frontiers | Frontiers in Ecology and Evolution

TYPE Original Research
PUBLISHED 04 January 2023
DOI 10.3389/fevo.2022.1094535

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OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Environmental Informatics and Remote Sensing,
a section of the journal
Frontiers in Ecology and Evolution

RECEIVED 10 November 2022
ACCEPTED 30 November 2022
PUBLISHED 04 January 2023

CITATION
Lyu C, Hu J, Zhang R, Chen W and Xu P (2023) Optimizing the evaluation model of green building management based on the concept of urban ecology and environment.
Front. Ecol. Evol. 10:1094535.
doi: 10.3389/fevo.2022.1094535

Optimizing the evaluation model of green building management based on the concept of urban ecology and environment

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Eco-city and green building are the global development strategies today. In order to improve the management level of green buildings in the urbanization process, a reciprocal symbiosis evaluation index model is proposed based on the theory of urban ecology. On this basis, the collaborative relationship model between Eco-city and green building is established, and the green building management framework based on the collaborative theory is constructed. The expert survey method was used to determine the evaluation indicators and analyze the relationship between various city subsystems. Then, the analytic hierarchy process is used to build a three-level evaluation index system, including the target layer, the criterion layer, and the index layer. The weight of the evaluation index system is calculated by combining of the chromatography method and the entropy weight method, and a scientific evaluation index system is established. The gray comprehensive evaluation method is used to evaluate the construction of the green building management system. Based on the index system, the analytic hierarchy process is used to calculate different weight coefficients, which makes the evaluation model easy to use and lays a foundation for subsequent research.

KEYWORDS

optimization of urban ecology, urban ecology concept, green building, entropy weight method, environmental evolution ecology

Introduction

The development of human society has led to the progress of industrial technology. The rapid development of the industry will take a large number of natural resources as the cost of consuming resources (Ernstson et al., 2010; Susca et al., 2011; Wolch et al., 2014; Haaland and van Den Bosch, 2015). If there is not enough social support to solve this problem, it is obvious that there will be a large-scale economic crisis soon. Currently, many countries still adopt the development mode at the expense of the natural environment and the consumption of non-renewable resources to develop their economies. Still, this mode will inevitably lead to engineering disasters (Cui et al., 2021; Li et al., 2021, 2022), serious environmental pollution, and resource abuse, and the ultimate consequences will be borne by humans (He and Kusiak, 2017; Li et al., 2021; Zhou et al., 2021). In addition, nowadays, the security, reliability, and availability of energy resources are essential for societies' stability and economic development (Umbach, 2010; Cherp and Jewell, 2011; Owusu and Asumadu-Sarkodie, 2016; Beheshtian et al., 2022; Jafarizadeh et al., 2022). Climate changes, insecurity of energy carriers (mostly renewable), and the growth of energy consumption have created many challenges in the field of energy and the environment (Kok and De Coninck, 2007; Mohanty, 2012). Therefore, in recent years, ideal concepts such as the concept of ZE or ZERO ENERGY have been used the attention of different countries has been focused on reducing the dependence on non-renewable energy sources (Elum and Momodu, 2017; Melnyk, 2020). The increase in energy demand, the limitation of fossil energy sources, the increase in their prices, and the lack of security and stability of the energy market in the last decade are the basis of the issue of pollution and global warming (Kaygusuz, 2007; Lefèvre, 2010; Sharvini et al., 2018; Najafi and Lajmorak, 2020; Rajabi et al., 2021). It is a new approach in the matter of energy (Tabasi et al., 2022). In the new perspective, two basic solutions are considered. (A) Optimizing consumption (reducing or controlling demand) and energy production; (B) Using alternative energy sources, mainly renewable energies.

The construction of cities and the development of buildings are inseparable (Zheng et al., 2017; Liu, 2018). Green buildings are the means of realization and urban ecology is the goal orientation (Ward et al., 2002; Jansson, 2013). To promote the ecological development of cities, we must change the management mode of architectural development. Many scholars, based on the background of big data, use machine learning and network iteration methods (Ottelé et al., 2011; Colding and Barthel, 2013; Perini and Magliocco, 2014; Cheng et al., 2021; Li, 2022) to solve the above problems. Then, urban ecological construction is the basic work of environmental protection and rational utilization of resources. As the main energy consumption body, we must start with urban construction, change the original urban development mode, and build an ecological and environmental protection green building management system to improve the construction concept of urban development. This is also the inevitable trend of the development of human life, and it is impossible to violate the natural law of the development of things (Lindberg and Grimmond, 2011; Derkzen et al., 2015).

