Evaluation of the Ecological Civilization Construction of Shenyang, Liaoning Province P.R. China

Chengzhong Ma[1], Jifeng Deng[2,3,*], Gang Wang[1], Xiangfei Kong[1], Qi Liang[4]

[1]Department of Architecture and Landscape Engineering, Dezhou Vocational and Technical College, Dezhou, 253034 Shandong, P.R. China

machengzhong1991@hotmail.com

[2]College of Forestry, Shenyang Agricultural University, Shenyang, 110866 Liaoning, P.R. China

[3]Research Station of Liaohe-River Plain Forest Ecosystem, Chinese Forest Ecosystem Research Network, Changtu, 112500 Liaoning, P.R. China

[4]Jilin Academy of Forestry survey and Design, Changchun, 130022 Jilin, P.R. China

*Corresponding author: jifeng-deng@syau.edu.cn

Abstract. This paper constructs an evaluation index system that assesses the ecological civilization construction level of Shenyang from 2011 to 2016 with the help of the analytical hierarchy process and the Delphi method. Although the results did show any apparent increase in the ecological civilization construction level of Shenyang, the city demonstrated a generally stable natural ecological level. The growing resource allocation and social civilization of the city were also accompanied by a decline in its population structure. Shenyang also demonstrated an initial decrease in its environmental guarantee that was immediately followed by an increase. However, the opposite trend was observed for its economic development.

1. Introduction

An ecological city is a cluster of human settlements where residents live together in harmony and use their materials, energy, information, and infrastructures in an efficient manner [1-2]. An ecological civilization is an important part of modern human civilization that embodies the harmonious relationship between man and nature. Since the 21st century, many countries and regions have paid attention to their ecological environments in response to the growing severity of ecological crises as well as the resource constraints and environmental pressures brought upon by their traditional industrial growth models. The degree of environmental degradation increases as an economy continues to develop and as the seriousness of problems related to resource constraints and environmental pollution grows increasingly severe. The absence of a coordinated and sustainable economic development has also necessitated the construction of a new ecological civilization [3]. Accordingly, the 18th CPC National Congress reported that the construction of an ecological civilization should be included as part of China's socialist construction projects, which presently focus on economic construction, political construction, cultural construction, and social construction.

Shenyang, a famous heavy industrial city, is the capital of Liaoning Province located in Northeast China. Figure 1 shows the geographical location of the city. As the oldest industrial base of key investments in China, Shenyang greatly contributed to the development of the country. After the

reform and opening up in 1978, several cities in Northeast China, including Shenyang and Harbin, demonstrated a gradual deceleration in their development. In response, government leaders launched successive projects to promote the urban development of Shenyang. Nevertheless, given its extensive and traditional economic model, shortage and wastage of natural resources, and fragile ecological environment, Shenyang is still far from reaching its goal of becoming an ecological city.

Figure 1. The geographical location of Shenyang, Liaoning Province P.R. China

2. Status of related research

With the growing popularity of ecological civilization construction at home and abroad, scholars have begun to examine the available mechanisms for evaluating regional ecological civilization construction [4-5]. Although an evaluation index system for ecological civilization construction has already been established, this system lacks theoretical support and shows many deficiencies. For instance, this system does not offer a clear positioning of the regional function and lacks pertinence.

Based on the definition and requirements of ecological civilization construction, in view of these problems, this paper constructs a targeted index system for evaluating regional ecological civilization construction. The direction and mode of Shenyang's ecological environment protection and economic development are then discussed in light of the evaluation results to facilitate the construction of an ecological civilization and to identify its main function area. This study provides a scientific basis for development and ecological protection of Shenyang city, Liaoning Province P.R. China.

3. Evaluation index system for the ecological civilization construction in Shenyang

3.1 Data source

Statistical data on Shenyang for the years 2011 to 2016 were collected from the Statistical Yearbook of Liaoning Province (2012-2017), Shenyang Statistical Bulletin of National Economic and Social Development (2012-2017), and Shenyang Statistical Yearbook (2012-2017).

3.2 Evaluation index

An index system that reflects the construction and development of an ecological civilization in Shenyang is developed based on existing scientific, systematic, dynamic, and quantitative principles, the findings of previous evaluation methods, and the present situation of the region [6].

