

## ORIGINAL RESEARCH ARTICLE

# Study on the construction index system of ecological garden city in Suihua

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## ABSTRACT

Ecological garden city is a healthy and harmonious urban development model. A set of urban comprehensive evaluation index system is established, including 3 primary indexes and 18 secondary indexes. The weight of each index is determined by entropy method. The statistical results show that the construction level of ecological garden city in Suihua City in 2016 is at a medium level. This paper analyzes the problems existing in the construction of ecological garden city in Suihua City, Heilongjiang Province, and puts forward corresponding countermeasures to provide reference for the construction of ecological garden city in Suihua City.

**Keywords:** ecological garden city; index system; urban construction

## 1. Introduction

With the continuous acceleration of China's urbanization process, urban ecological environment problems continue to appear. Ecological garden city is a healthy urban development model to improve urban living environment<sup>[1]</sup>. At the same time, ecological garden city is also an urban development model with Chinese characteristics<sup>[2]</sup>. In 2004, the Ministry of construction took the creation of "ecological garden city" as the phased goal of building an ecological city<sup>[3]</sup>. The creation of ecological garden city is a long-term and complex work, and it is necessary to establish a set of objective and applicable comprehensive evaluation index system of ecological garden city<sup>[4]</sup>. The quantitative evaluation of ecological garden city by using the evaluation index

system can judge the problems existing in the construction of ecological garden city and point out the direction and focus of the future construction of ecological garden city. Taking Suihua City of Heilongjiang province as the research area, this paper evaluates the construction level of ecological garden city in Suihua City in 2016, analyzes the problems existing in the research and construction of ecological garden city in Suihua City, and puts forward solutions, so as to provide reference for the construction of ecological garden city.

## 2. Overview of the study area

Suihua is located in the Songnen Plain in the south central part of Heilongjiang Province, with a total area of 34,338 km<sup>2</sup>, a current population of 5.8 million, a forest area of 12 million mu and a forest

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coverage rate of 19.2%. The region is rich in agricultural resources. It is an important agricultural city in Heilongjiang Province, a green industry and modern agricultural service base, an ecologically livable city characterized by cold black soil culture and a pastoral green city. In 2009, Suihua proposed to create an ecological garden city, highlighting the construction of urban landscaping, green space and roads. The per capita public green space area reached 10 m<sup>2</sup>, all the main roads in the urban area were afforested, and the greening coverage rate of counties (cities) and districts reached 40%. In 2011, West Lake Park and forest botanical garden were built. The West Lake Park covers an area of 344 hectares and the botanical garden covers an area of 725 ha, with a greening coverage rate of more than 85%.

### 3. Construction of evaluation index system

The selection of evaluation indicators mainly refers to relevant specifications<sup>[5]</sup>, such as national

ecological garden city standard, national ecological city standard, assessment indicators of national ecological demonstration areas and assessment indicators of national environmental protection model cities. Level I indicators include urban ecological environment indicators, urban living environment indicators and urban infrastructure indicators; remove the indicators that are difficult to obtain data from the secondary indicators, and determine the corresponding contents in combination with the actual situation of Suihua City. Suihua is an agricultural city with few types of industrial departments and relatively good natural ecological environment, which provides an important foundation for the construction of ecological garden city; in 2009, Suihua was rated as the top ten happiest cities in China. Urban infrastructure indicators were added to the index system of ecological gardens to make citizens' life more convenient and happier. Therefore, 18 indicators such as green space, park, road, heating and water supply are mainly selected as secondary indicators. See **Table 1** for details.

**Table 1.** Evaluation index system of ecological garden city construction in Suihua City

Primary index	Secondary index
Urban ecological environment	Number of comprehensive parks (pcs.)
	Botanical garden area (ha)
	Per capita public green space area (m <sup>2</sup> /person)
	Urban greening coverage (%)
	Per capita park green space area (m <sup>2</sup> /person)
Urban living environment	Free opening rate of the park (%)
	Compliance rate of drinking water source (%)
	Centralized sewage treatment rate (%)
	Harmless treatment rate of domestic waste (%)
	Comprehensive utilization rate of straw (%)
	Days with good air quality (days)
Urban infrastructure	Excellent rate of air quality (%)
	Tap water penetration rate (%)
	Intact rate of urban road construction (%)
	Municipal infrastructure investment (100 million yuan)
	Average speed of main and secondary roads (km/h)
	Number of hospital beds owned by 10,000 people (piece/10,000 people)
	Urban central heating penetration rate (%)

## 4. Data source and processing

### 4.1. Data sources

Most of the quantitative analysis data used in the article are from the statistical yearbook of Sui-

hua City in 2016, the statistical bulletin of national economic and social development of Suihua City in 2016, the 13th Five-Year Plan for national economic and social development of Suihua City and the work report of Suihua Municipal Government. The original data are used for evaluation.