At this stage, the mode of traditional urban development cannot be shared globally. Therefore, building a green ecological city is an advantageous way to solve the morbid situation of major cities at this stage. Under the endorsement of urban ecological theory, the evaluation model of building management system is constructed with green building as the connotation. The construction of the new magic heart can serve the construction management industry and achieve the goal of ecological city construction.

Zhang et al. (2011), in an article titled "green strategy for gaining competitive advantage in housing development: a China study, "investigated the benefits and resources of using green strategies in housing development and its infrastructure management. In this study, general green elements are identified and green elements that have been adopted in practice, such as solar systems, green technology and low-energy insulating windows, are highlighted, and also show the significant obstacles in using green elements. The main research question is why housing developers go green despite the obstacles in this market. This paper focuses on identifying green strategies implemented by housing developers. In addition, the government's guidance and commitments in promoting green housing development can motivate housing developers to adopt a green strategy (Zhang et al., 2011).

Sedlacek and Maier (2012), in an article titled "can green building councils serve as third party governance institutions? An economic and institutional analysis" They have examined these organizations' role from a construction perspective in the real estate industry and under what conditions green building councils can positively contribute to a greener or more sustainable building market development. This research shows the information that exists in connection with the identification of the quality of the building and can be a strong incentive for the fraud of developers and strongly hinders the development of the market of "green" or "environmentally friendly" buildings (Sedlacek and Maier, 2012).

Gou et al. (2013), in an article titled "Are green buildings more satisfying and comfortable?" They have investigated the comfort and well-being of residents of green buildings. This research shows that green building users get more comfort from their buildings and they believe it is more balanced to achieve an overall assessment of good versus bad features, which has important implications for designing green-friendly projects. It is the environment. Comparing the results with similar studies shows that the publication of satisfaction scores for green buildings has been a broad goal, that is, for green buildings, give a broader goal and there is a greater desire than the best conventional buildings (Gou et al., 2013).

Torgal (2013) have written a book entitled "nearly zero energy building refurbishment," and have investigated methods for the restoration and reconstruction of old buildings using renewable energy. In this book, An attempt has been made to provide readers with information about the creation of zero-carbon buildings (Torgal, 2013).

Di Giuseppe (2013) wrote a book entitled "nearly zero energy buildings and proliferation of microorganisms," which is a brief review of physical-thermal phenomena that regulate heat and humidity in zero energy buildings and are related to the growth of biological organisms. It also states that the consequences of biological growth are in durability, aesthetics and human health. Finally, through an examination of recent developments, it examines measures to deal with biological phenomena and provides an outline for future innovations (Di Giuseppe, 2013).

Chan et al. (2009) in an article entitled "market for green building in developed Asian cities - the views of building designers" green building and construction market situation in the common market in front of building construction as well as general logical reasons related to investment in green build and market have been considered by the designers from the point of view of construction. Examining the case and obtaining the reasons, and the obstacles of the popularity factors have also been investigated for the main factors and they have identified the aspect. This study of the situation gives a good insight into the current view of the building designers of the green building market in Hong Kong and Singapore. The findings show that government intervention, special incentives and economic supports are an option for investors who want to have interests in green building and investment (Chan et al., 2009).

Green building management system with urban ecology as the core

The meaning and development of urban ecological concept

Since the 19th century, scholars have been deepening the ecological theory summarized in exploring the law of natural ecological development (Rosindell et al., 2012; Shen, 2013). This theory reflects the important understanding of ecological protection and ecological balance. The ecological theory covers urban development, residents' lifestyle and top technology development in the future. It is an important method to realize the symbiosis between human and nature, the process of urbanization and the unified development of ecology. Eco city is the goal of future cities. The road of development requires the continuous development of science and technology and the continuous improvement of natural environment integration. Only in this way can we ensure the residents' physical and mental pleasure and the high-quality development of the environment. It is a human living place that gathers materials, capabilities and information for efficient utilization and ecological recycling.

