ISSN 2616-5805 Vol. 3, Issue 1: 23-29, DOI: 10.25236/AJMS.2022.030104

Research on the evaluation of ecological civilization construction based on TOPSIS

Yuting Liu

Department of Electrical and Electronic Engineering, University of Chongqing Technology, Chongqing, 400054, China

Abstract: *This paper discusses the problems related to the construction of ecological civilization based on the TOPSIS algorithm model. We also launched a mathematical modeling and other related analysis on the construction of ecological civilization in some provinces and cities in China based on the latest data in 2022. Under the consideration of various factors, we finally clarified the social security, ecological economy. The four levels of indicators are ecological security and environmental friendliness. For these four feasible evaluation indicators, we firstly list the attribute measures of single indicators, secondly find out the attribute measures of multiple indicators, and finally realize the attribute grading. Since there are many differences between regions in terms of economy and geographical location in the process of ecological civilization construction, we extensively collected and analyzed the latest data on ecological civilization construction in five provinces and cities, namely Sichuan, Chongqing, Guizhou, Hubei, and Yunnan, in recent years. We conducted a detailed and specific analysis of the problems that emerged during the study of the problem, evaluated the advantages and disadvantages of the model, and concluded that the results of the operational model were consistent with the real situation and its reference value was very reliable. In addition, we generalized the model to solve other practical problems with common features.*

Keywords: *TOPSIS, ecological civilization construction, entropy method*

1. Introduction

China's economy continues to grow, environmental pollution is getting worse, and the construction of ecological civilization is imminent. General Secretary Xi emphasized the importance of the community of human destiny in the report of the 19th National Congress[1]. Whether it is the publication of the United Nations Framework Convention on Climate Change, the signing of the Paris Agreement or the G20 Hangzhou Summit, the establishment of a sound economic system of green, low-carbon and cyclic development is always an inescapable topic. Green low-carbon life is the general trend and the general background of the times[2].

Firstly, this paper will list the evaluation indicators and models for the construction of ecological civilization in China on the basis of extensive collection of information and reading of literature. The existing indicators will be analyzed.

Secondly, based on the representativeness, authority and comprehensiveness to screen out the meaningful parts and establish a mathematical model combined with economic factors.

Again, evaluate the degree of ecological civilization construction in five regions of Chongqing, Sichuan, Guizhou, Hubei and Yunnan with reference to the latest data, collect information on each indicator, determine the corresponding weight percentage of each data with reference to the weight of the national ecological civilization construction system, process the offspring into TOPSIS model to analyze and solve with matlab software, and draw the obtained results into a bar chart with Excel The results were plotted in Excel as bar graphs.

Finally, analyzing the results of the modeling, the province with the lowest comprehensive evaluation is Guizhou Province. It is easy to find that the main reason for the low evaluation of ecological civilization construction in Guizhou Province is its high percentage of fossil fuel (non-renewable energy) use and low utilization rate of resources, which greatly pollute the environment. Therefore, the ecological environment improvement measures in Guizhou Province should focus on improving the energy structure, and the latest approval of the 14th National Congress on the construction plan of Guizhou Province's ecological civilization pilot zone should be combined with the corresponding improvement

ISSN 2616-5805 Vol. 3, Issue 1: 23-29, DOI: 10.25236/AJMS.2022.030104

suggestions[3].

2. Model Construction

2.1 Modeling ideas

Considering that the analyzed index data are many and relatively reasonable weights have been obtained, the TOPSIS model combined with the weights is chosen to solve for a reasonable evaluation index model of ecological civilization construction by considering each factor comprehensively.

2.2 Model Building

TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) [4] is an evaluation class analysis model first proposed by C.L. Hwang and K. Yoon in 1981, and the model is called "Approximation to Ideal Solution Ordering" in Chinese. It is also called "distance method of superior and inferior solutions" in China.

This method is a comprehensive distance evaluation method that ranks the evaluation objects according to their proximity to the idealized target. The basic idea is to assume the positive and negative ideal solutions, measure the distance between each sample and the positive and negative ideal solutions, and get the relative closeness to the ideal solution (i.e. the closer to the positive ideal solution and the farther to the negative ideal solution), and then rank the evaluation objects in terms of their advantages and disadvantages. The specific steps and concepts are as follows.

Step 1: Normalize the indicators, standardize the data matrix and obtain the weights of each data.

