data

When designing dynamic relational database, which is based on template, we make different system template corresponding to different data structure to meet different needs of urban land grading. The template can be divided into entity section, structure section, relation section, method section and parameter section. Now we introduce simply the writing rule of the template, taking entity section, structure section and method section as examples.

1) The example of entity section

```
SECTION LAND_INFO
BEGIN_DEFINE
    SUB L01 THE COMMERCIAL LAND USE END_SUB
    SUB L02 THE RESIDENCE LAND USE END_SUB
END_DEFINE
END SECTION
```

2) The example of structure section

```
SECTION-DB-FIELD-INFO
BEGIN_DEFINE
    SUB-A01
        A01 THE CENTER OF THE BUSINESS KEY NUMBER
        FIELD_DEFINE-BEGIN
            NUMBER |C|10|0|0|0|
            NAME OF CENTER |C|20|0|0|0|
        END_DEFINE
    END_SUB
END_DEFINE
END SECTION
```

```
ADDRESS |C|20|0|0|0|
NUMBER OF SHOPS |N|10|0|0|0|
INCOME OF ONE YEAR |N|16|2|0|0|
AREA OF THE USING LAND |N|16|2|0|0|
AREA OF BUSINESS |N|16|2|0|0|
NUMBER OF WORKERS |N|50|0|0|0|
PROFIT |N|16|2|0|0|
FUNCTION NUMBER |N|50|0|0|0|
RATIO OF THE MATURITY BUSINESS |C|10|0|1|
GRADE |C|6|0|1|
END-FIELD-DEFINE
END_SUB
END_DEFINE
END SECTION
```

3) The example of the method

```
SECTION-FACTOR-INDEX-AND-RADIUS-CAL
DEFINE-BEGIN
    SUB
        THE CENTER OF THE BUSINESS A01
        INDEX-CAL-METHOD 1
        RADIUS-FORMULA
        0.5642 × SQRT(|SN| + |PN|) / 1.91
        INDEXCAL-FIELDNUM 9
        FIELD-WEIGHT
            RATIO OF THE MATURITY BUSINESS |0, 20|
            NUMBER OF THE SHOPS |0, 05|
            AREA OF USING LAND |0, 05|
            GRADE |0, 70|
        END-FIELD-WEIGHT
    END_SUB
END_DEFINE
END SECTION
```

The structure information can be revised according to application requirement.
3.4.3 The link of the spatial data and attribute data

The system defines the structure of spatial data and attribute data respectively and links attribute data from various sources with spatial data through Open Database Connectivity (ODBC).

4 Application of the urban land grading system in Wuhan

4.1 Choosing the grading factors

Choosing different grade factors to aim at different cities, this system adopts effective and universal template method. It can organize all the possible grade factors into template (Fig. 3) and then choose them according to practical requirements, taking the factors system of the commercial land grading of the urban area in Wuhan City (Fig. 4) as an example.

![](image)

**Fig. 3 Example of choosing the grade factor**

| Layer of basic factors | Layer of factors | Layer of attributes |
|------------------------|-----------------|--------------------|
| Thriving degree        | Effect of business thriving | Business center |
| Traffic condition      | Convenient degree of the external traffic | Long-distance bus station |
|                       | Degree of the road open | Railway station |
|                       | Convenient degree of the public traffic | Dock |
| Condition of the base public | Perfect degree of base establishment | Water supply |
|                       | Maturity degree of the public establishment | Drainage |
| Environment condition  | Environment quality | Hospital |
| Population condition   | Natural condition | Telecommunication |
| Urban planning         | Population density | Noise pollution |
|                       | Road planning | Air pollution |
|                       | Land-use planning | Greenbelt |

![](image)

**Fig. 4 The system of the commercial land-grading factor**
4.2 Determining the weights of grade factors

The weight calculation is one of the two important calculations in multiple factor assessment method. The weight can reflect the importance of the land-grading factor and have great effect on the grade result. There are many methods to determine the weight, such as Delphi method, the comparison method of the conjugated factors, etc. In this paper we adopt the Delphi method.

The formula for calculating the average value is:

$$E = \frac{1}{m} \sum_{i=1}^{m} a_i$$  (4)

The formula for calculating the variance is:

$$\overline{O}^2 = \frac{1}{m-1} \sum_{i=1}^{m} (a_i - E)^2$$  (5)

where $m$ is the total number of the experts; $a_i$ is the score of expert No. $i$; $E$ is the average score; $\overline{O}^2$ is the variance (Fig. 5).