Connotation and development of green building management system

The concept of green building refers to the idea of saving resources to the greatest extent, reducing the waste of resources and reducing the pollution caused by buildings to the environment in the whole life cycle, to improve people's high-quality life, ensure people's life and health, improve the comfort of human living space, and achieve the harmonious coexistence of architecture and nature. In the 1990s, many western developed countries first paid attention to the field of green building and put forward a series of evaluation indicators, which are most famous for LEED in the United States and breed-am in the United Kingdom (Tongtuam et al., 2011; Mishra et al., 2013; Wu et al., 2016; Ravasio et al., 2020). In 2014, China issued new green building evaluation criteria. It takes LEED and BREEAM as templates. It mainly refers to the process of green building evaluation. At the beginning of this century, it is significant to build a green building ecological city in China (show Figure 1).

The traditional building mode needs to consume a lot of social resources and bring huge pollution to nature. Therefore, the green building management system based on the ecological city theory is very necessary in the urbanization process. As shown in Figure 1, it is the schematic diagram of a green building management system based on Eco urbanism.

Definition of the mutually beneficial symbiotic management system

The term "system" refers to the fact that each element within a certain range or among the same kind follows a specific order and has internal relations (Cox, 1981). The management system is a system that aims at the object of management, formulates management objectives and policies, and achieves its objectives according to certain methods (Shee and Abratt, 1989; Logenthiran et al., 2012).

The mutually beneficial symbiosis management system refers to the system established to realize the mutually beneficial symbiosis and common development of green buildings and ecological cities by formulating corresponding management objectives and policies, guiding the development of low-carbon buildings with the concept of ecological cities, and promoting the construction and development of ecological cities with the concept of low-carbon buildings according to certain management principles (Li et al., 2012; Zhou, 2012; Yu, 2014; De Jong, 2015).

Design of green building management method based on urban ecology

The construction industry can provide many jobs and promote the development of the national economy. Doing a good job in green building management is also conducive to protecting and constructing the ecological environment. Then, the establishment of an all-green building management system is not only a problem to be faced in the development of the construction industry but also a difficult problem to be overcome in the construction of an ecological city. Researchers must pay attention to it. With the continuous deterioration of the global environment, more and more scholars realize the importance of Eco-city construction and give the following construction methodology.

Components of sustainable development related to green building

In order to understand the roots of green building, one must first understand the components of sustainable development, then analyze their role in creating green building (Kibert, 2004; Furr, 2009). In sustainable human development, health, a healthy life, and harmony with nature are introduced as the axis of

FIGURE 1
Schematic diagram of green building management system based on Eco urbanism.

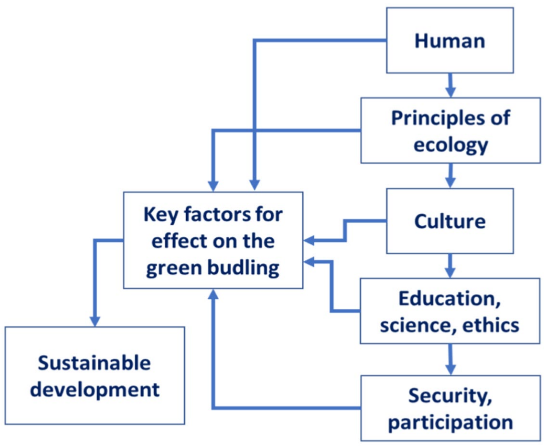

FIGURE 2
The relationship between green building and sustainable development components.

development and are deserved. Green buildings, with their therapeutic and sanitary properties, are also a step in the direction of a healthy life for the residents of the region and human-centered design (schematic show in the Figure 2; Reed, 2009; Kibert, 2016; Darko, 2019).

