ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0015

Research on the Selection of Green Building Projects based on Combination Weighting-Improved TOPSIS Method

Zhixia Wu[1, a], Shan Huang[2, b] and Wenli Hu[1, c]

[1]School of Management, Sichuan University of Science & Engineering, Zigong 643000, China.

[2]School of Architecture and Urban-Rural Planning, Sichuan Agricultural University, Dujiangyan 611830, China.

[a]2894754833@qq.com, [b]554911057@qq.com, [c]1061534160@qq.com

Abstract

The selection of green building schemes is a key link in realizing the continuous development of green buildings in southern Sichuan, and has a significant impact on the development of the southern Sichuan economic zone. Aiming at the characteristics of green buildings in the South Sichuan Economic Zone, firstly identify 20 factors that affect the development of green buildings in the South Sichuan Economic Zone, construct a comprehensive evaluation index system for green building plans, and use the coefficient of variation method and entropy weight method to determine the combined weight of the evaluation indicators Empirical analysis of the four green building projects in the South Sichuan Economic Zone using the combined weighting-improved TOPSIS method, calculated the overall balance of each program, and realized the optimization of the green building programs in the South Sichuan Economic Zone, with a view to making the South Sichuan Economic Zone green in the future The decision-making of construction and real estate enterprises brings certain enlightenment.

Keywords

Green building; topsis; building energy efficiency.

1. INTRODUCTION

According to data from the National Bureau of Statistics, the total output value of the construction industry in Sichuan in 2019 exceeded 1 trillion, but at the same time, the total consumption of construction energy in Sichuan has not slowed down, and the problems of environmental pollution and energy waste have not been improved. Therefore, in order to alleviate the negative impact of building energy consumption on environmental resources and social development, as the second largest economic zone in Sichuan, it should bear the burden of its green building development and accelerate the pace of green building development.

Green building refers to a building that creates a feeling close to nature for residents, provides users with a healthy, environmentally friendly, comfortable and economical space, and saves resources to the greatest extent [1]. In recent years, with the arrival of Landsea Real Estate, Country Garden, Greenland Group, Wanda and other real estate companies, some green buildings have appeared in the Southern Sichuan Economic Zone. However, in terms of quantity, there are not many green buildings in the southern Sichuan urban agglomeration, and they are obviously behind Chengdu, Chongqing and other cities, showing that the green building market in the Southern Sichuan Economic Zone has yet to be developed. The establishment of scientific green building decision-making optimization is an important means to promote the continuous development of green buildings in the Southern Sichuan Economic Zone. Green building

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0015

optimization refers to the decision-makers related to green real estate to achieve their own goals, according to scientific theories and through certain scientific methods. And mathematical principles, and use certain procedures to analyze the design of green buildings to completion, evaluation, decision-making benefits, etc. until the optimal plan is obtained.

2. RESEARCH REVIEW

By consulting the relevant literature, it is found that the research on the optimization of green buildings at home and abroad mainly focuses on the following aspects:

(1) Focus on the optimization of green building design schemes. Bao Xueying [2] (2014) used the improved three-scale AHP method as the perspective to analyze the candidate indicators in the design stage of a certain green building project, and select the best plan based on expert scores; Weimin Wang [3] (2005)is based on simulation-based optimization technology to assist green building design, and proposed a model that can solve the problem of green building design optimization, such as level variables and coupling with simulation programs. The model mainly uses genetic algorithms to solve unconstrained and constrained single-objective optimization decision-making problems and unconstrained multi-objective optimization decision-making problems; Chang [4] (2011) established a gray stochastic programming model in order to realize the analysis of the complex system of green building design to solve the optimal design strategy under mixed uncertain conditions.

(2)Focus on the optimization of green building construction schemes. Zhang Min [5] (2017)analyzed the status quo of China's green building construction stage, starting from the perspective of value engineering, mainly taking the building ceiling of a China-Denmark green demonstration project as an example, and analyzing its value coefficient to study green building Optimization and selection of construction plan; Some scholars combine the green building construction process to analyze the technology not considered in the general construction process and energy-saving construction process, and choose the green building alternative design to obtain the optimal construction scheme.

