



## Research on Eco-City Development Evolution Model with Environmental Protection Idea

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**Abstract:** This paper has considered about the ecological environment, social economic development level and urbanization process etc in Baotou city comprehensively, defined the category of eco-city development pattern suitable for the current development situation of this region; at the same time, to make horizontal comparison, this paper has constructed a set of evaluation index system which takes cities in western ethnic region of China as evaluation objects, made comparative analysis of Baotou city and some cities in this area with adoption of evaluation index system and explored the specific model that should be chosen by Baotou city to develop eco-city based on current economic, social and environmental situation in the whole western ethnic cities.

**Keywords:** Baotou, Eco-city Development Mode, Evaluation System

### 1. Introduction

In recent years, eco-city is always one of the hot subjects of ecology, urban science and other subject researches; it is easy to draw the attention of people to eco-city with the extensive implementation of sustainable development strategy in the worldwide range [1]. China has made exploration and research on this field since last century and has accumulated rich experience and achievements; but till today, the research is still at early phase and lacks integration and system of eco-city theory and technological methods [2]. Research on related fields in the world pays more attention to propose specific solutions for the development issue of one city, this method can handle the problems between eco-city planning and construction in a better way but it puts more focus on making research on local city or one specific question from microscopic angle and lacks comparative analysis of eco-city from the perspective of the whole region. Therefore, it needs to make deep research on eco-city theory from breadth and depth urgently [3]. In view of the city development mode, because the development conditions of the city itself are different; moreover, city development is a process, city at different development stages should have different development modes, eco-city development should not follow single development mode[4-5]. Therefore, it is necessary to further discuss the eco-city development mode suitable for current development status of nature and social economy and presenting city personality and promote sustainable development of regional economy and society.

### 2. Eco-city Development Goal

#### 2.1. Development goal

Figure 1 presents the simple relationship between ecological environment, social civilization, economic development, natural resources and national

development, in which natural resources and national development are subsystems of two bigger systems of ecological environment and social civilization respectively [6-7]. The reason why upgrade natural resources and national development to the same height of other three systems for study is that rich natural resources and ethnic minorities gathering is one of the features of Baotou city and Baotou needs to attach great importance to these two systems in eco-city development [8].

#### 2.2 Basic principles

Cities in western ethnic areas are different in city positioning, size, function, regional background, resource endowment and historical basis etc; in the process of eco-city construction in Baotou city, it is also faced with this problem. The writer believes that different cities should start from reality and based on local conditions in the process of eco-city construction. Eco-city construction needs to handle the dialectical relationship between economic development and maintaining the quality of ecological environment scientifically [9]. First, it needs to follow the principle of adapting to economic and social development [10].

In Figure 2, OA is the line of ecological environment quality, OB is the line of social development level, and OC is the line of economic development level, the further to coordinate origin O, the higher level. OE is the collection of the most advantages of ecological environment quality, social development level and economic development level, the further to coordinate origin O, the higher corresponding social and economic development level [11-12]. Taking O1 point on OE as example, on the points G1 and H1 of social development level and economic development level, ecological environment quality can only adapt to social development level and economic

development level at this point. If the ecological environment quality point is between OF, and then the quality is bad, which will impede the further improvement of social and economic development level; if it is between FA, it means ecological environment quality is higher than social economic development level [13]. The investment in ecological environment exceeds the optimal value that social and economic development level can bear, its economic and social development level is supposed to reach higher level, which is not good for realizing fast and good development and not good for sustainable progress of society either [14-15].

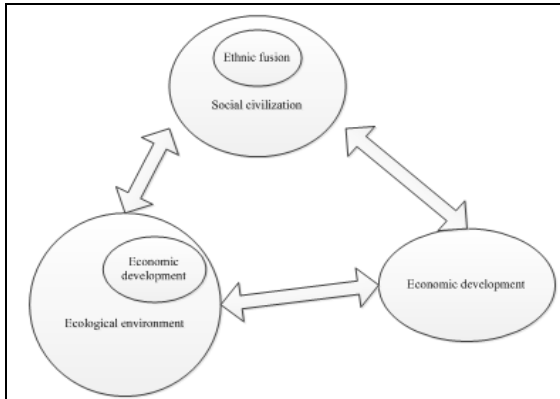


Figure 1: The relationship between the various systems

3. Construction of Evaluation Index System

3.1 Selection of index

Based on comprehensive consideration of nature, society and economy of eco-city construction in western ethnic areas, eco-city evaluation index is finally confirmed after discussing the specific meaning of each possible index on evaluating eco-city

construction in western ethnic areas as well as the accuracy and feasibility etc of index data in details (as shown in table 1~3).