Favorable culture, development factor

In the past, development was an attempt to "westernize" the world by pretending to be culturally and politically neutral. In fact, under the assumptions of ideological bias, the West was presented as "desired perfection" (Van Oord, 2007). Development in this way was a tool for Western countries benefiting from advanced technology to humiliate and destroy the culture and self-government of other nations and people (Xiaoquan, 2020). In recent years, the importance of culture and its true place in the debate has grown in light of various criticisms, as well as the deepening and expansion of awareness about the ineffectiveness of previous assumptions and theories, and especially with the building that the economy alone cannot provide a program for welfare and by human dignity (Morrow and Torres, 1995; Alvesson and Berg, 2011). The culture was also emphasized in the studies and analyses and the components of economy, environment, and social issues (Ho et al., 2012). It is obvious that by accepting culture as a principal pillar of sustainable development, the way was opened to enter other spiritual and immaterial components (Lehtonen, 2004; Stylianou-Lambert et al., 2014).

Preservation of the environment

The fact is that paying attention to the environment and nature has become a standard in our time, a standard that is becoming more common in the world every day (Lampland and Star, 2009; Csikszentmihalyi and Nakamura, 2010). In an environmental perspective, development is sustainable only based on ecological principles (Dewulf and Van Langenhove, 2005; Burns, 2011). The most important feature of the green roof is that it moves in the direction of nature's ecological principles. Plants have many benefits, both on the ground and hidden in the water and on the roof (van der Meulen, 2019; Jing et al., 2022). In photosynthesis, plants use solar energy to convert carbon dioxide into chlorophyll and oxygen. Leaves collect dust, spread moisture in the air, and produce soil. Plant roots hold soil and prevent soil erosion by keeping sediments on the banks of rivers. The roots of plants and their enzymes and fungi purify rainwater and improve the environment (Prospero, 2002). Transferring this process to the roof provides the basic benefits of flood control, energy savings, environmental ecology, and aesthetic benefits.

Determination of evaluation index system

After the completion of the green building management system, a perfect evaluation system is needed to test the construction results, especially under the guidance of the concept of ecological city, this diversified evaluation system should be used repeatedly as the basis for judgment. Then, only a scientific, objective, independent and factual evaluation system can ensure that the green building management system built does not deviate from the grand goal of ecological city. In the process of building the evaluation system, we must combine the characteristics and advantages of each city, put forward highly targeted evaluation indicators, and ensure the dynamic development, keep pace with the times, and meet the actual situation in the process of social and economic development. After deeply analyzing the structure and connotation of eco city development, this paper determines the hierarchical structure of the evaluation index system as three layers: target layer, quasi measurement layer and index layer. The target level is the green building management level based on the ecological city; The criterion layer is constructed according to the core elements of urban construction. At the index level, according to the connotation and characteristics of smart ecological city construction, after consulting relevant data, the index with importance less than 6 points in the expert questionnaire is selected. Therefore, combining the two methods is considered to make the weighting result as close as possible to the actual situation. In this paper, AHP and entropy weight method complement each other. The combination of the two meets the requirements of quantitative and qualitative analysis. It also makes the weight value of indicators more reasonable. Finally, an evaluation index system including 5 and 29 three-level indicators is formed, as shown in Table 1.

Weight determination by chromatography

After the hierarchical structure of the evaluation index system is determined, the subordinate relationship between the upper and lower levels is determined. The relative importance of each index at the same level is judged by expert judgment. In order to improve the accuracy of comparison, facilitate two-phase comparison, and reduce the comparison difficulties caused by many factors such as different properties of the indexes, the nine-level scale is introduced, as shown in Table 2.

a_{ij} in the judgment matrix represents the degree of importance of the elements I and J. After comparing all the indexes, the judgment matrix is obtained. Since the judgment matrix is orthogonal, the index on the diagonal of the matrix is 1, and the positions on both sides are reciprocal to each other.

In the hierarchical structure of the evaluation indicator system, there are multiple indicators except for the target level. The purpose of constructing the matrix is to quantify the indicators of this level for the convenience of judgment due to the different influence of the indicators of this level relative to the indicators of the previous level. For example, take the indicators B_1... Bn of the target level smart ecological city construction level and the next level criterion level to build a matrix to judge the relationship between level A and level B indicators (Equation 1).

$$A = \begin{pmatrix} b_{11} & \cdots & b_{1m} \\ \vdots & \ddots & \vdots \\ b_{n1} & \cdots & b_{nm} \end{pmatrix} \tag{1}$$

Calculate the product Mi of the elements in the judgment root (Equation 2).

$$\mathrm{M_i} = \prod_{j=1}^{n} b_{ij} \left(i = 1,2,3 \ldots n \right) \tag{2}$$

TABLE 1 Evaluation index system.