(3)Focus on green building evaluation and optimization research and others. Han Xiao [6] (2012) refers to the green building evaluation standards, the cost and benefit of green buildings under the whole life cycle are analyzed, and the corresponding optimization results and the benefits to developers and consumers under corresponding circumstances are obtained.

Based on the above, through the research status of green building optimization at home and abroad, it can be found that:

(1) Most of the existing research focuses on the optimization of the green building design phase, which can increase the overall building energy consumption of the green building. A small number of the existing green buildings carry out the post-project evaluation work, and this aspect reduces Building energy consumption and improving the ecological environment are also very helpful, and have certain enlightenment for future real estate companies' decision-making.

(2) Most of the optimization studies of existing green buildings are studies on the construction plan of a single project. The research objects are also representative green building demonstration projects.this type of green building often applies more advanced green building technology, and their building energy consumption is relatively low. However, as far as the actual situation of green buildings in the Southern Sichuan Economic Zone is concerned, there is no such application example for the time being, and there are few existing researches involving green building research in an urban agglomeration, and there are few existing researches involving green building research on a city cluster. Therefore, based on the specific characteristics of green buildings in the Southern Sichuan Economic Zone, multiple green buildings are selected for horizontal comparison and analysis.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0015

(3) In addition, most scholars use methods such as AHP method, entropy weight method, value engineering method, catastrophe progression method, gray correlation method, etc. when evaluating green buildings and making decisions. These methods have their own advantages and a wide range of applications, but there are also many disadvantages. For example, the AHP method uses expert scores to assign weights, which is subjective and arbitrary, and the evaluation results are often not convincing; the catastrophe progression method only considers the relative importance of each index, but does not apply weight to the index; some scholars use fuzzy numbers and fuzzy clustering to analyze green buildings, this method is easy to ignore the interaction of various indicators, and the degree of idealization is high, which affects the accuracy of the final result.

Therefore, by analyzing the advantages and disadvantages of the above methods and considering the distribution of weights and the simplicity of decision-making methods, a comprehensive objective weighting method combining the coefficient of variation method and the entropy weight method will be adopted. Considering the number of indicators that need to be considered in the selection of green building projects in the Southern Sichuan Economic Zone, using the improved TOPSIS method to comprehensively consider each evaluation index, construct a model for combination empowerment and improvement of TOPSIS to carry out green building evaluation. It provides a new theoretical tool for the optimal decision-making of green building schemes in South Sichuan, and accelerates the further development of green buildings in the South Sichuan Economic Zone.

3. CONSTRUCTION OF EVALUATION SYSTEM

The promotion of green building in Sichuan Province started in 2005, and it has made certain developments in the past ten years, and has been increasing year by year since 2008, however, Sichuan Province has fewer policy documents on green buildings than coastal cities. There are not many green buildings in the Southern Sichuan Economic Zone, which is not in line with the status of the second largest urban agglomeration in Sichuan. How to effectively promote the development of green buildings in the South Sichuan Economic Zone is the key to whether the number of green building policies stipulated by the cities in southern Sichuan can be completed, So what are the important factors affecting the development of green buildings in the Southern Sichuan Economic Zone? On the basis of consulting related literature on green buildings in Sichuan Province and the existing research results of scholars, specifically analyze the situation of green buildings in the Southern Sichuan Economic Zone, and through screening and stratification of its various indicators, Finally, the evaluation system is constructed from six aspects: natural conditions, urban development, policies, green building technology, resource utilization and other factors, which can be further subdivided into 20 indicator levels ,as shown in Table 1.

4. COMBINATION WEIGHTING—IMPROVING TOPSIS MODEL CONSTRUCTION

4.1. Coefficient of Variation Method to Determine Index Weight

The coefficient of variation method is an objective method to calculate the degree of change of each index by using relevant statistical methods. According to this method, the index with greater variation has a greater weight, and the index with less variation has a smaller weight to determine its importance.

