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Construction and application of smart city development evaluation index system

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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 Introduction.*

Keywords: *smart city, evaluation, index system.*

1. Introduction

Smart city aims at serving the people all the time, efficient and orderly urban governance, open, inclusive and shared data, green and open source economic development, and clear Cyberspace Security. Through system planning, information leadership, reform and innovation, smart city promotes the deep integration and iterative evolution of the new generation of information technology and urban modernization, so as to realize the new ecology of coordinated development between the country and the city[1]. At present, smart city construction is still in exploration and practice. How to evaluate the degree of smart city construction? What dimensions need to be evaluated? In the current research, it needs to be solved urgently[2]. Therefore, the establishment of local urban smart construction evaluation system according to local conditions has become an urgent problem to be solved.

2. Establishment of evaluation index system of sustainable development city

Firstly, the evaluation index system of urban sustainable development is constructed based on the research, as shown in Figure 1.

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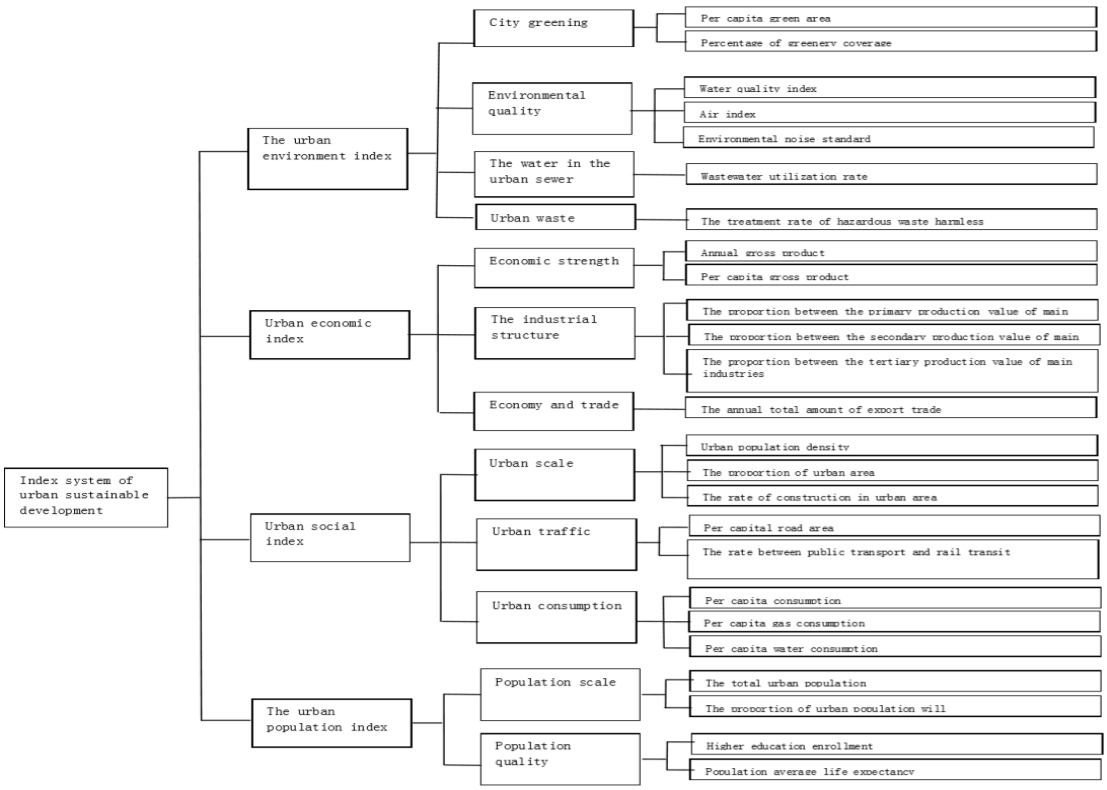

Figure 1: Index system of sustainable development city

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.

$$S_g = \frac{S_a}{T} \tag{1}$$

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

2.1.2. The water in the urban sewer

Wastewater utilization rate (R_w)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 purify the pollutants of the urban and the negative effects to the environment. The treatment rate of hazardous waste harmless ($\emptyset_t$)refers to the percentage of disposal of urban living garbage in the total amount of urban living garbage produced.

$$\emptyset_t = \frac{V_s}{V_h} \times 100\% \tag{4}$$

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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.

$$\emptyset_{si} = \frac{G_{si}}{G_s} \tag{6}$$

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. ifgUrban population density(ρ_T) refers to the level of population in the urban scope. The proportion of urban area (Ω_c) refers to the rate between urban area and total area of this region.

$$\Omega_c = \frac{S_c}{S} \tag{7}$$

ΩS_c refers to urban area.

The rate of construction in urban area (Ω_{tp}) refers to in this area the construction takes up in the total area of this region.

$$\Omega_b = \frac{S_b}{S} \times 100\% \tag{8}$$

S_b refers to construction takes up in 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(Ω_{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.

$$S_{rp} = \frac{S_r}{T} \tag{10}$$

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[3].

