Analysis and Research on Green Building Technology Based on Big Data Analysis

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Abstract. In recent years, with the application, development and popularization of network technologies such as cloud computing, Internet and Internet of Things (IoT), human society has entered the era of explosive growth of data, and the generation and circulation of massive data have become the norm, and the application of big data in various fields such as economy, finance and biomedicine has attracted great attention from all walks of life. Big data has significant positive externalities on green development. China is experiencing a critical period of economic transformation and upgrading. This paper argues that green development emphasizes the harmonious coexistence of human beings and nature, and aims at efficiency, coordination and sustainability, taking into account the balanced development of the economy, society and nature. The increasing development and wide application of modern information and communication technologies, such as big data, cloud computing, the Internet and intelligence, have permeated all aspects of the economy, society and ecology. Big data, through its own characteristics, promotes economic transformation and upgrading, optimizes the demand structure, improves quality and efficiency, and promotes the coordinated development of the economy, society and the environment. Big data has significant positive externalities on green development. Based on the support of big data foundation, this paper analyzes the influencing factors of green building, and gives an outlook and development prediction of green building industry.

Keywords: Big Data; Green Building; Intelligent Context; Intelligent Construction

1 Introduction

Currently, with the rapid economic and social development, the whole process of energy consumption in the construction industry has gradually exceeded that of industry and transport, accounting for about 45% of China's total energy consumption, and has become a major consumer of energy, therefore, the development of green buildings is imperative. With more and more green buildings in China, people's attention to energy consumption is also increasing, and it is believed that with the continuous penetration of big data technology, people use big data technology to mine the user behavior data, energy consumption data, climate and regional differences and other valuable data

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generated in the operation of green buildings will be more scientifically sound, so as to put forward more scientific and perfect ideas for the future of big data technology in the prediction of energy consumption, optimization of design, energy scheduling, user comfort, etc., in order to achieve the true meaning of the green building [1]. With more and more green buildings in China, people's attention to energy consumption is also increasing, and it is believed that with the continuous penetration of big data technology, people use big data technology to mine the user behavior data, energy consumption data, climate and regional differences and other valuable data generated in the operation of green buildings will be more scientifically sound, so as to put forward more scientific and perfect ideas for the future of big data technology in the prediction of energy consumption, optimization of design, energy scheduling, user comfort, etc., in order to achieve the true meaning of the green building [2].

2 Modeling of Green Building Evaluation System

To apply the comprehensive evaluation index system of green building in practice, certain mathematical methods and means are needed to quantify and unify these indexes, so the operability of the evaluation system is improved by constructing a comprehensive evaluation model. In this paper, we will analyze and explore the method of constructing the model, and select the appropriate method to calculate the weights of the indicators to construct the comprehensive evaluation model according to the interrelationships and characteristics of the indicators [3].

2.1 ANP's Method of Determining Weights

(1) Construction of Network Hierarchy Diagrams

There is a dependency relationship between the element sets and between the elements within the element sets, which affect each other. This system structure with network feedback is applicable to the comprehensive evaluation of green buildings, and based on the correlation of indicators obtained from the analysis, the network diagram of the comprehensive evaluation model of green buildings is obtained [4].

(2) Indicator relevance judgment scale and questionnaire design

Like AHP, ANP also uses a scale from 1 to 9. The questionnaire was designed based on the constructed network hierarchical model and the complexity between the indicators. The respondents fill in the questionnaire according to the two-by-two comparison matrix of the associated indicators using the 9 scale method.

(3) Determination of the unweighted supermatrix

Assuming a system consisting of N clusters or components, and that elements within each component may actively or passively influence elements within that component or within other components, the whole system interacts under the dominance of a certain property. Suppose that a system consists of N clusters or components, and that elements in each component may actively or passively affect elements within that component or within other components, and that the whole system interacts under the dominance of some property. Suppose there are components C_h and contain n_h elements

$e_{h1}, e_{h2}, \ldots, e_{hnk}$,wherein $h = 1,2, \ldots, N$. A priority vector representing the influence of an element in a component on other elements in the system is obtained by two-by-two comparison, and when there is no influence between the elements it is recorded as having an influence of zero.

A portion of the columns of the supermatrix is composed of priority vectors normalized by the two-by-two comparison judgment matrix. The constructed supermatrix W, where columns denote sources and rows denote sinks, reflects the importance of sources relative to sinks based on the two-by-two comparisons of sources to elements in sinks with respect to the interactions and feedback information in the network structure.