Table 1. Comprehensive evaluation index system affecting the development of green building projects

Decision goal	Middle layer	Index layer
Comprehensive evaluation index of green building	Natural conditions	Location
		Sunshine rate
		Air quality
	City development level	Urban residents' demand for green buildings
		Working capital invested
		Green building investment payback period
		Green building materials
	Policy	Government's mandatory documents for green buildings
		Government's incentive policies
		Standardization degree of green building evaluation system
	Green building technology	Green building technology R&D investment
		Green building environmental protection and energy saving technology
		Green building technical staff level
	Resource utilization	Rationality of construction land
		Water saving rate
		Building energy consumption
		Rainwater recycling capacity
		Acoustic environmental impact around the construction site
	Other factors	Promotion of green building
		Project management staff level

(1) Construct a standardized decision matrix $(y_{ij})_{m\times n}$.weighted decision matrix $(z_{ij})_{m\times n}$.

In order to eliminate the possible decision errors of each indicator due to the difference in the dimension and size of the evaluation index and the influence direction of the bid evaluation target, the decision matrix X needs to be processed in the same direction and dimensionless to construct a standardized decision matrix $(y_{ij})_{m\times n}$. In order to reduce the complexity of calculation, the range method is used here. Among them, the benefit-type and cost-type indicators are treated as follows:

$$y_{ij} = \{x_{ij} - \min(x_{ij})\} / \{\max(x_{ij}) - \min(x_{ij})\} \quad (1)$$

$$y_{ij} = \{\max(x_{ij}) - x_{ij}\} / \{\max(x_{ij}) - \min(x_{ij})\} \quad (2)$$

(2) Calculate the mean and standard deviation of the index data of the standardized matrix:

$$\overline{y_j} = \frac{1}{m}\sum_{i=1}^{m} Y_{ij}' \quad (3)$$

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0015

$$S_{\mathrm{i}}=\sqrt{\frac{1}{m}\sum_{i=1}^{m}(Y_{ij}^{'}-\overline{y_{i}})^{2}}\ ,\mathrm{i}=1,2,\ldots,\mathrm{m};\ \ \mathrm{j}=1,2,\ldots,\mathrm{n} \quad (4)$$

(3) Calculate the coefficient of variation of the index:

$$V_j=\frac{s_j}{\left|\bar{y}_j\right|} \quad (5)$$

(4) Process the coefficient of variation to obtain the index weight:

$$\varpi_{\mathrm{i}}^{\alpha}=v_j\Big/\sum_{j=1}^{n}v_j \quad (6)$$

4.2. Entropy Method to Determine Index Weight

Entropy method refers to the use of the amount of information of a certain index to judge the degree of influence of the evaluation index on the entire evaluation system. It can be used to describe the degree of dispersion between the index values of a specific evaluation index. The more obvious the degree of dispersion of the index value, the larger the corresponding information entropy value and the correspondingly larger the index weight; On the contrary, the weight is smaller. Since the entropy method can reflect some objective conditions of the index, the index weight value given by the entropy method is more credible than the expert method, fuzzy comprehensive evaluation method, etc., can greatly avoid subjective errors, and provide for the evaluation and optimization of multi-index programs Reliable basis. The basic idea is: in the above standardized decision matrix $(y_{ij})_{m\times n}$, for a given j-th index, the greater the difference of y_{ij} (i=1,2,…,m; j=1,2,…,n), the greater the role of the indicator in the comprehensive evaluation, that is, the greater the amount of information of the indicator, the smaller the uncertainty and the greater the entropy weight. The algorithm implementation process is as follows.

(1) Calculate the entropy value of the j-th index:

$$\mathrm{H_j}=-\frac{1}{In_m}\sum_{i=1}^{m}f_{ij}Inf_{ij} \quad (7)$$

In this formula, $f_{ij}=\frac{y_{ij}}{\sum_{i=1}^{m}y_{ij}}$. In addition, in order to avoid meaningless entropy value when calculating the logarithm, it is stipulated that when $f_{ij}=0$, $f_{ij}In(f_{ij})=0$ (j=1,2……n).