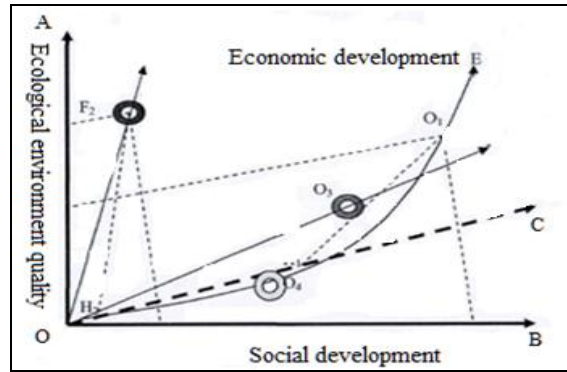


Figure 2: Ecological city construction path selection

3.2 Determination of weight

When confirming index weight with practical methods, define the weight of index at each level as following:

(1)Weight of first level index, because there are totally five first level indexes, set the weight of each index as positive number bigger than 1, while the sum of the weight of the whole five first level indexes is 6, in this way, the right digit of each index is between 1~2. To make the calculation convenient, first confirm the weight of first level index of each city as 1.2, and then make adjustment based on if the quantity of second level index within each first level index bigger than 1 exceeds 50% of the total index number; the weight will increase by 0.1 if the quantity of second level index bigger than 1 exceeds 50% of the total number of this index; conversely, reduce by 0.1 when less than one weight, but can't be smaller than 1.

Table 1: Ecological city evaluation index

First level indicators	Second level indicators
Level of economic development	Per capita gross domestic product (GDP)
	Per capita income
	The proportion of the third industry and GDP
	The proportion of investment in fixed assets and GDP
	Industrial output value

Table 2: Ecological city evaluation index

First level indicators	Second level indicators
Ecological environment quality	Forest coverage rate
	Urban air quality
	The proportion of environmental investment and GDP
	Sewage concentrated treatment ratio
	Pollution area ratio

Table 3: Ecological city evaluation index

First level indicators	Second level indicators
Level of resources	The area of cultivated land per capita
	Per capita water resources
	Tourism revenue
	Mineral species

## Coal reserves

(2) Weight base of the second level index, define the weight basis of the first second level index within each first level index as 1, the comparison between the weight base of the rest second level index and the first second level index presents arithmetic regularity, the D-value equals to the countdown of the total number of second level index. If the first level index includes five second level indexes in total, and then

the weight base of the first second level index is 1, the second is 0.8, and so on; the weight base of the fifth second level index is 0.2.

(3) The actual weight of first level index equals to weight base; the actual weight of the second level index equals to the product of weight base and corresponding weight of first level index.

**Table 4: Ecological city building indicators and weights**

Indicators	Expression	Weight	Weight coefficient	Actual weight
1 Level of economic development	T1	C1	1.20	1.20
1.1 Per capita gross domestic product (GDP)	T11	C11	1.010	1.20
1.2 Per capita income	T12	C12	0.875	1.05
1.3 The proportion of the third industry and GDP	T13	C13	0.750	0.90
1.4 The proportion of investment in fixed assets and GDP	T14	C14	0.625	0.75
1.5 Industrial output value	T15	C15	0.500	0.60

**Table 5: Ecological city building indicators and weights**

Indicators	Expression	Weight	Weight coefficient	Actual weight
2 Ecological environment quality	T2	C2	1.20	1.20
2.1 Forest coverage rate	T21	C21	1.010	1.20
2.2 Urban air quality	T22	C22	0.875	1.05
2.3 The proportion of environmental investment and GDP	T23	C23	0.715	0.86
2.4 Sewage concentrated treatment ratio	T24	C24	0.575	0.65
2.5 Pollution area ratio	T25	C25	0.425	0.50