Target layer A	Sub target layer	Indicator layer
Green building management system A	Architectural environment B_1	Indoor Air Quality C_{11}
		Indoor light quality C_{12}
		Indoor thermal qualityC_{13}
		Indoor sound quality C_{14}
		Energy system optimization C_{15}
		Renewable energy utilization C_{16}
	Community environment B_2	Equipment selection C_{21}
		Energy recovery C_{22}
		Public lighting C_{23}
		Sewage treatment and recycling C_{24}
		Rainwater collection and use C_{25}
		Water saving facilities appliances C_{26}
	Global environmental impact B_3	Place and address C_{31}
		Per capita residential land C_{32}
		Architectural style C_{33}
		Spirit of place culture C_{34}
		Public space accessibility C_{35}
		Ozone consumption C_{36}
		Sulfide from combustion C_{37}

TABLE 2 Grade 9 scale.

Grade	Interpretative statement
1	Comparison of index i and index j, equally important
3	Comparison of index i and index j, i indicators are slightly important
5	Comparison of index i and index j, i indicators are obviously important
7	Comparison of index i and index j, i indicators are strongly important
9	Comparison of index i and index j, I indicators are extremely important
1/3	Comparison of index i and index j, i indicators are slightly less important
1/5	Comparison of index i and index j, i indicators are obviously secondary
1/7	Comparison of index i and index j, i indicators: strong (secondary)
1/9	Comparison of index i and index j,i indicator and j indicator are compared, i indicator is extremely secondary

Remarks: Take 2, 4, 6, 8, 1 /2, 1 /4, 1 /6, 1/8 as the intermediate value between all the above judgments.

The nth root of Mi $\overline{W_i}$ (Equation 3).

$$\overline{W_i} = \sqrt[n]{M_i}\left(i = 1,2,3\ldots n\right) \tag{3}$$

Normalize the vector $\overline{W_i}$,calculate the weight vector Wi (Equation 4).

$$W_i = \frac{\overline{W_i}}{\sum_{i=1}^{n}\overline{W_i}}\left(i = 1,2,3\ldots n\right) \tag{4}$$

Calculate the maximum eigenvalue of the judgment matrix $\lambda_{\max}$ (Equation 5).

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{\left(AW\right)_i}{W_i}\left(i = 1,2,3\ldots n\right) \tag{5}$$

Check the consistency of the matrix (Equation 6):

$$CI = \frac{\lambda_{\max} - n}{n-1} \tag{6}$$

The average random consistency index RI is introduced to measure whether the consistency of judgment matrices with different orders meets the requirements and eliminates the influence of Order CI. When the order $n > 2$, the consistency ratio of the judgment matrix CR = CI / ri; when $CI < 0.10$, it is considered that the consistency of the judgment matrix meets the requirements; When $CI > 0.10$, the judgment matrix is considered. $CI < 0.10$ is the standard for conformance.

Entropy weight method to determine the weight

The original evaluation matrix is first constructed when there are m evaluation objects and N evaluation indexes show in Equation 1.

The physical quantity attributes and units of each indicator are different. Due to different concepts, it is impossible to compare and calculate each other directly. Therefore, before calculation, it is necessary to standardize (Equations 7 and 8).

$$\text{Positive indicator } \mathrm{Y_{ij}} = \frac{x_{\mathrm{ij}} - minx_{\mathrm{ij}}}{maxx_{\mathrm{ij}} - minx_{\mathrm{ij}}}\left(i = 1,2,3\ldots n\right) \tag{7}$$

$$\text{Negative indicator } \mathrm{Y_{ij}} = \frac{maxx_{\mathrm{ij}} - x_{\mathrm{ij}}}{maxx_{\mathrm{ij}} - minx_{\mathrm{ij}}}\left(i = 1,2,3\ldots n\right) \tag{8}$$

After the indicator data is standardized, some indicator values may be small or negative. In order to simplify the calculation, the processed value needs to be translated to change the situation where the value is small or negative (Equation 9).

$$x'_{\mathrm{ij}} = H + x'_{\mathrm{ij}} \tag{9}$$

Where, h is the exponential translation, usually 1.