Minimal normalization formula:

$$\widetilde{x}_i = \max - x \tag{1}$$

If the data is all positive also can take the inverse method, in this paper the choice is to take the difference.

The intermediate type normalization formula:

$$M = \max\{|x_i - x_{best}|\},\ \ \widetilde{x}_i = 1 - \frac{|x_i - x_{best}|}{M} \tag{2}$$

Interval-type forwarding equation:

$$M = \max\{a - \min\{x_i\}, \max\{x_i\} - b\}, \widetilde{x}_i = \begin{cases} 1 - \dfrac{a-x}{M}, x < a \\ 1 \qquad\qquad , a \leqslant x \leqslant b \\ 1 - \dfrac{x-b}{M}, x > b \end{cases} \tag{3}$$

Matrix normalization equation:

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix}, z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} {x_{ij}}^2}} \tag{4}$$

There are many ways to standardize the matrices to eliminate the effects of dimensionality, and one of the more common ones is selected here.

Step 2: Obtain the weighted normalized matrix

ω Indicates the size of the weights, usually defined by experts, in this paper reference is made to the target scores corresponding to the national ecological civilization construction assessment target system, the weights of the indicators of the national green development index system and the information of many papers on the knowledge network.

The weighting matrix formula is obtained:

$$Z=(z_{ij})_{n\times m}=(p_{ij}\cdot\omega_j) \tag{5}$$

Step 3: Determine the positive and negative ideal solutions. The positive ideal solution is the solution that obtains the maximum value in the sample for all data indicators after forwarding, while the negative ideal solution is the solution that obtains the minimum value in the sample for all data indicators after forwarding

Positive ideal solution formula:

$$\begin{gathered}Z^+=(Z_1^+,Z_2^+,\cdots,Z_m^+)\\=(\max\{z_{11},z_{21},\cdots,z_{n1}\},\max\{z_{12},z_{22},\cdots,z_{n2}\},\cdots,\max\{z_{1m},z_{2m},\cdots,z_{nm}\})\end{gathered} \tag{6}$$

The negative ideal solution of Eq.

$$\begin{gathered}Z^-=(Z_1^-,Z_2^-,\cdots,Z_m^-)\\=(\min\{z_{11},z_{21},\cdots,z_{n1}\},\min\{z_{12},z_{22},\cdots,z_{n2}\},\cdots,\min\{z_{1m},z_{2m},\cdots,z_{nm}\})\end{gathered} \tag{7}$$

Step 4: Calculate the distance between each evaluation object and the positive and negative ideal solutions.

The distance between the i-th (i=1,2,...,n) object and the positive ideal solution is given by:

$$D_i^+=\sqrt{\sum_{j=1}^{m}(Z_j^+-z_{ij})^2} \tag{8}$$

The distance between the i-th (i=1,2,...,n) object and the negative ideal solution is given by:

$$D_i^-=\sqrt{\sum_{j=1}^{m}(Z_j^--z_{ij})^2} \tag{9}$$

Step 5: Calculate the closeness of each evaluation object to the ideal solution to derive the final score:

$$S_i=\frac{D_i^-}{D_i^++D_i^-},0\leqslant S_i\leqslant 1 \tag{1}$$

Obviously, a score closer to 1 indicates a smaller distance from the positive ideal solution and the solution obtained is closer to the maximum value. Normalizing the final result can give us a clearer and more intuitive impression of the result, which can be more easily used to interpret the problem.

3. Model solving

3.1 Evaluation indicators of ecological civilization construction

There are dozens of existing indicators for the construction of ecological civilization in China, and each provincial area has different requirements for its lower prefecture-level cities due to its geographical location and its own ecological environment. Vigorously promoting the construction of ecological civilization is inevitable to overcome the drawbacks of industrial development and establish a society of peaceful development between human beings and nature. Mu Yanjie et al. conducted an analysis on the path of ecological civilization construction in the context of the new economic normal. Zhang Xiu et al. constructed an evaluation system for the construction of ecological civilization based on the subordination hierarchy model. From Yujia et al. gave a comprehensive evaluation and prediction on the construction of ecological civilization. Wang Xuesong et al. gave the index system and process design of classification assessment for the construction of ecological civilization in China.

At present, the domestic models used to analyze the evaluation of ecological civilization construction are affiliation hierarchy model, AHP model, entropy power method and TOPSIS analysis method. Figure 1 shows the evaluation indicators.