The proposed index system is divided into three layers, namely, the target, criteria, and function layers. The comprehensive index of ecological civilization construction is used as the target layer to reveal the present development of regional ecological civilization construction. Natural ecology (B1), environmental guarantee (B2), resource allocation (B3), population structure (B4), social civilization (B5), and economic development (B6) are included in the criteria layer. A total of 34 evaluation indexes, including regional GDP per capita, total water supply, and environmental information

disclosure rate, are assessed in each layer. The proposed evaluation index system is then established by merging the 34 aforementioned indices as shown in Figure 2.
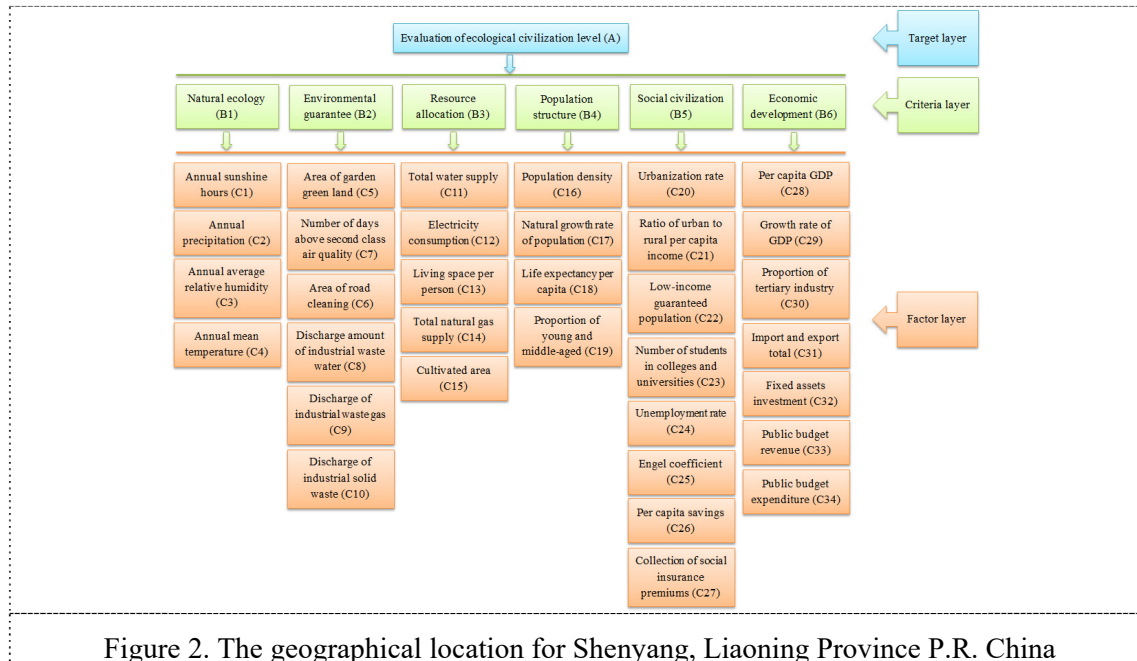

Figure 2. The geographical location for Shenyang, Liaoning Province P.R. China

3.3 Evaluation method and weights

The data for the 34 indexes were analysed. The weight of each index in the criteria layer was calculated by applying the analytic hierarchy process (AHP) and the calculated weight was tested based on its consistency ratio (CR<0.1). Meanwhile, the weight of each index in the factor layer was calculated by using the Delphi method [7-9]. The weights calculated by the AHP were then multiplied by those calculated by the Delphi method to obtain the actual weight of a specific index. The indices in these three layers are listed in Table 1.

Table 1. Indices in the three layers of the proposed evaluation index system

Target layer	Criteria layer	Factor layer	Weight
Evaluation of ecological civilization level (A)	Natural ecology (B1)	Annual sunshine hours (C1) // h	0.0261
		Annual precipitation (C2) // mm	0.0227
		Annual average relative humidity (C3) // %	0.0218
		Annual mean temperature (C4) // °C	0.0240
	Environmental guarantee (B2)	Area of garden green land (C5) // ha	0.0453
		Area of road cleaning (C6) // km^2	0.0601
		Number of days with above second class air quality (C7) // d	0.0570
		Amount of discharged industrial wastewater (C8) // 10k·t	0.0520
		Amount of discharged industrial waste gas (C9) // 10k·m^3	0.0465
		Amount of discharged industrial solid waste (C10) // 10k·t	0.0523

