Study on Evaluation of Eco-city Construction Based on Sustainable Development

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Abstract. According to the local development plan of Edinburgh, this paper establishes the evaluation system of ecological city construction, and combines the statistical data of 2014-2018, and uses the analytic hierarchy process and entropy weight method to calculate the index weight. The comprehensive evaluation of urban ecological construction in Edinburgh is carried out by the method of “model and sum”. The results show that the construction of ecological city in Edinburgh has shown an upward trend from the publication of the manuscript of local development plan in 2014, in which the construction effect has increased significantly from 2016 to 2017, and the evaluation value has reached the highest point. And then 2018 appeared a downward trend. Finally, on the basis of the evaluation of its implementation, discusses the enlightenment to the construction of ecological city and the realization of sustainable development in China.

1. Introduction
At present, ecological civilization construction has become a national strategy in China. Faced with the tradeoff between development and protection, the vast majority of cities regard "ecology","green" and "energy saving" as the guiding ideology and development goal of urban construction. Since the "Dongtan Ecological City" in Shanghai in 2005, various regions have started the exploration of eco-city construction. By formulating the guide index system of eco-city construction, the core problems and development assumptions of eco-city construction in this region are reflected. However, the problem of mismatch between planning and implementation is common in the practice of ecological city construction in China. How to make a reasonable index system in line with the actual development of the city and correctly evaluate the actual effect of ecological city construction has become an urgent problem to be solved in the construction of ecological city in China at present.

Taking Edinburgh City as an example, By combing the index framework of local development planning, this paper analyzes the course and characteristics of ecological city construction in this city from the aspects of urban design, environment, economy and employment, housing and community, land use, transportation, energy and waste treatment, in order to provide reference for correctly evaluating the actual effect of ecological city construction in China.
2. Research methodology

2.1. Screening and classification of indicators
According to the framework and specific policy indicators of Edinburgh Local Development Plan, combined with the main dimensions of urban construction and the main direction of ecological city development, the indicators are divided into seven main target items: urban design, environment, economy and employment, housing and community, land use, transportation, energy and waste treatment. At the same time, the final evaluation index system of Edinburgh urban ecological construction is formed by combining the corresponding index items of each project, and selecting the index items which can quantitatively reflect the implementation of the target items, as shown in Table 1.

| Target                      | Indicator items                                      |
|-----------------------------|------------------------------------------------------|
| Urban design                | Public satisfaction with landscape                   |
|                             | Public Satisfaction with New Buildings               |
|                             | Building energy efficiency                           |
| Environment                 | Investment Construction Open Space Expenditure       |
|                             | Investment in outdoor sports facilities              |
|                             | Proportion of surface water above good               |
| Economy and employment      | Tourism investment                                   |
|                             | Number of enterprises associated with leading industries |
|                             | Industrial and Commercial Land Supply Area           |
|                             | Unemployment rate                                    |
| Housing and communities     | Housing construction                                 |
|                             | Diversity of occupants                               |
|                             | Social benefits of housing design                    |
|                             | Proportion of residents with green space within 5 minutes |
|                             | Proportion of affordable housing                     |
|                             | Number of Roma population sites planned              |
| Land use                    | Agricultural land area                               |
|                             | Proportion of green space                           |
| Traffic                     | Public Transport Satisfaction                        |
|                             | Green travel ratio                                   |
| Energy and waste management | Renewable energy supply ratio                        |
|                             | Waste recovery                                       |

2.2. Index layer calculation

2.2.1. Grey Correlation Analysis of Frame Indicators.
The grey correlation method is used to analyze the importance of each index to the ecological city. Taking unit GVA carbon emission as the target value of ecological city, this value excludes the
income and carbon emission from non-national factors compared with unit GDP carbon emission, and more scientifically reflects the actual economic development, ecological environment and the overall development of national life.

2.2.2. Determination of Weight of Index Layer by Entropy Weight.
Because the influence degree of each index selected in the model on the construction of ecological city is different, it is necessary to determine the weight. Because the indicators selected in this model construction involve many systems and elements, the AHP analytic hierarchy process is chosen. Each index layer under each target layer is calculated by entropy method, and the comprehensive weight of each index item can be obtained by AHP-entropy method, as shown in Table 2.