ISSN 2616-5805 Vol. 3, Issue 1: 23-29, DOI: 10.25236/AJMS.2022.030104

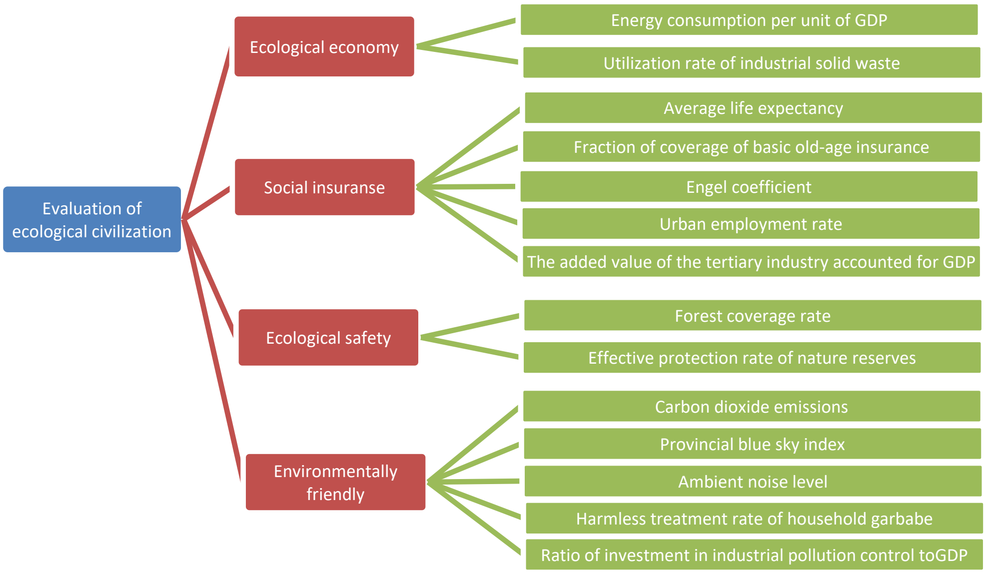

Figure 1: The evaluation indicators

3.2 Final index selection

In order to obtain an objective, up-to-date data-based evaluation system for the construction of ecological civilization, we removed the indicators related to green life, growth quality and public satisfaction from the national-based green development index system, and selected the secondary indicators with the highest weight among the remaining primary indicators to ensure comprehensiveness and representativeness [5].In addition, considering that the area of each province varies, the indicators we selected are more inclined to those that are not related to the absolute area and are mostly evaluated in the form of proportions. (Specific indicators were obtained from the National Bureau of Statistics, National Development and Reform Commission, National Energy Administration, Ministry of Water Resources, Ministry of Environmental Protection, State Forestry Administration, Ministry of Land and Resources, and China Ecological Environment Network).

The final indicators selected are.

(economic-related resource utilization indicators)

GDP per capita, electricity consumption per unit of GDP, CO2 emissions per unit of GDP, water consumption per 10,000 yuan of GDP, arable land holdings, GDP share of tertiary industry.

(Ecological and environmental protection indicators)

Percentage of renewable energy power consumption, ratio of good air quality days in cities above prefecture level, concentration of fine particulate matter (pm2.5), forest coverage rate, effective protection of nature reserves.

3.3 Data compilation and ranking

In order to use TOPSIS method to analyze the evaluation of ecological civilization construction in five provinces (municipalities directly under the central government), we need to collect the data of each indicator. To ensure the authority of the data, we first choose the information published by the ecological environment bureau and ecological environment department of each province (municipality directly under the central government) in the ecological environment status bulletin. The information we needed was captured in the report and organized into tables. The units are chosen from the standard units selected by the National Bureau of Statistics and will not be added later.

For some missing data, we supplemented them with data from the most recent years to finally obtain Table 1 and Table 2.