	Total water supply (C11) // 10k·m^3	0.0297
	Electricity consumption (C12) // 10MW·h	0.0250
Resource allocation (B3)	Living space per person (C13) // m^2	0.0239
	Total natural gas supply (C14) // 10k·m^3	0.0287
	Cultivated area (C15) // ha	0.0247
	Population density (C16) // person/km^2	0.0136
	Natural growth rate of population (C17) // ‰	0.0095
Population structure (B4)	Life expectancy per capita (C18) // years	0.0098
	Proportion of young and middle-aged people (C19) // %	0.0100
	Urbanization rate (C20) // %	0.0324
	Ratio of urban to rural per capita income (C21)	0.0392
	Low-income guaranteed population (C22) // million people	0.0351
	Number of students in colleges and universities (C23) // million people	0.0445
Social civilization (B5)	Unemployment rate (C24) // %	0.0337
	Engel coefficient (C25) // %	0.0373
	Per capita savings (C26) // ¥	0.0337
	Collection of social insurance premiums (C27) // ¥	0.0336
	Per capita GDP (C28) // ¥	0.0172
	GDP growth rate (C29) // %	0.0164
	Proportion of tertiary industry (C30) // %	0.0213
Economic development (B6)	Total imports and exports (C31) // $	0.0183
	Fixed assets investment (C32) // ¥	0.0163
	Public revenues (C33) // ¥	0.0215
	Public expenditures (C34) // ¥	0.0166

3.4 Calculation of evaluation value
The dimensionless treatment value was multiplied by the weight calculated by using the Delphi method to obtain the evaluation value for the indices in the target and criteria layers.

3.5 Determination of evaluation grade
The evaluation grade of an index is used to scientifically assess the evaluation results [10]. Following previous research, this paper divides the evaluation grade into five, while the value of the ecological civilization construction comprehensive index (ECI) is taken as the evaluation standard (Table 2).

Table 2. Classification standards for the indices in the proposed evaluation index system

Grade	Range of composite indices	State	Description
I	$0.8 < ECI \leq 1.0$	Advanced stage (Ideal state)	The best state of urban ecological spatial pattern, industrial structure, mode of production, and way of life. A harmonious development is observed between man and nature.
II	$0.6 < ECI \leq 0.8$	Stable stage (Good state)	Substantial progress has been achieved in transforming the mode of economic development. The improvements in people's livelihood have been synchronized with urban and rural planning. The ecological environment is relatively optimized.
III	$0.4 < ECI \leq 0.6$	Intermediate stage (General state)	The energy utilization efficiency and the state of urban ecosystems have been improved. Ecological civilization needs to be improved further.
IV	$0.2 < ECI \leq 0.4$	Developmental stage (Poor state)	Resource constraints, environmental pollution, and a single economic structure are apparent. Social problems also stand out.
V	$0.0 < ECI \leq 0.2$	Initial stage (Abominable state)	Contradictions, such as overpopulation, resource depletion, and environmental pollution, are becoming increasingly prominent. The health of the urban ecosystem is threatened.