(2) Calculate the entropy weight of the j-th index:

$$\mathrm{W_j}=\frac{1-H_j}{n-\sum_{j=1}^{n}H_j} \quad (8)$$

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0015

(1-H_j)is the difference coefficient of the j-th index.

4.3. Determination of Comprehensive Index Weight

The methods for determining weights can generally be divided into two categories: one is subjective weighting method, which assigns weights through expert scores, which is subjective and arbitrary, and the evaluation results are often not convincing. The second is the objective weighting method, which is based on the objective data of the indicator to assign weights. Its advantage is that it has strong objectivity, but a single objective weighting method has a certain dependence on the data, and sometimes the weights will be biased. Therefore, in the evaluation process of the green building development, in order to prevent some indicators from being too discrete in individual weights when making decisions, a comprehensive objective weighting method combining the coefficient of variation method and the entropy weight method will be introduced. Integrating the advantages of the two weighting methods makes the final weight more reflective of the true objective situation. Under normal circumstances, the combination weighting method often adopts the linear weighted combination method, and the calculation formula for the comprehensive index weight is:

$$\omega_i = \alpha\omega_i^a + (1-\alpha)\omega_i^b \tag{9}$$

$\alpha \in (0,1), \omega_i \in (0,1)$, $\sum_{i=1}^{m} \omega_i = 1$, α is the ratio of the weight w_i^a determined by the coefficient of variation method to the combination weight; (1-α) is the ratio of the weight WIB determined by the entropy weight method to the combination weight. The combination weight ω_i changes with the change. When α=1and α=0, ω_i is a combination weighting method that becomes a single weighting method. In order to minimize the deviation of the weight values of the three weighting methods, the following objective function is established:

$$MinU = \sum_{i=1}^{m}[(\omega_i - \omega_i^a)2 + (\omega_i - \omega_i^a)2] \tag{10}$$

Simultaneous equations can get α=0.5.ω_i=0.5ω_i^a+0.5ω_i^b, the deviation generated at this time is the smallest.

4.4. 4.4 Improve the Construction of TOPSIS Model

TOPSIS is a sorting method that approximates an ideal solution, the ideal solution and negative ideal solution of the evaluation problem can be constructed simply and intuitively, and the Euclidean distance and closeness of the ideal solution and the negative ideal solution of the problem can be measured and sorted. However, when evaluating the overall situation of each green building, because the evaluation of a green building project consists of multiple parts, it may appear that some aspects of the green building project are particularly well-developed, which is the core selling point of the green building. Other important aspects of the project may be neglected. Therefore, the evaluation of green building projects only considers the closeness ranking of its various schemes, which is imperfect. It should also consider the balance of each evaluation index in the entire index evaluation system. Combining the short-board effect and the chain theory, that is, each evaluation index is related to a certain degree. When evaluating the pros and cons of a green building project, it is necessary not only to consider the quality of a single aspect, but also to consider all parts of the situation. Therefore, entering the equilibrium degree in the traditional TOPSIS method, the calculation steps of the improved TOPSIS model are as follows:

(1) Construct a standardized decision matrix $Y=(y_{ij})_{m\times n}$, weighted decision matrix $Z=(z_{ij})_{m\times n}$.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0015

(2) Determine ideal solution and negative ideal solution.

$$Z^{+}=\{(\max Z_{ij} \mid j \in J_1),(\min Z_{ij} \mid j \in J_2 | i=1,2,\ldots,m\}=\{Z_1^+, Z_2^+,\ldots, Z_n^+\}, \tag{11}$$

$$Z^{-}=\{(\min Z_{ij} \mid j \in J_1),(\max Z_{ij} \mid j \in J_2 | i=1,2,\ldots,m\}=\{Z_1^-, Z_2^-,\ldots, Z_n^-\}. \tag{12}$$

In the above formula, J_1 is the benefit index set, and J_2 is the cost index set.