The proportion of index *xij* in index j in the i_{th} evaluation object (Equation 10).

$$P_{\mathrm{ij}} = \frac{x_{\mathrm{ij}}}{\sum_{i=1}^{n} x_{\mathrm{ij}}} \tag{10}$$

Calculate information entropy (Equation 11):

$$e_{\mathrm{ij}} = -\frac{1}{\ln n}\sum_{i=1}^{n} P_{ij}\ln P_{ij} \tag{11}$$

Calculate weight (Equation 12):

$$W_{\mathrm{ij}} = \frac{1 - e_{\mathrm{ij}}}{n - \sum_{j=1}^{n} e_{\mathrm{ij}}} \tag{12}$$

Using analytic hierarchy process to calculate the weight of evaluation indicators at all levels $W_{\mathrm{layer}} = \left(W_{\mathrm{layer1}}, W_{\mathrm{layer2}} W_{\mathrm{layer3}}, \cdots, W_{\mathrm{layern}}\right)^T$, the entropy weight method is used to calculate the weight of each evaluation index $W_{\mathrm{entropy}} = \left(W_{\mathrm{entropy1}}, W_{\mathrm{entropy2}} W_{\mathrm{entropy3}}, \cdots, W_{\mathrm{entropy}}\right)^T$. The weights calculated by the two methods are combined to obtain the weights of the evaluation indicators at all levels, i.e., the combination weighting equation (Equation 13).

$$W_{\mathrm{i}} = \frac{\sqrt{W_{\mathrm{layeri}} \times W_{entropyi}}}{\sum_{i=1}^{n}\sqrt{W_{\mathrm{layeri}} \times W_{entropyi}}} \tag{13}$$

10.3389/fevo.2022.1094535

Evaluation model weight calculation results

Construction and assignment of judgment matrix by chromatography

In this paper, 10 experts from relevant departments and scientific research institutes are selected to conduct a questionnaire survey, score the first and second level indicators, give a score of 1–9 to the importance degree, take the geometric average value of the collected data, and obtain the importance of each indicator. Then, the AHP method is used to calculate the product Mi of the elements of each row B in the A matrix and the n_{th} root of Mi, and then normalize the data to calculate the maximum characteristic root $\overline{W_i}$, Finally, the consistency $\lambda_{\max}$ test was carried out.

The overall objective level judgment matrix: the construction of smart ecological city is a, the Architectural environment is B_1, the Community environment is B_2, the Global environmental impact is B_3, the infrastructure index is B_4, and the innovation ability index is B_5. The results of the judgment matrix are shown in Figure 3.

The weights calculated by the two methods are combined to obtain the weights of each evaluation index, as shown in Figure 4.

This chapter studies the existing evaluation system, summarizes the existing problems, such as weak emphasis on indicators, and constructs the evaluation index system according to the construction principles. Through the How Net search, the expert questionnaire survey method has preliminarily determined the indicators. Based on the analytic hierarchy process, a three-level indicator system has been constructed consisting of the target level, the criteria level, and the indicator level. Among them, the target layer is to measure the construction of smart ecological city. The criterion layer includes five first-class indicators, corresponding to 29 s-class indicators of the indicator layer. The chromatography and entropy weight method is used to calculate the index weight, which combines qualitative and quantitative methods. It improves the defect caused by the original qualitative or quantitative method for determining the evaluation index weight.

Establishment of evaluation model by grey system correlation method

Stable site design

Sustainable site design aims to minimize urban sprawl and the destruction of valuable land (Couch, 2008; Hepcan, 2013). Encouraging the development of urban density, city reconstruction, and the development of the use of brownfields to maintain green space are among the solutions of sustainable site design (De Sousa, 2003; Jim, 2004; Scott, 2016). This principle, when new development is inevitable. It became efficient to protect the places that play a key role in the ecosystem (Blowers, 2013). Other solutions that this principle suggests in green building design include: evaluating each place according to local laws, building proper orientation for optimal use of solar energy and natural light, and natural wind for ventilation, maximizing the use of surfaces and using light-colored buildings, providing natural shadows from buildings and paved areas with trees and other mixed landscapes, preserving the natural ecosystems of the region and using drought-resistant trees, reducing light pollution at night by avoiding of clarification as much as possible (Anselm, 2006; Dehghani-sanij et al., 2015).