4. Analysis of evaluation value

The evaluation value of ecological civilization construction (the comprehensive evaluation value of target layer) during 2011 to 2016 in Shenyang is shown in Figure 3. And the evaluation value of criteria layer is shown in Figure 4. The evaluation value is between 0~1 and as can be seen from Table 2, the higher of the evaluation value, the higher level of ecological civilization construction.
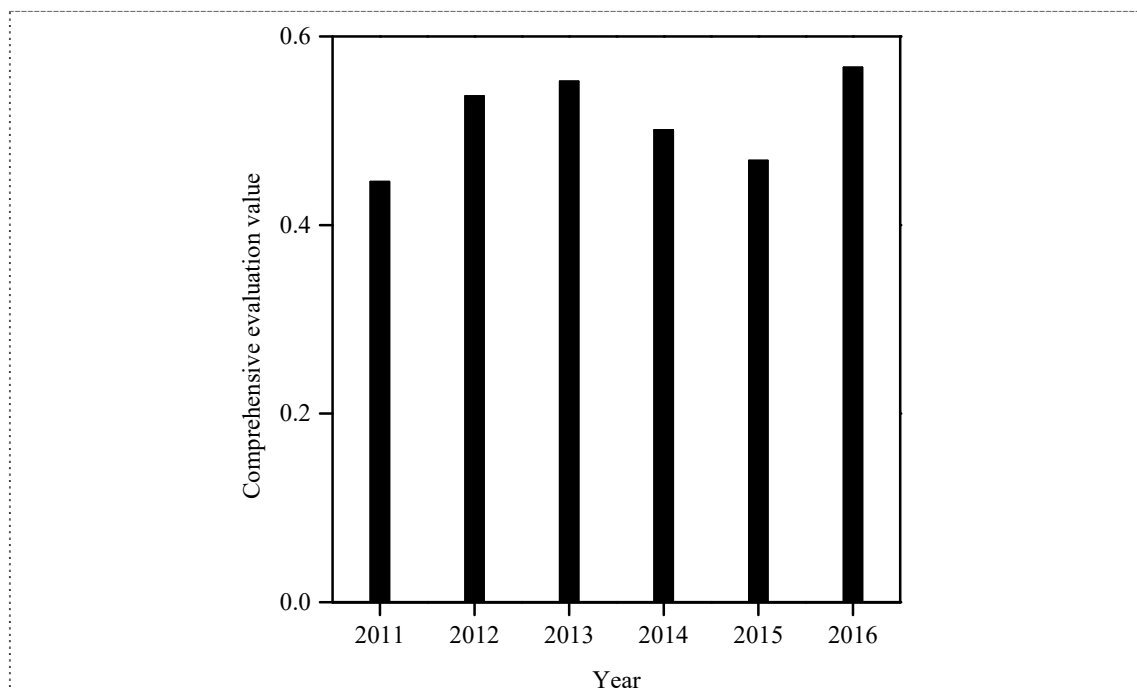
Figure 3. Evaluation value for the ecological civilization construction in Shenyang
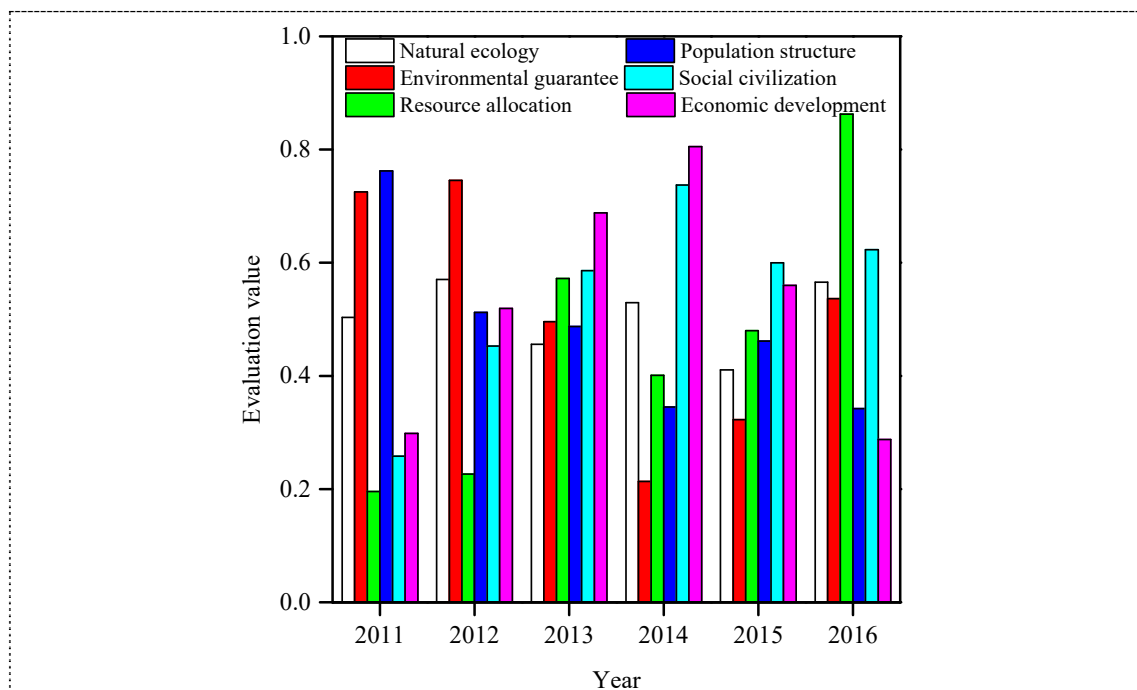

Figure 4. Evaluation value of the criteria layer

Figure 4. Evaluation value of ecological civilization construction of criteria layer in Shenyang

(1) The level of ecological civilization construction in Shenyang showed a fluctuating trend and a slight increase of 0.4160 from 0.4379 in 2011 to 0.8539 in 2016. In other words, the level of Shenyang's ecological civilization construction is currently at the intermediate stage and still has a large room for development.