**Table 6: Ecological city building indicators and weights**

Indicators	Expression	Weight	Weight coefficient	Actual weight
3 Level of resources	T3	C3	1.20	1.20
3.1 The area of cultivated land per capita	T31	C31	1.010	1.20
3.2 Per capita water resources	T32	C32	0.875	1.00
3.3 Tourism revenue	T33	C33	0.715	0.80
3.4 Mineral species	T34	C34	0.575	0.60
3.5 Coal reserves	T35	C35	0.425	0.45

Mathematical expression form of each index is as shown in the table 4-6.

### 3.3 Comprehensive evaluation model

If express the second level index group of No. i first level index with  $\alpha_i$ , and then each second level index group can be expressed as following with one-dimensional row vector expression method [16]:

$$\alpha_i = (T_{i1}, T_{i2}, \dots, T_{ij}, \dots, T_{im}) \quad (1)$$

In which, m is the quantity of the second level index in No. i first level index;  $T_{im}$  is the value of the last second level index in No. i first level index.

If  $\beta_i$  is the corresponding weight group of the second level index in No. i first level index, and then the weight group of each second level index group can be

expressed as following with one-dimensional row vector expression method:

$$\beta_i = \begin{pmatrix} C_{i1} \\ C_{i2} \\ \dots \\ C_{ij} \\ \dots \\ C_{im} \end{pmatrix} \quad (2)$$

In the above formula, m is the quantity of second level index in No. i first level index; that is  $C_{im}$  is the weight of the last second level index in No. i first level index [17].

Multiply the standardized value of each second level index in one first level index and the corresponding

actual weight and then sum, the value is the comprehensive development level of this first level index, that is:

$$T_i = \beta_i \times a_i = \begin{pmatrix} C_{i1} \\ C_{i2} \\ \dots \\ C_{ij} \\ \dots \\ C_{im} \end{pmatrix} \times (T_{i1}, T_{i2}, \dots, T_{ij}, \dots, T_{im}) = \sum_{j=1}^m C_{ij} \times T_{ij} \quad (3)$$

Similarly, the comprehensive development level of eco-city can be expressed as:

$$S = \sum_{i=1}^5 C_i \times T_i \quad (4)$$

If  $N_i$  is the quantity of super average index within No.i first level index, and then the quantity of all super average indexes can be expressed as:

$$N = \sum_{i=1}^5 N_i \quad (5)$$

Based on the above results, the evaluation of the comprehensive ecological construction level of one city can be expressed with following results:

- S:** Ecological city evaluation index
- T1:** Level of economic development
- T2:** Ecological environment quality
- T3:** Level of resources

### 3.4 Elaboration of eco-city evaluation index system

Harmonious eco-city requires that the development level of each index is high and relatively even. Therefore [18], if taking harmonious eco-city as development goal, first level and second level indexes should meet following two conditions:

(1) For first level index:

$$R_i - \sqrt{\frac{\sum_{i=1}^5 \left( \frac{2}{m+1} T_i - R_i \right)^2}{5}} \leq \frac{2}{m+1} T \quad (6)$$

$$\leq R_i + \sqrt{\frac{\sum_{i=1}^5 \left( \frac{2}{m+1} T_i - R_i \right)^2}{5}}$$

$$R_i = \frac{2}{m+1} \frac{\sum_{i=1}^5 T_i}{5}$$

The above formula presents the ideal situation after construction of harmonious eco-city, that is all the first level index data stays in the balanced range of this theory [19]. If there are over 60% of first level index data reaches this demand, and then it can be regarded as satisfying the basic conditions of constructing harmonious eco-city and harmonious mode can be selected to develop eco-city.

(2) For second level index:

$$N_i \geq 0.8mN \geq 0.7 \times 34 = 23.8$$

$$i = 1, 2, 3, 4, 5, m = 8, 7, 9, 6, 4 \quad (7)$$

The above formula presents the ideal situation after construction of harmonious eco-city, that is the quantity of all the second level index data bigger than 1 should exceed 70% of the total second level index and also with even distribution, that is the quantity of second level index under first level index bigger than 1 should exceed 80% of the quantity of second level index contained in first level index.