(3) Calculate Euclidean distance and relative closeness

① Calculate the Euclidean distance between each solution and the ideal solution:

$$D_i^+ = \sqrt{\sum_{j=1}^{m} w_j (a_{ij} - a_{ij}^+)^2} \text{ .i=1,2…,m} \tag{13}$$

$$D_i^- = \sqrt{\sum_{j=1}^{m} w_j (a_{ij} - a_{ij}^-)^2} \text{ .i=1,2…,m} \tag{14}$$

② Calculate the relative closeness of each plan:

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \text{ .,i=1,2…,n} \tag{15}$$

According to the relative proximity, each green construction plan is sorted. The greater the proximity C_i is, the better the plan. Conversely, the smaller C_i is, the worse the plan will be. Therefore, under the same conditions, the solutions ranked first will be preferred by developers and purchasers.

(4) Introduce the degree of balance: Normally, there are multiple construction methods for the degree of balance, such as information entropy, standard deviation, and maximum difference degree. Now select the standard deviation structure, the formula is as follows.

$$B(x) = \frac{M}{N} \tag{16}$$

$M = \frac{1}{n}\sum_{j=1}^{n}(x_i - \frac{1}{n}\sum_{j=1}^{n} x_{ij})^2$ is the standard deviation of each index in statistics, reflecting the degree of dispersion of each index value from the average value, $N = \frac{1}{n}\sum_{j=1}^{n} x_{ij}$ is the average of each indicator.

(5) Comprehensive scoring method: The commonly used comprehensive evaluation scoring methods mainly include additive scoring method, multiplicative scoring method, and weighted additive scoring method. In order to calculate simple and intuitive, the multiplication scoring

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0015

method is selected. The general formula is $P=f(x_1,x_2,...x_n)=\sum_{i=1}^{n}x_i$, The comprehensive evaluation formula of the improved TOPSIS method is $P_i=C_i*B(x)$. According to the numerical value obtained by the comprehensive scoring method, combined with the optimization principle of the traditional TOPSIS method, the various green building construction plans are ranked, the larger P_i is, the better the plan is. On the contrary, the smaller P_i is, the worse the plan is. The comprehensive scoring method can more objectively and truly reflect the actual situation of each green building project. Therefore, under the same conditions, green building developers will give priority to green building developers.

5. EMPIRICAL ANALYSES

This paper selects 4 construction projects in the South Sichuan Economic Zone. One of the green buildings is a low-density livable ecological villa in a new urban area, the second is a small high-rise garden house in an urban area, and the third is a commercial and residential high-rise residential building in the urban area, the fourth green building is a large-scale high-end residential building. Through the green building evaluation index system, combining the coefficient of variation, the entropy method and the improved TOPSIS method, comprehensively prioritize the four green building projects in southern Sichuan from the perspectives of green building environmental protection and energy saving, construction investment, investment income, and construction period. The aim is to obtain green buildings that are more environmentally friendly, more profitable, and more popular with consumers, in order to provide a certain basis for future green building development and construction decisions in the Southern Sichuan Economic Zone. Considering that some indicator data is difficult to obtain and the data missing is relatively serious, the following 16 indicators are mainly selected for analysis. Table 2 shows the original data.

Table 2. Raw data of environmental protection and energy saving evaluation indicators for green buildings in the Southern Sichuan Economic Zone

Indicator/Green Building Project Plan	First project	Second project	Third project	Fourth project
Environmental investment A/(ten thousand yuan)	415	385	630	455
Green area B/(ten thousand yuan)	10000	15122.89	14715.95	11200.5
Environmental protection investment ratio C/(%)	2.16	1.28	0.63	1.95
Rainwater utilization capacity D (m^3/d)	50	72.35	311.28	74.7
Sewage pretreatment capacity E/ (m^3)	6.12	12.26	21.5	9.32
Sunshine rate F/(%)	1100	1289.8	1174.9	1216.2
Sales revenue G/(ten thousand yuan)	42908.07	77459.625	243000	51758.59
Average outdoor temperature H/(°)	17.5	18.3	17.3	18
Development period J/(month)	17	23	24	17
Daily dosage K/ (m^3/d)	244.42	377	1031.5	366.17
Daily displacement L/ (m^3/d)	167.62	281	825.2	255.28
Ambient air quality M/ (mg/m^3)	0.065	0.057	0.0573	0.065
Daytime environment N/(decibel)	50.6	55.625	53.725	50.6
Night sound environment O/(decibel)	39.7	46.65	44.313	39.4
Garbage from construction P/(t)	1172	1375.87	865	1400
Total investment I/(ten thousand yuan)	19224.8	30000	10000	23364

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0015

Data source description (The main data comes from the Urban Housing and Urban-rural Construction Bureau of the Southern Sichuan Economic Zone, and the weekly reports of green building projects.