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.

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$$\emptyset_c = \frac{T_c}{T} \tag{11}$$

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

$$S_{rp} = \frac{S_r}{T} \tag{12}$$

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.

$$\emptyset_s = \frac{T_s}{T} \times 100\% \tag{13}$$

2.5. Calculating model of each grading evaluation index

2.5.1. The calculating model of 4-grade index

Index Oi is also called subindex, which is the basement of building up evaluation index system. The formula is as followed.

$$O_i = \frac{C_i}{S_i} \tag{14}$$

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_i is calculated by arithmetic mean value of each 4-grade index value, the formula is as followed:

$$V_i = \sum_{i=1}^{n} \frac{O_i}{m} \tag{15}$$

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

$$O_i = \sum_{i=1}^{n} W_i \times V_i \tag{16}$$

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 o with of this city. The formula is as followed:

$$EQI = \sum_{i=1}^{n} W_i \times U_i \tag{17}$$

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

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comprehensive judgement, finally determine the general ranking of relative importance. It can be carried out by four steps,as shown in Table 1.

Table 1. Index weight at all levels

The weight of the index	Weight value	The weight of the index	Weight value	The weight of the index	Weight value	The weight of the index	Weight value
Evaluation Metric of urban environment index	0.81	urban economic index	0.39	Urban social index	0.23	Urban Population index	0.20
City greening	0.21	Economic aggregate	0.44	Urban scale	0.36	Population scale	0.60
City environment	0.31	Industrial structure	0.29	Urban traffic	0.33	Population quality	0.40
The water in the urban sewer	0.26	Economy and trade	0.27	Urban consumption	0.31		
Ueban waste	0.22						

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, as shown in Table 2.

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	Under developed
5	<0.30	Very under developed

3. Establishment of evaluation index system of sustainable development city

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.

$$EQI = \sum_{i=1}^{4} W_i \times U_i = 0.79 \tag{18}$$

The comprehensive index of adjusted future development plan in xi'an

$$EQI = \sum_{i=1}^{4} W_i \times U_i = 0.88 \tag{19}$$

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.

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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}、 Ω_{tp}、 Ω_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.

$$max(EQI) \tag{20}$$

$$s.t.\begin{cases} S_g \quad 12.3 < S_g < 14.8 \\ G_p \;\; 8124 < G_p < 8700 \\ M \;\; 288 < M < 386 \\ S_{rp} \;\; 22.2 < S_{rp} < 31. \\ \Omega_{rp} \; 50.9 < \Omega_{rp} < 60.12 \\ \Omega_c \;\; 47.41 < \Omega_c < 51.83 \end{cases}$$

For Xi'an City, the optimal solution is obtained by MATLAB.

$s_g = 14.1, G_P = 8571, M = 359, s_{rp} = 28.4, \Omega_{tp} = 58.2, \Omega_c = 50.83$

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 clarify the first and most important development indicators, which is conducive to the more orderly implementation of the smart plan in the city. Therefore, the entropy method is used to rank each plan in the redesigned intelligent growth plan 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. Basic steps of entropy method

The first step is to quantify each index in the same degree and calculate the index value proportion of the i-th city under index p_{ij}:

$$p_{ij} = x_{ij} / \sum x_{ij} \tag{21}$$

The second step is to calculate the entropy of the j-th index e_j : $e_j = -k\sum p_{ij} \ln p_{ij}$, order $k = 1/\ln m$,then

$$e_j = -(1/\ln m)\sum p_{ij} \ln p_{ij} \tag{22}$$

The third step is to calculate the difference coefficient of the j-th index g_j . The smaller the entropy, the greater the difference between indicators, and the more important the indicators are:

$$g_j = 1 - e_j \tag{23}$$

The fourth step: weight a_j :

$$a_j = {a_j}\Big/{\sum_{j=1}^{n} g_j} \tag{24}$$

3.3.3. Priority ranking of key indicators

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

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Table 3. Index ranking

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.

5. Conclusion

Over the past 30 years of reform and opening up, China's urbanization construction has made remarkable achievements[4]. Especially after entering the 21st century, the pace of urbanization construction has been accelerating, and tens of millions of rural people enter cities every year. With the continuous expansion of urban population, "urban disease" has become the primary problem perplexing the construction and management of various cities. Problems such as resource shortage, environmental pollution, traffic congestion and potential safety hazards have become increasingly prominent. In order to solve the dilemma of "urban disease", smart city came into being. As smart cities comprehensively adopt a new generation of information technology, including RF sensing technology, Internet of things technology, cloud computing technology and next-generation communication technology, they can effectively solve the problem of "urban disease". The application of these technologies can make the city easier to be perceived and the urban resources easier to be fully integrated. On this basis, it can realize the fine and intelligent management of the city, so as to reduce resource consumption, reduce environmental pollution, solve traffic congestion, eliminate potential safety hazards, and finally realize the sustainable development of the city.

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