4.3 Calculating the influences of grade factors

Grading factor analysis is such an analysis process that is in accordance with affecting feature, effects and quantization method. It mainly calculates the scale index, the function score and impact radius of the grade factors. This paper chooses the center of business and service, which mainly affects the commercial land, to explain the calculating process. After we collect the information, we must put the attributes of the center of business and service into a computer and save the data in FoxPro table. (Fig. 6 and Fig. 7).

Four fields, such as the ratio of maturity degree of business and service, the number of shops, etc., are used for calculating the service radius of the business center. In this system's template, we give scores to the ratio of maturity degree of business, for example, 100 indicates "excellent", "good" 75, "common" 50 and "bad" 25. Likewise, we give scores to land grades. There are different weights of the four fields in the calculation, for example:

- RATIO OF THE MATURITY BUSINESS [0.20]
- NUMBER OF SHOPS [0.20]
- AREA OF THE USING LAND [0.20]
- GRADE [0.40]

After giving scores, we can use the formula to work out the service radius of the center of business and service.

4.4 The calculation of the effect values of the grade parcel factors

According to the distributing type and the different impact mode to the land, we can divide the
grade factors into point factor, line factor and polygon factor. Aiming at the different use types, the effect value attenuation of the factors is different. It can be divided into exponent attenuation and line attenuation. The center of business is a point factor and belongs to exponent attenuation.

\[ f_j = \begin{cases} F_i^{1-r}, & (r < 1) \\ 1, & (r \geq 1) \end{cases} \]

where \( f_j \) is the effect value of the \( i \)th factor to \( j \)th grid; \( F_i \) is the function score of the \( i \)th factor, \( r \) is the relative distance of the \( i \)th factor to \( j \)th grid (Fig. 8).

4.5 Calculating the general value

4.5.1 Calculating the sum of grid points

Because the grid is the basic grade parcel in this system, we must calculate the sum of grid point, whose value reflects land grades. The formula for calculating the sum of grid point is:

\[ S_f = \sum_{k=1}^{k} (f_k p_k) \]

where \( S_f \) is the sum of the grid; \( k \) is the number of the grade factors; \( p_k \) is the value of every grade factor affecting the grid; \( f_k \) is the weight of every grade factor.

4.5.2 Calculating the sum of effect values for each land use parcel

Average the sum of the grids covered by evaluation units as the sum of the evaluation units (Fig. 9).

4.6 Determining the land grade

4.6.1 Determining the grade score boundary and member

The system adopts frequency curve method. It can plot the frequency histogram based on the frequency statistic of the sum of effect values. Then we can determine the critical value of the sum in terms of the actual condition of the land. The system plots the isoline according to critical value of the sum. Lastly, it determines every grade through the isoline. We can use the turning point in frequency map as the score limit of the land grade, and then grade the commercial land and calculate the average score of each grade.

4.6.2 Determining the land grade

The urban area of Wuhan City can be classified into nine grades. The highest land grade is in Hankou area and the lowest is in the urban fringe area (Fig. 10).

4.7 Checking the land grades

The land grade that is determined by multiple factors assessment method can reflect the difference of land quality in the aspect of land location. However, whether it can reflect the difference of land in the economic aspect accurately cannot be known until we validate it by calculating land’s rank revenue. This paper chooses rented shop as the study object. By determining sample price, we can verify the correctness of commercial land grade. After examining, correcting the sample price, the average sample price could be obtained from the statistical results(Table 1).
We verify the land grade through two methods, which are the calculating land rank revenue and the grading by market trading price. It thoroughly proves that the rudiment land grade reflects the difference of the land quality in the aspects of location, and economy. So we can say that the commercial land grading of the urban area of Wuhan City is reasonable.

5 Conclusion

By using GIS, the system provides a effective method for urban land grading. Adopting the idea of building template and designing relevant data structure can make this system more agile, more universal and more practical. It overcomes the disturbance of the optional and subjective in traditional methods. This system has the function of analysis, statistics and query. This system can also be applied to updating the land grading. The result of test area are reasonable through the system.

In the future, this system can be developed in network. It can use WebGIS to receive the basic data more timely and more exactly, and provide the inquiry function more conveniently and more quickly. It can contribute more to the "Digital City".

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