If the quantity of second level index bigger than 1 reaches over 40% of the total quantity of second level index and with even distribution, that is the quantity below the first level index with three or above three first level indexes and index value bigger than the quantity of second level index exceeds 40% of the quantity of second level index within first level index, harmonious mode can be chosen to develop eco-city [20].

Table 7: Index data processing results

Indicators	T <sub>ij</sub>	C <sub>ij</sub>	T <sub>ij</sub> × C <sub>ij</sub>	S <sub>i</sub>	$\frac{2T_i}{(m+1)}$	Tmax	Tmin
1 Level of economic development		1.20	5.585				
1.1 Per capita gross domestic product (GDP)	1.02	1.20	1.224				
1.2 Per capita income	0.75	1.05	0.7875				
1.3 The proportion of the third industry and GDP	1.12	0.90	1.008	6.75	1.20	1.80	0.42
1.4 The proportion of investment in fixed assets and GDP	0.85	0.75	0.6375				
1.5 Industrial output value	0.76	0.60	0.456				

Table 8: Index data processing results

Indicators	T <sub>ij</sub>	C <sub>ij</sub>	T <sub>ij</sub> × C <sub>ij</sub>	S <sub>i</sub>	$\frac{2T_i}{(m+1)}$	Tmax	Tmin
2 Ecological environment quality		1.20	5.659	6.79	1.38	1.91	0.65

2.1 Forest coverage rate	1.44	1.20	1.224
2.2 Urban air quality	1.07	1.05	0.7875
2.3 The proportion of environmental investment and GDP	0.95	0.86	0.817
2.4 Sewage concentrated treatment ratio	0.82	0.65	0.533
2.5 Pollution area ratio	1.37	0.50	0.685

**Table 9:** Index data processing results

Indicators	$T_{ij}$	$C_{ij}$	$T_{ij} \times C_{ij}$	$S_i$	$\frac{2T_i}{(m+1)}$	$T_{max}$	$T_{min}$
3 Level of resources		1.20	5.659				
3.1 The area of cultivated land per capita	1.44	1.20	1.224				
3.2 Per capita water resources	1.07	1.00	1.07	18.81	4.13	4.52	1.08
3.3 Tourism revenue	0.95	0.80	0.76				
3.4 Mineral species	0.82	0.60	0.492				
3.5 Coal reserves	1.37	0.45	0.616				

#### 4. Comprehensive evaluation model of eco-city

Make dispose for original data of eco-city index in Baotou based on evaluation method, evaluation model as well as specific definition in the elaboration of index evaluation system and attain following table 7~9.

#### 5. Conclusion

- (1) First level development index in Baotou city indicates that at present, the indexes of economic development level, ecological environment quality, degree of social progress, resource endowment level and the development of ethnic minority are 1.24, 1.42, 1.28, 4.15 and 1.33 respectively, in which economic development level index and ethnic minority development index should be bigger than 0.9, it can be judged that Baotou city meets the basic conditions for tourism eco-city development mode.
- (2) In the category of ecological environment quality, except that the proportion of protected area to land area as well as two second level index brought about by emission of sulfur dioxide not in the equilibrium interval from 0.65 to 1.95, all the other indexes are within the theoretical equilibrium interval, there is 71% of second level index data under ecological environment quality meets the demand; in the category of minority development situation, except for the proportion of ethnic autonomous counties (banners) 2.26 is bigger than the maximum value 1.83 within theoretical numerical range, all the other indexes are within the theoretical equilibrium interval of this value. There is 75% of second level index data under the development of ethnic minorities meets demand, therefore, it meets the basic conditions for tourism eco-city development mode.
- (3) It can be judged that Baotou city can choose tourism eco-city development mode. The indexes of economic development level, ecological environment quality, degree of social progress,

resource endowment level and the development of ethnic minority are 1.24, 1.41, 1.28 and 1.33 respectively. Theoretically speaking, these four indexes should be between 1.38 and 1.26, in which degree of social progress and the index of ethnic minority development are all within the theoretical equilibrium interval. It can be seen that the development of this city is relatively balanced, which meets the expansion conditions of tourism eco-city development mode.

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