Construction of smart city evaluation system based on big data

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Abstract. Big data makes data sharing possible. The existing database of the government management can realize efficient interconnection, greatly improve the collaborative office capacity of all departments of the government, improve the efficiency of serving the people, and greatly reduce the cost of government management. The most important thing is to provide strong support for government decision-making. His continuous "wisdom" will promote the smart city to be more intelligent and more intelligent. Scientific and more efficient goal. Based on the principle of wisdom, this paper first analyzes and selects 25 important indicators from the four aspects of environment, economy, society and population to establish the indicator system of sustainable urban development; then establishes the evaluation model of urban intelligent growth, and uses the size of the comprehensive index to measure the degree of urban development wisdom. Taking Xi'an as an example, the comprehensive index of the city based on the current development plan is obtained by using the urban smart growth evaluation model, and a new development plan is made for the city by using the urban smart growth evaluation model.

1. Introduction

In recent years, science and technology have driven the rapid development of major industries, which has further promoted the optimization of the national economic system, and the development of cities is more intelligent. At present, the construction of smart city is still in exploration and practice, especially in the study of smart city evaluation, the evaluation dimension is not comprehensive, scientific and practical. Therefore, it is an urgent problem to establish a reasonable evaluation index system for sustainable urban development.
2. Establishment of evaluation index system of sustainable development city

2.1. establishment of evaluation index of urban environmental index

2.1.1. Urban greening: City greening is presented by per capita green area and percentage of greenery coverage, which reflects the urban environmental level. Urban per capita green area is the per capita of urban green area.

\[
S_G = \frac{S_a}{T} \\
S_G = \frac{S_a}{T} \times 100\% \tag{2}
\]

2.1.2. The water in the urban sewer. Wastewater utilization rate (Rw) represents the rate between wastewater re-used in the productive technology after disposing and total wastewater. The formula is as followed:

\[
R_w = \frac{V_{af}}{V} \times 100\% \tag{3}
\]

2.1.3. City environment. City environment includes water quality index, air index and environmental noise standard, which is to measure whether the urban has the standards of good city environment.

2.1.4. Urban waste. Urban waste reflects the ability to purified the pollutants of the urban and the negative effects to the environment. The treatment rate of hazardous waste harmless (\( \Phi_t \)) refers to the percentage of disposal of urban living garbage in the total amount of urban living garbage produced.

\[
\Phi_t = \frac{V_t}{V_h} \times 100\% \tag{4}
\]
2.2. **Buildup urban economic index**

2.2.1. **Economic aggregate.** The Gross Domestic Product includes the Gross Domestic Product for the year. Annual gross product includes gross domestic product and gross national product in this year. Per capita gross product refers to the value that per capita takes up in the total gross product.

\[ G_P = \frac{GDP}{T} \tag{5} \]

2.2.2. **Industrial structure.** The industrial structure reflects the structure of the urban economy, and gets the tendency and range of the economy development. The industrial structure includes the proportion between the production value of main industries in this area and the production value of this industry.

\[ \phi_{si} = \frac{G_{si}}{G_s} \tag{6} \]

2.2.3. **Economy and trade.** Economic and trade show town ability of foreign trade, and objectively reflect the production capacity of the town.

2.3. **Build up urban social index**

2.3.1. **Urban scale.** The urban scale is the basic principles to evaluate urbanization. Urban population density \((\rho T)\) refers to the level of population in the urban scope. The proportion of urban area \((\Omega_c)\) refers to the rate between urban area and total area of this region.

\[ \Omega_c = \frac{Sc}{S} \tag{7} \]

\(Sc\) refers to urban area.

The rate of construction in urban area \((\Omega_b)\) refers to in this area the construction takes up in the total area of this region.

\[ \Omega_b = \frac{Sb}{S} \times 100\% \tag{8} \]

\(Sb\) refers to construction takes up in the this region.

2.3.2. **Urban traffic.** Urban traffic reflects the schedule and profundity of the urbanization. The rate between public transport and rail transit \((\Omega_{tp})\) refers to the value of public transport capacity and rail transit capacity.

\[ H = \frac{H_g}{H_{gui}} \tag{9} \]

Per capital road area \((S_{rp})\) refers to per person has road area according to the calculating urban population.

\[ S_{rp} = \frac{Sr}{T} \tag{10} \]

2.3.3. **Urban consumption.** Urban consumption mainly includes electricity, gas consumption and water consumption, which objectively reflects the consumption of the city and then gets the schedule of the urbanization of the community.

2.4. **Buildup urban population index**

2.4.1. **Population scale.** Population scale is the basic condition of urbanization of population. The proportion of urban population refers to the rate of urban population taking up in the total population.

\[ \phi_c = \frac{Tc}{T} \tag{11} \]
Per capital road area ($S_{rp}$) refers to per person has road area according to the calculating urban population.

$$S_{rp} = \frac{S_r}{T}$$

(12)

2.4.2. Population quality. Population quality is mainly manifested in the physical and mental health and education levels, which includes the body quality of population and cultural qualities of the population.

$$\varnothing_s = \frac{T_s}{T} \times 100\%$$

(13)

2.5. Calculating model of each grading evaluation index

2.5.1. The calculating model of 4-grade index. Index $O_i$ is also called subindex, which is the basement of building up evaluation index system. The formula is as followed.

$$O_i = \frac{C_i}{S_i}$$

(14)

$O_i$: refers to the evaluation index value of one of 4-grade index

$C_i$: refers to evaluation standard value of one of 4-grade index

$S_i$: refers to the present value or planning value of one of the 4-grade index selected by the evaluation purpose.