(2) Figure 2 shows that the natural ecology level of Shenyang generally lies between the stable and intermediate stages, but this level changes every year. Natural ecology is determined by the geographical location of the study area rather than by human factors.

(3) The environmental guarantee of Shenyang significantly changed from 2011 to 2016 as shown in Figure 2. Specifically, in 2011-2012, Shenyang's level of environmental guarantee remained at the stable stage before rapidly falling to the intermediate stage and then to the developmental stage in the next two years. Meanwhile, the level of ecological security gradually increased to the intermediate stage from 2014 to 2016, thereby indicating that the ecological security problem of the city has grown very serious in recent years. Some protective measures have been applied to address this problem and certain effects have been reported.

(4) The resource allocation level of Shenyang gradually increased from the initial stage to the advanced stage, which can be ascribed to the recent great improvements in the industrial production level of the city.

(5) The level of population structure sharply decreased from the stable stage to the developmental stage. This trend coincides with the great population loss in Northeast China.

(6) Despite showing a decline in certain periods, the level of social civilization significantly increased from the developmental stage to the stable stage. The administrative management and urban construction departments of Shenyang have implemented effective measures for developing the ecological civilization of the city.

(7) By taking 2014 as the node, the level of economic development of Shenyang fluctuated between the developmental stage and the advanced stage. Economic development is an important index for evaluating the comprehensive development of a region. A reduction in the level of economic development warrants further attention, and certain effective measures must be implemented to reverse this trend.

5. Conclusions

Evaluating ecological civilization construction is the most important part of urban development. This paper proposed an evaluation index system for assessing the ecological civilization construction in Shenyang. The results did not show an apparent increase in the ecological civilization construction level of Shenyang, which presently lies at the intermediate stage. Each component index showed a different development trend. Given the fact that natural ecology cannot be artificially altered, Shenyang must maintain the good momentum in its environmental guarantee, resource allocation, and social civilization as well as implement effective measures for achieving acceptable levels of population structure and economic development to reverse the unfavourable development state of the city.

References

[1] Van J V, Block C, Cramm P, Mortier R, Vandecasteele C. Improving eco-efficiency in the steel industry: The ArcelorMittal Gent case[J]. Journal of Cleaner Production, 2010, 18(8): 807-817.

[2] Li D, Wang Y L, Fu Y and Niu W Y. The efficiency analysis of material flow account for the 19 cities of China[J]. Bemuse Science, 2007, 29(6): 177-182.

[3] Qiu S F and Zhu D J. Eco-efficiency indicators for China and their applications[J]. Scientific Management Research, 2007, 25(1): 20-24.

[4] Wursthom S and Poganielz S L. Economic-environmental monitoring indicators for European countries: A disaggregated sector-based approach for monitoring eco-efficiency [J].Ecological Economics, 2011, 70(3): 487-496.

[5] Caneghem J V, Block C, Hooste H V and Vandecasteele C. Eco-efficiency trends of the Flemish industry: decoupling of environmental impact from economic growth. [J]. Journal of Cleaner Production, 2010, 18(14): 1349-1357.

[6] Charles O J, An Introduction to the Study of Public Policy[M], 2nd. North Scituate, Mass.: Duxbury Press, 1977.

[7] Wei Z Y, Wang D F, Zhou H P and Qi Z. Assessment of soil heavy metal pollution with principal component analysis and geo-accumulation index[J]. Environmental Sciences, 2011, (10): 1946-1952.

[8] Farsari Y and Prastacos P. Sustainable development indicators: an overview[J]. Foundation for the Research and Technology Hellas, 2002, 24: 197-208.

[9] Grigoroudis E, Kouikoglou V S and Phillis Y A. Phillis. Approaches for Measuring Sustainability[J]. Sustainable Practices: Concepts, Methodologies, Tools and Applications 2013: 158.

[10] Song T, Zheng T G, Tong L J. An empirical test of the environmental Kuznets curve in China-A panel cointegration approach [J]. China Economic Reviews 2008, 19(3):381-392.