ISSN 2616-5805 Vol. 3, Issue 1: 23-29, DOI: 10.25236/AJMS.2022.030104

Table 1: Statistics on economic indicators of the five provinces

Region	GDP per capita	Electricity consumption per unit of GDP	CO2 emissions per unit of GDP	Arable land holdings	Water consumption of 10,000 Yuan GDP
ChongQing	8.69	474.75	0.70	217.07	32.40
YunNan	5.77	826.20	1.02	598.00	66.70
SiChuan	6.43	589.52	0.66	588.80	54.20
GuiZhou	5.08	889.68	1.20	437.07	64.40
HuBei	8.64	493.52	0.83	463.13	66.10

Table 2: Statistics on indicators related to environmental protection in five provinces

Region	Forest cover	Efective protection of nature eserve	Fine particulate matter Pm2.5 concentration	Ratio of good air quality days
ChongQing	54.50	10.04	29.0	92.60
YunNan	65.04	7.32	10.4	98.80
SiChuan	40.03	17.80	31.8	87.30
GuiZhou	62.12	5.08	39.0	99.20
HuBei	41.84	5.70	52.0	86.70

The data were organized into corresponding matrices and multiplied by the weights to be solved in the program to obtain the final scores for each province as shown in Figure 2 Below.

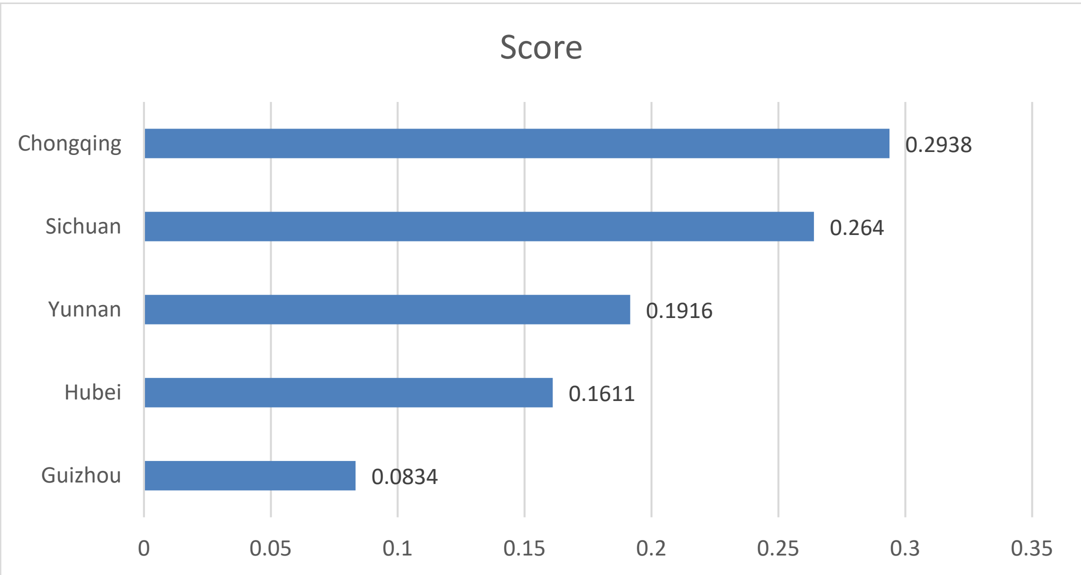

Figure 2: Final ecological civilization evaluation scores by province

The evaluation rankings of ecological civilization construction in the five provinces are:

Chongqing, Sichuan, Yunnan, Hubei, Guizhou.

3.4 Suggest improvements

According to the results of the modeling solution, we found that the province with the lowest comprehensive evaluation is Guizhou Province. Analyzing the data for vertical comparison, it is easy to find that the main reason for Guizhou Province's low evaluation of ecological civilization construction is its high percentage of fossil fuel (non-renewable energy) use, high energy consumption per unit of GDP, and low utilization of resources, which greatly pollutes the environment.

Therefore, for the construction of ecological civilization in Guizhou province, we wrote the following suggestions for improvement to its competent authorities.

(1) Adhere to the five in one, and constantly explore the pursuit

The 19th Party Congress expressed adherence to the five-in-one, combining ecological civilization with economic, political, social and cultural aspects. Guizhou should use bottom-line thinking, synchronous thinking as well as insisting on open thinking to continuously explore the development momentum of ecological civilization construction and adhere to the five-in-one strategy to the end.

(2) Linkage innovation, multi-win

Guizhou should unite the government, enterprises and the public to form a kind of synergy with leadership and continuous advancement; at the same time, institutional innovation, technological innovation and conceptual innovation should be linked; life improvement, ecological goodness and production development should progress in the same direction in time and space, so as to achieve a win-win situation; among them, we must start from the concept, pay close attention to the ecological civilization awareness of the public and lead the concept of green consumption; especially in the Energy utilization concept, the government and enterprises should start from themselves, overcome the technical bottleneck, use less fossil fuels and more emerging energy such as hydrogen energy.