## 4.2. Data processing

Since the types and sources of the factor data of each evaluation index are different, it is necessary to use the extreme value standardization method to process the original data, and then compare them after processing, so that the original data can be standardized into data between (0–1), which has comparability. The calculation formula is as follows:

Positive indicators:

$$S_i = \frac{M_i - M_{\min}}{M_{\max} - M_{\min}} \quad (1)$$

Negative indicators:

$$S_i = 1 - \frac{M_i - M_{\min}}{M_{\max} - M_{\min}} \quad (2)$$

For positive indicators, the larger the current value of the indicator for negative indicators is the better. That is the smaller the current value of the indicator, the better<sup>[5]</sup>. Where  $M_i$  is the current value of secondary indicators,  $M_{\max}$  is the maximum value of corresponding relevant indicators,  $M_{\min}$  is the minimum value of corresponding relevant indicators, and  $S_i$  is the value after index standardization.

**Table 2.** Classification of ecological garden city

Classification	Score	Evaluation description
1	0.9–1.0	The construction level of ecological garden city is very high
2	0.8–0.9	The construction level of ecological garden city is high
3	0.7–0.8	The construction level of ecological garden city is medium
4	0.6–0.7	The construction level of ecological garden city is low
5	<0.6	The construction level of ecological garden city is very low

## 4.3. Calculate the weight by entropy method

Calculate the proportion of index  $i$  under index  $j$  in this index:

$$p_{ij} = \frac{X_{ij}}{\sum_{i=1}^n X_{ij}}, \quad i=1, \dots, n, \quad j=1, \dots, m$$

(3)

Calculate the entropy of index  $j$ :

$$e_j = -k \sum_{i=1}^n p_{ij} \ln(p_{ij})$$

(4)

Calculate the weight of each index:

$$w_j = \frac{d_j}{\sum_{j=1}^m d_j}$$

(5)

Calculate the comprehensive score of each index:

$$S_i = \sum_{j=1}^m w_j \cdot p_{ij} \quad (6)$$

By comparing with the National Ecological Garden City Standard (Provisional) and the National Ecological City Standard, and referring to the classification methods of various comprehensive indexes at home and abroad, the five-level classification standard is adopted to classify the construction level of ecological garden city, as shown in **Table 2**<sup>[6]</sup>.

## 5. Results and analysis

Through the application of extreme value standardization method and entropy method, the evaluation values of primary and secondary indicators of ecological gardens in Suihua are shown in **Tables 3–5**.

**Table 3.** Current situation and evaluation value of secondary indicators of ecological garden city in Suihua in 2016

Secondary index	Standard value/reference value	Current value	Evaluation value (0–1)
Number of comprehensive parks (pcs.)	10	20	1.000
Botanical garden area (ha)	400	725	1.000
Per capita public green space area (m <sup>2</sup> /person)	100	57	0.566
Per capita park green space area (m <sup>2</sup> /person)	120	84	0.700
Free opening rate of the park (%)	950	1,000	1.000
Urban greening coverage (%)	450	312	0.693
Centralized sewage treatment rate (%)	700	500	0.714
Comprehensive utilization rate of straw (%)	900	720	0.800
Days with good air quality (days)	2,920	3,200	1.000
Excellent rate of air quality (%)	850	849	0.998
Compliance rate of drinking water source (%)	960	870	0.906
Harmless treatment rate of domestic waste (%)	900	500	0.556
Tap water penetration rate (%)	1,000	900	0.900
Urban central heating penetration rate (%)	650	850	1.000
Intact rate of urban road construction (%)	950	820	0.863
Municipal infrastructure investment (100 million yuan)	1,568	1,169	0.746
Average speed of main and secondary roads (km/h)	400	400	1.000
Number of hospital beds owned by 10,000 people (piece/10,000 people)	900	700	0.778

**Table 4.** Evaluation value of primary index and weighted value of secondary index of ecological garden city in Suihua City in 2016

Primary indicator name	Evaluation value of primary index (0–1)	Secondary index	Weighted evaluation value of secondary index (0–1)
Urban ecological environment	0.291	Number of comprehensive parks	0.180
		Botanical garden area	0.180
		Per capita public green space area	0.138
		Urban greening coverage	0.180
		Per capita park green space area	0.154
		Free opening rate of the park	0.154
Urban living environment	0.295	Centralized sewage treatment rate	0.156
		Comprehensive utilization rate of straw	0.164
		Days with good air quality	0.205
		Excellent rate of air quality	0.204
		Standard rate of drinking water source	0.163
		Harmless treatment rate of domestic waste	0.109
Urban infrastructure	0.414	Tap water penetration rate	0.208
		Urban central heating penetration rate	0.187
		Intact rate of urban road construction	0.152
		Municipal infrastructure investment	0.143
		Average speed of main and secondary roads	0.187
		Number of hospital beds per 10,000 people	0.157

**Table 5.** Comprehensive evaluation value and weighted value of primary indicators of ecological gardens in Suihua City in 2016

Comprehensive index	Comprehensive evaluation value	Primary indicator name	Primary index weight	Evaluation value (0–1)	Weighted evaluation value
Construction level of ecological garden city in Suihua	0.771	Urban ecological environment	0.327	0.873	0.333
		Urban living environment	0.328	0.872	0.334
		Urban infrastructure	0.332	0.868	0.332

It can be seen from **Table 5** that the evaluation value of the first level index of Suihua ecological garden city is 0.771, and the evaluation values of the three second level indexes of urban ecological environment index, urban living environment index and urban infrastructure index are 0.873, 0.872 and 0.868 respectively. The evaluation values of the three secondary indicators are not much different, and the evaluation values of the urban ecology and living environment indicators are relatively high. The index values of urban ecology and living environment are relatively high, indicating that the ecological environment of Suihua City is in good condition. The suburban greening, shelterbelt, farmland, water surface and other natural ecological environments outside the city are connected. The proportion of green space in the city is increased, and the green space in roads and residential areas are greened.