Calculation steps of evaluation model

The model bridges theoretical research and practical application of the grey system. The most important thing of grey correlation analysis is determining the optimal sample. In this paper, there are positive indicators and negative indicators. The maximum value of positive indicators and the minimum value of negative indicators are taken as the optimal samples. There are 7 steps in the process of grey correlation analysis.

Step 1: select a reasonable method to determine the reference sequence; The second is to determine the comparison series. Generally, in the process of establishing the series, the standard optimal series will be taken as the reference series, and the obtained indicators that need to be evaluated will be taken as the comparison series; Third, according to the determined reference number series, the original data of the indicators are dimensionless quantized to make the indicator data comparable; Fourth, calculate the absolute difference between the comparison series and the reference series; The fifth is to find the grey correlation coefficient of the index system; Sixth, calculate the grey correlation degree and arrange the correlation order; Seventh, calculate the comprehensive evaluation coefficient and analyze the results of comparative samples (Equations 14 and 15).

Establish reference series (Equation 14).

$$x_0 = \{x_0(k)\} \tag{14}$$

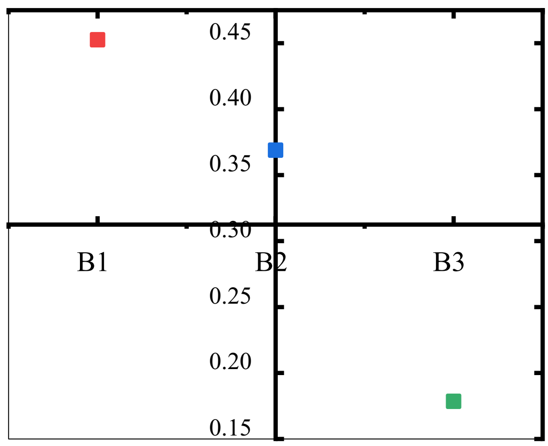

FIGURE 3
Total target judgment matrix value.

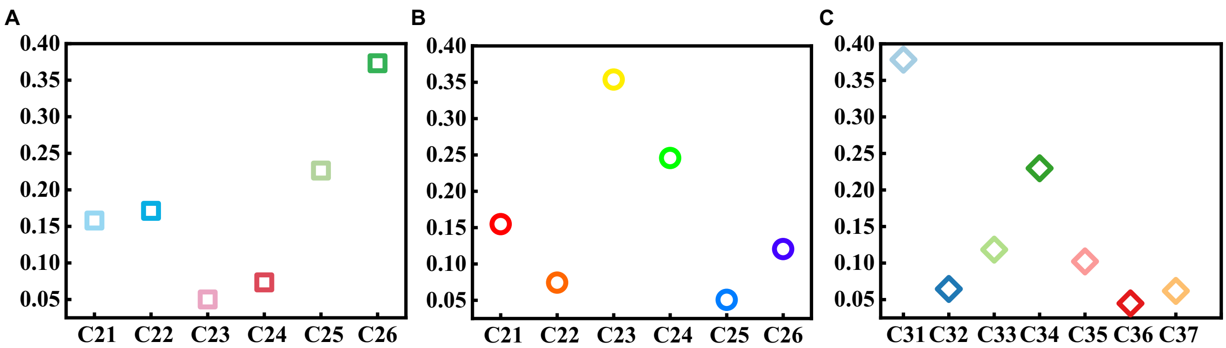

FIGURE 4
(A) Weight value of architectural environment B_1; **(B)** Community environment B_2; **(C)** Global environmental impact B_3.

Establish comparison series (Equation 15).

$$x_i = \{x_i(k)\} \tag{15}$$

Calculate the absolute difference between the comparison series and the reference series (Equation 16):

$$\left|x_{ij} - x_{0j}\right| = "\ _{0i}(J))_{n\times p} \tag{16}$$

Grey correlation coefficient is the embodiment of correlation in grey theory. Correlation essentially refers to the degree of difference in geometry between curves, so the difference between curves can be used to measure the degree of correlation. The correlation coefficient in the grey correlation analysis is the geometric distance between the reference sequence and the comparison sequence at each time point. The higher the value, the higher the correlation between the corresponding two indicators.