Table 2. Consolidated weights for indicators.

| Target                        | Weight | Indicator items                                      | W(before weighting) | We*  |
|-------------------------------|--------|-----------------------------------------------------|----------------------|------|
| Urban design                  | 3.50%  | Public satisfaction with landscape                  | 29.59%               | 1.04%|
|                               |        | Public Satisfaction with New Buildings              | 33.25%               | 1.16%|
|                               |        | Building energy efficiency                          | 37.16%               | 1.30%|
| Environment                   | 19.42% | Investment Construction Open Space Expenditure      | 26.19%               | 5.09%|
|                               |        | Investment in outdoor sports facilities             | 43.92%               | 8.53%|
|                               |        | Proportion of surface water above good              | 29.89%               | 5.80%|
| Economy and employment        | 5.97%  | Tourism investment                                  | 40.44%               | 2.41%|
|                               |        | Number of enterprises associated with leading industries | 12.31%            | 0.73%|
|                               |        | Industrial and Commercial Land Supply Area          | 30.28%               | 1.81%|
|                               |        | Unemployment rate                                   | 16.98%               | 1.01%|
| Housing and communities       | 8.61%  | Housing construction                                | 21.12%               | 1.82%|
|                               |        | Diversity of occupants                               | 17.28%               | 1.49%|
|                               |        | Social benefits of housing design                    | 9.11%                | 0.78%|
|                               |        | Proportion of residents with green space within 5 minutes | 16.14%          | 1.39%|
|                               |        | Proportion of affordable housing                     | 17.96%               | 1.55%|
|                               |        | Number of Roma population sites planned             | 18.39%               | 1.58%|
| Land use                      | 9.45%  | Agricultural land area                              | 43.23%               | 4.09%|
|                               |        | Proportion of green space                           | 56.77%               | 5.36%|
| Traffic                       | 18.05% | Public Transport Satisfaction                       | 58.85%               | 10.62%|
|                               |        | Green travel ratio                                  | 41.15%               | 7.43%|
| Energy and waste management   | 34.99% | Renewable energy supply ratio                       | 36.60%               | 12.81%|
|                               |        | Waste recovery                                      | 63.40%               | 22.18%|

*Comprehensive weight
2.3. Target Layer Calculation

Combined with the correlation degree and weight of the index layer mentioned above, the correlation degree between the development of each target layer and the construction of ecological city is obtained. As shown in Table 3, the formula is (1).

\[ Z = \sum_{i=1}^{n} a_i \cdot W_{Ci} \]  

(1)

Z is the correlation degree between the target layer and the ecological city construction, \(a_i\) is the correlation degree of the i index layer, and \(W_{Ci}\) is the comprehensive weight after the third index layer is weighted.

Table 3. Related Table of Target Level Index and Development of Eco-city Construction.

| Target layer          | Urban design | Environment | Economy and employment | Housing and communities | Land use | Traffic | Energy and waste management |
|-----------------------|--------------|-------------|------------------------|-------------------------|----------|---------|-----------------------------|
| Attribute value       | 0.03         | 0.14        | 0.05                   | 0.07                    | 0.07     | 0.16    | 0.32                        |
| Sort                  | 7            | 3           | 6                      | 4                       | 4        | 2       | 1                           |

2.4. Calculation of comprehensive evaluation values

2.4.1. Calculation of Ecological Urban Construction Index.

In this paper, the calculation model of evaluation value of ecological city construction index refers to the calculation model of water safety degree. Because the logarithmic function relation can better reflect the relationship between the index and the evaluation of ecological city construction, the logarithmic function is used to calculate the evaluation value of ecological city construction. The calculation method is suitable for simple index calculation. The calculation model is formula (2).

\[ Y = a + b \log(x) \]  

(2)

a and b are the parameters in the model.

According to the accounting standard of Edinburgh ecological city construction index and the substitution formula (2), the calculation model of bearing capacity of various evaluation indexes of Edinburgh ecological city construction is obtained by establishing the equation, as shown in Table 4.

Table 4. Calculation Model of Evaluation Index for Eco-city Construction in Edinburgh.

| Indicator name                                      | Calculation Model of Evaluation Value of Ecological Construction |
|----------------------------------------------------|---------------------------------------------------------------|
| Public satisfaction with landscape                 | \(y=-1.862+1.431\log x\)                                       |
| Public Satisfaction with New Buildings             | \(y=-1.862+1.431\log x\)                                       |
| Building energy efficiency                         | \(y=-7.248+4.124\log x\)                                      |
| Investment Construction Open Space Expenditure     | \(y=-2.306+0.769\log x\)                                      |
| Investment in outdoor sports facilities            | \(y=0.419+0.6\log x\)                                         |
| Proportion of surface water above good             | \(y=-3.162+2.141\log x\)                                      |
| Tourism investment                                 | \(y=-3.076+0.769\log x\)                                      |
| Number of enterprises associated with leading industries | $y = -22.28 + 6.186 \lg x$ |
| Industrial and Commercial Land Supply Area | $y = -7.806 + 1.661 \lg x$ |
| Unemployment rate | $y = 1.518 - 1.087 \lg x$ |
| Housing construction | $y = -10.268 + 2.294 \lg x$ |
| Diversity of occupants | $y = -1.048 + 1.048 \lg x$ |
| Social benefits of housing design | $y = 18.182 \lg x$ |
| Proportion of residents with green space within 5 minutes | $y = -2.161 + 1.661 \lg x$ |
| Proportion of affordable housing | $y = -0.827 + 1.183 \lg x$ |
| Number of Roma population sites planned | $y = 0.858 \lg x$ |
| Agricultural land area | $y = -32.395 + 6.452 \lg x$ |
| Proportion of green space | $y = -9.102 + 5.682 \lg x$ |
| Public Transport Satisfaction | $y = -1.862 + 1.431 \lg x$ |
| Green travel ratio | $y = -3.096 + 2.096 \lg x$ |
| Renewable energy supply ratio | $y = 0.961 \lg x$ |
| Waste recovery | $y = -1.183 + 1.183 \lg x$ |