2.5.2. The model of calculating 3-grade index. 3-grade index $O_1$ is calculated by arithmetic mean value of each 4-grade index value, the formula is as followed:

$$V_i = \sum_{i=1}^{n} \frac{O_i}{m}$$

(15)

$V_i$: refers to 3-grade index

$m$: refers to number of terms of evaluation index value of 4-grade index

$O_i$: refers to evaluation index value of 4-grade index.

2.5.3. The calculating model of 2-grade index. To do gathering evaluation to different kinds of indexes in elements in the same class evaluation, the first one is to add the each 3-grade index according to their respective weight, and the sum index is the secondary index, represented by $O_i$.

$$O_i = \sum_{i=1}^{n} W_i \times V_i$$

(16)

2.5.4. Calculating the comprehensive index. Comprehensive index is obtained by adding each respective weight based on the indexes at all levels. It can be showed by EQI, which can reflect objectively the level of smart growth of this city. The formula is as followed:

$$EQI = \sum_{i=1}^{n} W_i \times U_i$$

(17)

$U_i$: refers to 2-grade evaluation index

$W_i$: refers to the weight of 2-grade index.

2.5.5. The confirmation of weight value of 2-grade and 3-grade index. Adopting analytic hierarchy process to determine the weight value of kinds of index.

Analytic hierarchy process decomposes the comprehensive problems into component element, and group these elements according to the dominance relation and then form the hierarchical structure. By the way of comparison, it can determine the relative importance of each element, and make the comprehensive judgement, finally determine the general ranking of relative importance. It can be carried out by four steps.
### 2.6. Grading of the comprehensive index

The numerical value of comprehensive index doesn’t have the figurative meaning, and it should define the meaning of a series of value to express the meaning of the figure. According to the index classification method, it designs a multi-grading index.

### Table 2. Composite index classification

| Classification | Index value | Reviews       |
|----------------|------------|---------------|
| 1              | >1.5       | developed     |
| 2              | 0.80-1.50  | More developed|
| 3              | 0.50-0.79  | Less developed|
| 4              | 0.30-0.49  | Underdeveloped|
| 5              | <0.30      | Very underdeveloped|

### 3. The application of sustainable urban evaluation metric system

#### 3.1. The confirmation of research object

**3.1.1. The resource of data.** The sample cities development plan and growth plan based on the collected data from Minneapolis.

**3.1.2. Analysis and result.** The growth plan and development plan in xi’an can be calculated by the above model. The comprehensive index of current growth plan in xi’an

\[ EQI = \sum_{i=1}^{4} W_i \times U_i = 0.79 \]  

**The comprehensive index of adjusted future development plan in xi’an**

\[ EQI = \sum_{i=1}^{4} W_i \times U_i = 0.88 \]  

The comprehensive index of future development plan in the city are both more than comprehensive index of current growth plan. Thus we can get that based on the established urban sustainable development metric system, the future development plans in xi’an are effective.

#### 3.2. Setting out and estimating the growth plan

**3.2.1. Problem analysis.** The general impact is mainly to limit growth and hinder economic opportunities, mainly affected by the following indicators:  \( s_g, G_P, M, s_{rp}, \Omega_{tp}, \Omega_c \).

**3.2.2. Establishing optimization model of comprehensive index.** According to the variation coefficient caused by influential element, we can get the following model.

\[ \text{mas}(EQI) \]
For Xi’an City, the optimal solution is obtained by MATLAB.
$$s_g = 14.1, G_p = 8571, M = 359, s_{rp} = 28.4, \Omega_{rp} = 58.2, \Omega_c = 50.83$$

### 3.3. Evaluation index ranking of improved smart plan based on research object

Based on the smart development plan made above, many indicators need to be developed, but we need to make clear what the first and most important development indicators are, which is conducive to the city's more orderly implementation of smart plan. Therefore, the entropy method is used to rank each of the redesigned intelligent growth plans from the most potential to the least potential.

#### 3.3.1. Improved entropy method

Supposing that there are n indexes, m cities, it will form a the original data matrix $X = (X_{ij})_{m,n}$. For index $X_j$, the gap of index value $x_{ij}$ wider, it means this index take a more important effect in the comprehensive evaluation, the smaller the vice. If the index value of some index are equal, it means this index takes no effect in the comprehensive evaluation.

#### 3.3.2. Priority Indicator Ranking

Based on the improved entropy method, the most urgent development indicators of Xi'an are listed in Table 3:

| Index ranking | Index name          |
|---------------|---------------------|
| 1             | Gross domestic product |
| 2             | Green area per capita |
| 3             | Green coverage       |
| 4             | GDP per capita       |

There are GDP, per capita green area, green coverage, per capita GDP, etc. The important indicator of Xi'an's development is GDP. Xi'an focuses on the economic development of the whole city, and also on sustainable development. However, its economic foundation is general, and development needs a certain time to accumulate capital.

### 4. Model evaluation

The evaluation index system of smart city proposed in this paper is a comprehensive system evaluation problem, involving all kinds of multi factor indexes. The model built on the existing methods is practical and easy to be applied in real life. Excluding the interference of unstable factors, this model well evaluates the ability of sustainable development of cities, and clearly reflects the impact of 25 indicators on sustainable development of cities. For the evaluation system of the development of smart city established in this paper, Xi'an City in Western China is selected for evaluation, and compared with the actual situation, it is proved that the evaluation index system constructed in this paper is feasible and can be used for the evaluation of smart city in China.

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