(3) Improve the system and build the mechanism

The topography of Guizhou is intricate and complex, and its mountainous terrain makes it extremely susceptible to soil erosion. Even though it is surrounded by green mountains and water, its large population and strong development have made its natural ecosystem less advantageous than the surrounding areas; therefore, Guizhou should focus on improving its ecological service functions and implement the strictest water resource management system, land conservation system and environmental protection system.

(4) Develop circular economy growth model

From the previous analysis, the ratio of non-renewable energy use in Guizhou exceeds the standard, which greatly contradicts the original intention of sustainable development strategy. Therefore, Guizhou should vigorously develop circular economy, promote the growth of intensive utilization rate of resources, and create a strict recycling system of waste materials and resource recycling type industrial system; furthermore, Guizhou should have to coordinate planning and strive to establish a whole chain recycling system, focusing on key areas and targeted scientific layout; finally, systematic policy guarantee should be put into practice, and efforts should be made to develop new technologies like carbon neutral. Only in this way can the high-quality development of Guizhou be accelerated.

(5) Leading energy utilization with science and technology

Guizhou Province is rich in hydraulic resources, but the degree of openness is high; coal resources are excellent, but limited by the double control of energy consumption; photovoltaic resources have great potential for development but are constrained by the land use index. Therefore, the key to effectively solve the energy problem should be to strengthen technological innovation, coordinate and take into account the advantages of various new energy sources, accelerate the construction of multi-energy complementary projects, and improve the flexibility of thermal power stations; at present, there are still many technical bottlenecks in the new energy-based power system, and only by increasing investment in science and technology will Guizhou's energy sector be able to achieve further development.

4. Conclusion

For the sake of simplicity, the above modeling has made idealized assumptions about the indicators that may change over the years, which to a certain extent reduces the authenticity of the results and increases the errors. However, after our modeling and calculation analysis, the relevant indicators always change steadily without any other optimization measures, which will not affect the final ranking; due to the limited data search channels and the limited data information provided by the relevant websites, this leads to the limitation of the results and the degree of accuracy is not perfect; due to the lack of guidance from environmental professionals, the data processing Lack of precision in data processing due to the lack of guidance from environmental professionals; the inclusion of subjective factors causes the results to deviate from the actual.

The modeling results are not affected by changes in indicators over the years; the overall simplicity and clarity make it easy to understand; the intuitive formulae make it easy for the reader to observe as

ISSN 2616-5805 Vol. 3, Issue 1: 23-29, DOI: 10.25236/AJMS.2022.030104

well as analyze; the model makes idealized assumptions, which greatly saves the time cost of analysis, and although it leads to errors, it is convenient to derive the results and highly consistent with the reality.

The above model can be applied to many fields such as evaluation of enterprise economic efficiency, evaluation of e-commerce product purchase decisions, and evaluation of resource carrying capacity. As many factors that may affect the change of indicators over the years are statistically analyzed, the algorithmic model is improved, more arithmetic factors are injected, and the error is brought to zero as much as possible.

References

[1] Gong Xiaofang,Ge Dabing. Research on the assessment of ecological civilization construction level based on the entropy TOPSIS method--Take Changde City as an example[J]. Hunan Journal of Ecological Science, 2020,7(04):68-74.

[2] Gou, Tingjia, Lu, Weiwen. The evaluation of ecological civilization construction based on the combined empowerment TOPSIS model--Taking Qinghai Province as an example[J]. Statistics and Decision Making, 2020,36(24):57-60. DOI:10.13546/j.cnki.tjyjc.2020.24.012.

[3] Zhou Zhenyan. Research on the evaluation of ecological civilization construction performance based on entropy power TOPSIS model--Taking Hebei Province as an example[J]. Modern Marketing (Business Edition), 2020(07):124-126.DOI:10.19921/j.cnki.1009-2994.2020.07.060.

[4] Wang Erwei, Zhu Baowen, Cui Chunsheng. Evaluation of urban ecological civilization construction in Pearl River Delta region based on entropy power TOPSIS method[J]. Mathematical Practice and Understanding, 2020,50(12):28-37.

[5] Zhou Hongchun, Song Wisdom, Liu Yunfei, Zhang Xiaolei. Review, comparison and improvement of the evaluation index system of ecological civilization construction[J]. Ecological Economy, 2019,35(08):213-222.