2.4.2. Value Calculation of Target Level Assessment.

The evaluation value of ecological construction in the target layer is calculated using the following models:

$$ E = \sum_{i=1}^{n} E_i \cdot W_i $$

(3)

$E$ is the evaluation value of the ecological construction of the target layer, $E_i$ is the value of the $i$ index, the $W_i$ is the weight of the third index, and $m$ is the number of the indicators.

2.4.3. Calculation of comprehensive evaluation values.

Comprehensive evaluation of eco-city construction using the "model and sum" method, namely:

$$ |E| = \left( \sum_{i=1}^{7} W_i \cdot E_i \right)^{1/2} $$

(4)

$|E|$ is the total value of ecological city construction evaluation; $W_i$ is the weight of the $i$ target layer; $E_i$ is the value of the $i$ target layer.

3. Empirical Research

3.1. Evaluation of Eco-city Construction in Edinburgh

From the relevant data on Edinburgh and Scotland, such as Edinburgh by Numbers, Edinburgh People Survey, Housing Land Audit, the data of five years from 2014 to 2018 are counted, and the original values of each index are replaced by the calculation model of the bearing capacity of the specific indexes established in Table 5. The evaluation value of various indexes of ecological city construction in Edinburgh is obtained. According to the weight of each index in the system calculated by analytic
hierarchy process (AHP) and the formula (3), the target layer of Edinburgh ecological city construction is calculated. The results of ecological construction evaluation value are calculated and brought into formula (4), and the results of comprehensive evaluation value of ecological city construction in Edinburgh are obtained, as shown in Table 5. At the same time, the development trend of comprehensive evaluation value of Edinburgh ecological city construction from 2014 to 2018 and the development trend of each target layer are drawn, as shown in figures 1 and 2.

Table 5. Evaluation of Eco-construction in Edinburgh Ecological City.

|                          | 2014 | 2015 | 2016 | 2017 | 2018 |
|--------------------------|------|------|------|------|------|
| Urban design             | 0.837| 0.855| 0.798| 0.728| 0.879|
| Environment              | 0.572| 0.519| 0.472| 0.685| 0.567|
| Economy and employment   | 0.678| 0.550| 0.651| 0.614| 0.589|
| Housing and communities  | 0.670| 0.643| 0.652| 0.671| 0.636|
| Land use                 | 0.331| 0.342| 0.381| 0.446| 0.460|
| Traffic                  | 0.773| 0.758| 0.778| 0.792| 0.790|
| Energy and waste management| 0.636| 0.725| 0.723| 0.720| 0.723|
| Comprehensive Evaluation of Ecological Urban Construction | 0.632| 0.641| 0.644| 0.690| 0.670|

Figure 1. Development trend of each target level of Edinburgh Eco-city Construction, 2014-2018.

Figure 2. Development trend chart of comprehensive evaluation value of ecological city construction in Edinburgh, 2014-2018.
4. Conclusion
Through the study of urban ecological construction in Edinburgh, there are the following conclusions: (1) in the process of ecological city construction, it is of great guiding significance to formulate appropriate index system for construction. At the same time, it can evaluate the implementation more comprehensively and change the direction in time. (2) In the process of ecological construction, the goal of each dimension should be people-oriented. As the cornerstone of urban development, the satisfaction of infrastructure and basic human mobility in the construction is to further enhance the internal environment and external development of the city on the basis of the strong system of urban services and the convenience of citizens' travel and life, and to meet the rigid demand Urban aesthetics beautifies the landscape. (3) The environment still plays an important role in the construction of ecological cities, which to a large extent determines the ecological degree of cities, annexing the construction of natural and artificial environments, especially the attention paid to human activity space in the artificial environment, which can improve the living environment. (4) A city is very affected by the large environment in terms of economy, and the long-term fixed economic development model is vulnerable to the interference of unexpected events and international forms of reversal. It should adjust the model in time and carry out economic transformation to realize the sustainable development of urban economy. At the same time, the city should focus on investment in work to seek sustainable economic growth, add new jobs, strengthen the diversity of employment, develop talent training programs, and ensure the innovation and vitality of pillar industries.

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