(1) Same direction dimensionless standardization processing

The raw data of environmental protection indicators in Table 1 are subjected to dimensionless standardization, and the value of the normalized matrix Y_{ij} is:

Table 3. Normalized matrix Y_{ij}

Indicator/Green Building Project Plan	First project	Second project	Third project	Fourth project
A	0.122	0	1	0.286
B	0	1	0.921	0.234
C	1	0.425	0	0.863
D	0	0.086	1	0.095
E	0	0.399	1	0.208
F	0	1	0.395	0.612
G	0	0.173	1	0.044
H	0.2	1	0	0.7
I	1	0.867	0	0.949
J	1	0.143	0	1
K	1	0.832	0	0.845
L	1	0.828	0	0.867
M	0	1	0.963	0
N	1	0	0.378	1
O	0.959	0	0.322	1
P	0.426	0.045	1	0

(2) Combination weighting method to determine weight

①The coefficient of variation method determines the weight. Due to the limited space of the article, the results after each process are not repeated, and the final coefficient of variation method weight w_i^a is obtained.w_i^a=(0.079.0.057.0.049.0.099.0.067.0.052.0.096.0.060.0.039.0.063.0.042.0.042.0.072.0.052.0.053.0.078).

②The entropy method determines the weight. From the formulas (1) and (2) of the entropy method, the weight $\mathrm{w_i^b}$ can be calculated as w_i^b=(0.050.0.063.0.058.0.062.0.045.0.047.0.061.0.053.0.072.0.072.0.071.0.072.0.068.0.066, 0.064, 0.057).

③Combination weighting. The weights w_i^a and w_i^b of the coefficient of variation method and entropy method are integrated, and the combined weight $\omega_i=0.5\,\omega_i^a+0.5\,\omega_i^b$. Get the combined weight ω_i of each indicator:

ω_i =(0.065.0.060.0.054.0.081.0.056.0.049.0.079.0.056.0.055.0.067.0.056.0.057.0.080.0.059. 0.059.0.068),And the weighted matrix X_{ij} value is:

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0015

Table 4. The weighted matrix X_{ij} value

Indicator/Green Building Project Plan	First project	Second project	Third project	Fourth project
A	0.008	0	0.065	0.018
B	0	0.06	0.055	0.014
C	0.054	0.023	0	0.046
D	0	0.007	0.081	0.008
E	0	0.022	0.056	0.012
F	0	0.049	0.019	0.03
G	0	0.014	0.079	0.003
H	0.011	0.056	0	0.039
I	0.055	0.048	0	0.053
J	0.067	0.01	0	0.067
K	0.056	0.047	0	0.048
L	0.057	0.047	0	0.049
M	0	0.08	0.077	0
N	0.059	0	0.022	0.059
O	0.056	0	0.019	0.059
P	0.029	0.003	0.068	0

(3) Determine the ideal solution and its Euclidean distance

①Determine the positive ideal solution Z^+ and negative ideal solution Z^- of the weighted normalized matrix, and the results are as follows : Z^+={0.065.0.060.0.054.0.081.0.056.0.049.0.079.0.056.0.055.0.067.0.056.0.057.0.080.0.059.0.059.0.068}. Z^- ={0.000.0.000.0.000.0.000.0.000.0.000.0.000.0.000.0.000.0.000.0.000.0.000.0.000.0.000.0.000.0.000}.

②Calculate the Euclidean distance between the positive ideal solution Z^+ and the negative ideal solution Z^- of each index: D_i^+={0.183.0.140.0.145.0.156}.D_i^-={0.131.0.154.0.171.0.132}.