(4) Create a weighted supermatrix

Each element (submatrix) W_{ij} of the supermatrix W is a priority vector normalized by a two-by-two comparison judgment matrix, but W is not a normalized matrix. Normalization of the supermatrix is required due to non-uniform weights. The importance of each element group under the corresponding criterion P_s is compared to the individual element group C_j. As show in table 1.

Table 1. Comparison judgment matrices for sets of elements

C_j	$C_1, \ldots, C_N$	**Arrangement vectors (normalized)**
C_1		a_{1j}
…	$j = 1,2, \ldots, N$	…
C_N		a_{Nj}

Get the normalized sorting vector A

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \cdots & \cdots & \cdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

A is multiplied by W to obtain the weighted supermatrix W':

$$\mathrm{W}' = a_{ij} W_{ij} \quad (2)$$

Among them,$i = 1,2, \ldots, n; j = 1,2, \ldots, n;$

(5) Solve the limit supermatrix

In the network analysis method, to reflect the relationship of the influence of all elements on an element, it is necessary to stabilize the weighted supermatrix W', and solve the limit relative ordering vector based on Equation 3:

$$\overline{W} = \lim_{\to} W^{`R} \quad (3)$$

(6) Deriving weights

Calculating the limiting supermatrix under each criterion layer gives the weights of the importance of each element.

3 Overview of the Fuzzy Integrated Evaluation Method

1. Construction of fuzzy comprehensive evaluation index

The fuzzy comprehensive evaluation index system is the basis for comprehensive evaluation, and whether the selection of evaluation indexes is appropriate or not will directly affect the accuracy of comprehensive evaluation. The construction of evaluation indexes should be based on a wide range of industry information or relevant laws and regulations.

2.Adopt the construction of good weight vector

Construct the weight vector by expert experience method or AHP hierarchical analysis method.

3.Construct affiliation matrix

Establish a suitable affiliation function to build a good affiliation matrix.

4.Synthesis of subordinate matrix and weights

4 Use Suitable Synthesis Factors to Synthesise and Interpret the Resultant Vectors

The fuzzy comprehensive evaluation method is based on the fuzzy mathematics theory of subordination degree to quantify the qualitative problems, to make the overall evaluation of things or objects constrained by multiple factors [5]. From the comprehensive evaluation system of green buildings studied in this paper, the selection of evaluation indexes and the determination of weights are all with a certain degree of fuzzy, and the method needs to be used to quantify the qualitative problems. Therefore, this paper chooses fuzzy comprehensive evaluation to carry out comprehensive evaluation of green buildings.

The specific steps for its construction model are as follows:

(1) Determination of the set of factors to be evaluated

First of all, according to the comprehensive system of evaluation indicators established above to determine the indicator factor set $U = \{U_1, U_2, \ldots, U_m\}$, there are m evaluation indicators, indicating that our team evaluation object from m aspects of the judgment. If there are too many indicators, secondary evaluation indicators can be constructed [6].

(2) Determination of the set of rubrics for evaluation subjects

The set of comments is the set consisting of the aggregation of the various evaluation results that the evaluator may make about the object being evaluated, often denoted by V: $V = \{V_1, V_2, \ldots, V_m\}$.

(3) Perform a single-factor fuzzy evaluation and establish a fuzzy relationship matrix R

A factor is evaluated individually to determine the degree of affiliation of the evaluated object to the evaluation set V. After constructing the registered fuzzy subsets, the evaluated objects are quantified one by one from each factor, and then the fuzzy relationship matrix is obtained:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{4}$$

Where $r_{ij}(i = 1,2, \dots, m; j = 1,2, \dots, n)$ represents the affiliation of the evaluated object to a V_j hierarchical fuzzy subset from the factor U_i. The fuzzy vector $r_i = (r_{i1}, r_{i2}, \dots, r_{im})$ is used to characterize the performance of an evaluated object in terms of a factor U_i and, therefore, r_i is referred to as a single-factor matrix as a fuzzy relationship between the factor set U to the evaluation set V. When determining the degree of affiliation, the evaluation object is generally scored by experts or professionals, and the structure of the statistics is based on the absolute value of the subtraction method to find r_{ij},that is:

$$r_{ij} = \begin{cases} 1, (i = j) \\ 1 - c \sum_{k=1} \left| x_{ik} - x_{jk} \right|, (i = j) \end{cases} \tag{5}$$

where c can be appropriately chosen such that $0 \le r_{ij} \le 1$.