The calculation formula of comprehensive grey correlation degree obtained by weighted average of grey correlation coefficient and combination weight is as follows (Equation 17):

$$r_{0j} = \sum_{j=1}^{p} \omega_j \xi_{0j}(j)\, i = 1, 2 \ldots n \tag{17}$$

In order to keep consistent with the percentage system, the scale coefficient in this paper is taken as 100 (Equation 18).

$$\mathrm{E} = \mathrm{i} \times 100 \tag{18}$$

Calculation steps of the evaluation model

After completing the weight calculation of the evaluation indicators of the smart ecological city, to better evaluate the smart ecological construction of the city, the evaluation degree of various indicators of the city is graded. According to the grade distribution and the comprehensive evaluation coefficient of the city, the degree of the green building management system of Ecological Urbanization is divided into three different development stages; namely, the initial stage, the development stage and the mature stage, to facilitate the objective evaluation of the city, As shown in Figure 5.

Conclusion

Considering the climate changes (global warming and the energy crisis), optimizing energy consumption in buildings that are the major consumers of these types of fuels seems necessary. Therefore, the construction of buildings that are more compatible with the environment is important. It is special, and as a result, one of the ways to save energy consumption is to create a green building. The necessity and importance of a green building from a national and corporate point of view include things such as: limited fossil fuel energy sources in the world, the growing trend toward The price of energy in Iran and the world, the importance of observing environmental issues in economically active units, the rapid acceleration of industrial development in developing countries and the third world, and, as a result of increasing competition, the growth of the world's population, and the greater need for energy and welfare, the attention of advanced industrial countries to increasing the percentage of energy from renewable energy sources in the basket The main reason for the difference between green buildings and ordinary buildings is the use of efficient technologies and materials, as well as environmentally friendly technologies.

Based on the urban ecological theory analysis and the main concepts and construction matters of the green building management system, this paper selects different evaluation indicators of the model. According to the development requirements of green buildings, the weight coefficient of each indicator is given through AHP. The main conclusions are as follows:

Serial number	Comprehensive evaluation coefficient of green building management system	Development stage
NO.1	0-60	Initial stage
NO.2	60-80	Development stage
NO.3	80-100	Mature stage

FIGURE 5
Evaluation coefficient of green building management system.

1. Based on the concept of Eco-city and the management system of green building, this paper discusses the necessity of establishing a management system and different matters needing attention. Therefore, based on the traditional evaluation model, an evaluation model of the mutually beneficial coexistence of green buildings and Eco-city is proposed.
2. The mutual benefit symbiosis evaluation model created considers the impact of green building environment on the external environment. It takes the urban ecology concept as the core and improves the traditional model. It considers 29 impact indicators and provides an alternative calculation method.
3. The action mechanism of the driving mechanism for the development of mutually beneficial symbiosis is that under the action of internal and external power sources, all parties involved regulate their behaviors according to the market law, promote the green ecology of buildings, the green ecology of the environment, the green of cultural ecology and the low-carbon of living ecology, and build a mutually beneficial symbiosis development mode of "four in one" sustainable development.

Recommendation

Many countries have not seriously considered BMS due to a lack of culture and clarity among specialized companies active in greening existing buildings. Allocation of energy subsidies has made the building builders refuse to accept the initial cost during the operation, even assuming that energy is wasted. They continue to insist on the traditional operation of the facilities. The lack of acceptance of the smart building management system by the buyers of building units is another reason for the resistance of building builders to the implementation of projects.

Smartening is considered to be an automatic sign. Medium leads to energy savings of up to 92%. Future researchers should look into more details of the intelligent building management system in all existing buildings. In this research, the input energy only includes gas and electricity, and water is not considered. One of the significant problems for future generations is the lack of water resources, which should be reduced to some extent by managing water consumption. Therefore, in future research on the optimization of non-drinking uses, should water from the integrated well be used? Is the cost of separating drinking water from non-drinking water economically justified? In the green building, waste is minimized, and one of the concerns of the green building is the separation of dry and wet waste at the source, which does not exist in this complex.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval were not required for the study of human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

Each author made significant individual contributions to this manuscript. CL: methodology, data analysis, and writing; JH and RZ: writing-reviewing and Editing; PX and WC: data analysis and article review.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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