(4) Calculate the relative closeness C_i, balance and ranking

①The relative closeness C_i ={0.417.0.524.0.542.0.458},The order of closeness is $C_3>C_2>C_4>C_1$.

②Balance P_i ={0.474.0.565.0.530.0.516} ,sort the balance degree of the 4 schemes from large to small, and you can get: $P_2>P_3>P_4>P_1$.Combining the selection principle of combination weighting scheme and the optimization principle of the improved TOPSIS method, the larger the P_i of the scheme, the higher the relative development value of green buildings. Therefore, the four green building priorities are: Second project, Third project, Fourth project, First project. It can be concluded that the optimal plan for the development of green buildings in southern Sichuan is Second project, followed by Third project. In other words, among the four different types of green buildings, a small high-rise garden house in an urban area and a commercial and residential high-rise residential building in an urban area have relative development value.

(5) Result analysis

① Compare the comprehensive portfolio weights. Sort the weights obtained after combination weighting, and the weight difference of each indicator is not significant. The top

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0015

six are rainwater recycling capacity, ambient air quality, sales revenue, garbage generated by construction, length of development period, and investment in environmental protection. Regarding the indicators selected in this article, real estate developers should focus on these six indicators in future development decisions to promote the continuous development of green buildings in the Southern Sichuan Economic Zone.

② Analysis of the results of the three weighting methods. Bring in the weights of the coefficient of variation method and the entropy method respectively, and get the equilibrium degree under the weight of the coefficient of variation method is {0.392.0.501.0593.0.450}.the equilibrium degree obtained under the weight of the entropy method is {0.551.0.631.0.467.0.581}.Plotting the equilibrium degree obtained by the three methods into a columnar discount graph, the optimal evaluation results obtained are basically the same. This verifies the feasibility of combined weighting method and improved TOPSIS method to some extent. However, the results of the three methods have certain deviations, mainly due to the use of the coefficient of variation method and the entropy weight method to obtain discrete and fluctuating data, there may be deviations in the actual optimization evaluation, which deviates from the actual situation. The combined weighting method will relatively shrink the more discrete values in the evaluation system, and will automatically process some higher or lower values, and the overall weighted result will tend to be stable without obvious discrete distribution.

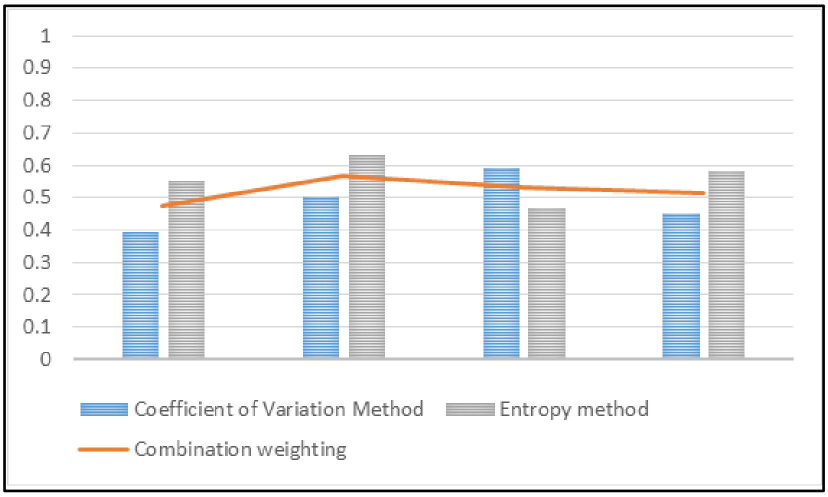

Fig 1. Comparison of the balance of the three weighting methods

③Analyze the results obtained by the traditional TOPSIS method and the improved TOPSIS method. It can be seen from the line chart of Figure 2 that after the analysis of the equilibrium degree, it is found that the values of the green building projects have roughly the same trend. Some data fluctuate, which shows that although some green building projects are doing well in some aspects, they are not doing well in some indicators, and they have not developed in a balanced and coordinated manner. It verifies the rationality of improving the TOPSIS method to some extent.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0015