The index values of urban ecology and living environment are relatively high, indicating that the ecological environment of Suihua City is in good condition. The suburban greening, shelterbelt, farmland, water surface and other natural ecological environments outside the city are connected. Through the green space pattern of “ten gardens, seven belts, six points and one ecological ring”, the proportion of green space in the city is increased, and the green space in roads and residential areas are greened. Shape and linear green space, form an urban green space system combining point, line and surface, and comprehensively improve the urban ecological environment of Suihua City. The index value of urban infrastructure construction in the second-level index is slightly lower, indicating that Suihua City should increase urban infrastructure construction in the future construction of ecological garden city, which is directly related to the overall economic development level of Suihua City. However, in recent years, Suihua City has also increased investment in infrastructure construction, investing 56 million yuan in the centralized transformation of the city’s secondary water supply, gradually canceling the self-provided wells in the community, and canceling the secondary water supply. Invest

RMB 180 million to build a 36,000 m<sup>2</sup> film and television center on the north side of Fugan. Community and on the west side of the Science and Technology Museum. Invest RMB 30 million to build a foreign investment service center in the development zone. However, due to the long-term nature of ecological garden city construction and the long-term formation of ecological effects, the living environment and infrastructure construction of ecological garden construction in Suihua need to be improved, the infrastructure construction needs to be further optimized, and the living environment needs to be further improved.

## 6. Conclusions and discussion

### 6.1. Conclusions

The comprehensive evaluation value of Suihua’s urban ecological garden construction level in 2016 was 0.771, and the evaluation values of its urban ecological environment, urban living environment and urban infrastructure were 0.873, 0.872, and 0.868, respectively. According to the construction level grading table, the ecological garden construction level of Suihua City is C-level. Judging from the evaluation results, the level of ecological garden construction in Suihua City is moderate, which is also in line with the current actual situation in Suihua City, and there is still a certain gap with the construction target of Grade A (over 0.9 comprehensive evaluation value). The evaluation value of the 3 first-level indicators is above 0.8, and only 8 of the 18 second-level evaluation indicators (per capita public green space area, per capita park green space area, urban green coverage rate, centralized sewage treatment rate, domestic waste, the evaluation value of harmless treatment rate, municipal infrastructure investment, and number of hospital beds per 10,000 people) is below 0.8, the indicators are all positive indicators, so in general, the scores of each indicator are relatively high.

### 6.2. Discussion

The indicators selected in the index system are

objective indicators, lacking subjective indicators and the selection of dynamic evaluation indicators. The goal of ecological garden city is not static, but developing and changing with the development of society. The indicators should not only reflect the construction level of the ecological garden city at a certain point, but also reflect the dynamic development and evolution trend of the ecological garden city<sup>[7]</sup>. Suihua is a plain city with no landscape resources and no unique advantages in urban landscape. Therefore, in the future research, from the perspective of ecological aesthetics, we will investigate whether the citizens are satisfied with the current ecological environment beauty of Suihua by constructing subjective indicators such as public satisfaction with urban gardens, architectural landscape beauty, urban central area landscape beauty, community landscape beauty and city appearance<sup>[8]</sup>, and put forward reasonable measures to increase the beauty of urban ecological environment. In the future research, the selection of subjective and dynamic indicators shall be added, the dynamic point of view shall be used to analyze the problem, and the subjective and objective indicators shall be combined.

## **7. Countermeasures**

### **7.1. Carry out reasonable urban planning and adjust urban land use**

In the new urban master plan of Suihua City, urban land is organized with the north-south “ecological axis” and the east-west “humanity axis” as the main axes, and the urban master plan is partially adjusted to better improve the efficiency of land use and increase the number of parks and green spaces along the street. In the urban long-term layout structure, the central urban area continues the overall structure of “one city and six groups”, and continues to adjust the urban land in the future urban construction to provide a basic guarantee for the construction of an ecological city.

### **7.2. Strengthen the construction of urban green space system and create a beautiful**

### **urban landscape**

In 1997, Suihua City proposed to implement the “Suihua Green Corridor Project”. 2009 is the year of urban greening.

### **7.3. Increase investment in environmental protection and improve urban infrastructure construction**

Suihua City has strengthened the hardening of urban roads, focused on breaking through the broken road, highlighted the greening of main roads and squares, strengthened the greening of courtyards and communities, implemented all-weather cleaning of urban environmental sanitation, strengthened garbage removal and transportation, and strengthened the sanitation management of squares and parks.

## **Conflict of interest**

The authors declare no conflict of interest.

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