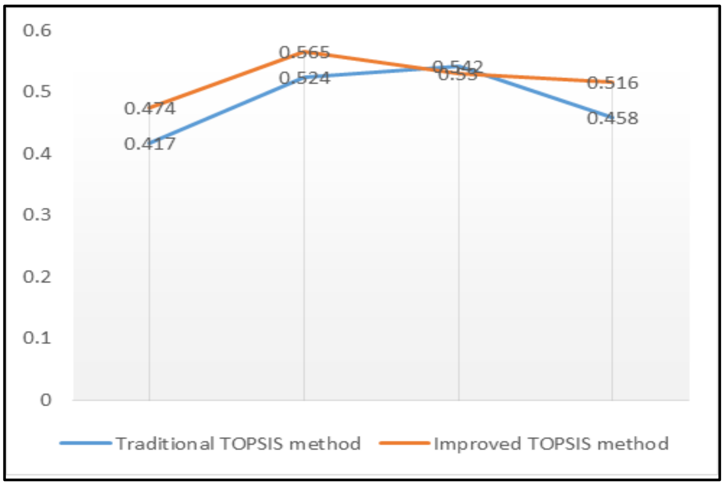

Fig 2. Comparison of traditional TOPSIS method and improved TOPSIS method

6. CONCLUSIONS

The combined weighting and improved TOPSIS method is applied to the optimal decision-making of green building schemes in southern Sichuan, and the coefficient of variation method and entropy method are introduced to determine the weight of indicators, which effectively compensates for the lack of single objective weighting and reduces the weight deviation. Improve the rationality of the evaluation process and results, make the evaluation results closer to the actual situation of the South Sichuan Economic Zone, and provide a certain basis for measuring the development of green buildings in the South Sichuan Economic Zone and for future real estate development decisions. It is concluded that in the future development of green buildings in the Southern Sichuan Economic Zone, green buildings should be combined with energy-saving technologies, air quality, and environmental protection investment, and focus on green houses such as small high-rise garden houses in the urban area and high-rise residential buildings in urban areas. However, it needs to be pointed out that the combined weighting and improvement TOPSIS method can only horizontally compare the relative advantages and disadvantages of various green building schemes, and then optimize the schemes, and cannot truly reflect the absolute level of merits and disadvantages of each scheme. In actual applications, the indicators of different green building projects are not the same, the relevant green building decision makers should combine the differences of specific construction projects to improve the rationality of the evaluation index weights. Make the corresponding green building construction plan optimal, and provide a certain reference for subsequent green building projects.

REFERENCES

[1] Qin Xuan, Li Huaiquan, Mo Yiyi. Study on construction and evaluation of green building project risk network based on SNA perspective. China Civil Engineering Journal. Vol. 50(2017)No. 2, p. 119-131.

[2] Bao Xueying, Wang Qicai, Wang Enmao. Application of Improved Analytic Hierarchy Process in the Selection of Green Building Design Schemes. Building Science Research of Sichuan. Vol. 40 (2014)No. 2, p. 320-322+326.

[3] Weimin Wang, Hugues Rivard, Radu Zmeureanu. An object-oriented framework for simulation-based green building design optimization with genetic algorithms. Advanced Engineering Informatics. Vol.19 (2005)No. 1 , p. 5-23..

ISSN: 2472-3703
DOI: 10.6911/WSRJ.202010_6(10).0015

[4] Ni-Bin Chang, Brian John Rivera, Martin P. Optimal design for water conservation and energy savings using green roofs in a green building under mixed uncertainties. Journal of Cleaner Production. Vol.19(2011)No. 11, p. 1180-1188.

[5] Zhang Min, Zhan Wei, Ai Yongfei. Application research on optimization of green energy-saving building construction scheme based on value engineering. Value Engineering. Vol. 36(2017) No. 15, p. 50-53.

[6] Han Xiao, Li Baiyi, Fu Xiaohui. Research on Green Building Optimal Decision Model Based on Life Cycle. Sichuan Architecture. Vol. 32 (2012)No. 3, p. 61-62.