(4) Determine the weight vector of evaluation factors

The key point of constructing the fuzzy comprehensive evaluation model is to find a reasonable weight value, let $W = \{w_1, w_2, \dots, w_m\}$ be the weight set, the factors U should be assigned the corresponding weights $w_i(i = 1,2, \dots, m)$,where, $w_i \ge 0; \sum_{w_i} 1$.

There are various methods to determine the weights and in this paper ANP is used to calculate the weights.

(5) Comprehensive multi-indicator evaluation

Choose a suitable synthesis operator to synthesize W and R to get the fuzzy comprehensive evaluation result vector Z of the evaluated object.

$$Z = W^{\circ}R = (w_1, w_2, \dots, w_m)^{\circ} \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} = (z_1, z_2, \dots, z_n) \tag{6}$$

Where, $Z_j(j = 1,2, \dots, n)$ is obtained from the jth column of W and R by operation, indicating the affiliation of the evaluated object to the hierarchical fuzzy subset V_j on the whole. ° is the fuzzy operator symbol, which can be calculated by selecting the appropriate operator according to the need. As show in table 2.

Table 2. Operator Characterization

operator (math.)	Embodiment weights	Utilization of R information	degree of aggregation	typology
$M(\wedge, \vee)$	inconspicuous	inadequate	young	Primary factor highlighting type
$M(\cdot, \vee)$	conspicuous	inadequate	young	Primary factor highlighting type
$M(\wedge, \oplus)$	inconspicuous	fuller	vigorous	weighted average
$M(\cdot, \oplus)$	conspicuous	adequately	vigorous	weighted average

(6) Analyzing fuzzy comprehensive evaluation results

The result of fuzzy comprehensive evaluation reflects the affiliation of the evaluated object to each level of fuzzy subset, which is usually a fuzzy vector. The principle of maximum affiliation or the principle of weighted average is usually used to deal with the fuzzy comprehensive evaluation vector [7]. In this paper, the principle of maximum affiliation is chosen, i.e., if the maximum value $z_r = \max\{z_j\}\ (1 \leq j \leq n)$, in the result $Z = (z_1, z_2, \ldots, z_n)$, then the evaluated object belongs to the rth rank in general.

5 Green Assembly Comprehensive Fuzzy Evaluation Model Construction

From the above analysis, it can be seen that the comprehensive evaluation index content of green building is based on the whole life cycle of the building, from the ecological environment, economy, assembly level and social benefits and other aspects of the factors, the concept of sustainable development will be instilled into it, to establish a comprehensive evaluation model [8]. The ANP is utilized to calculate the weights of the indicators and establish a fuzzy comprehensive evaluation model, the process of which is shown in Figure 1.

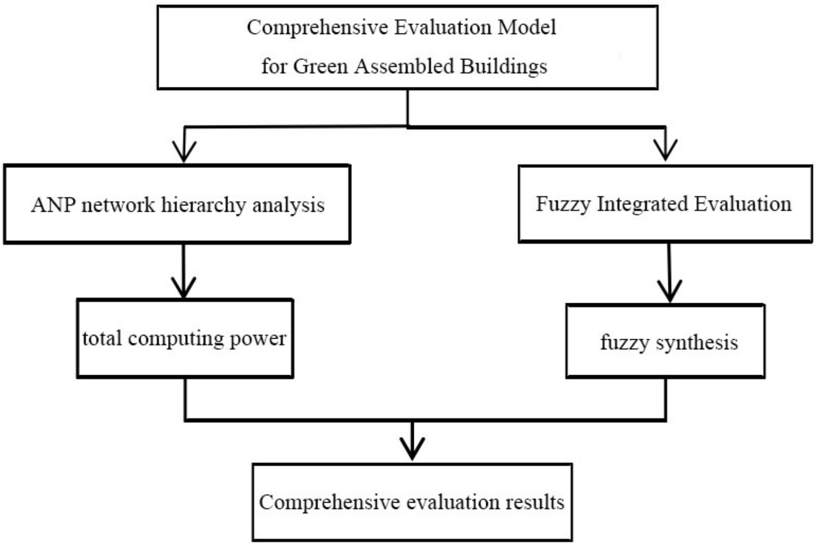

Fig. 1. Flow chart of fuzzy comprehensive evaluation model

5.1 Model Weight Determination

(1) Construction of the evaluation indicator system and correlation between indicators

In this paper, after analyzing the evaluation factors of green building, the comprehensive evaluation index system of green building is obtained, but only the evaluation indexes are identified, to establish the ANP model also needs to make clear the influence relationship between the indexes (dependence or feedback), and to get the correlation of the indexes can be obtained as the comprehensive evaluation ANP model of the green building is shown in Fig. 2.

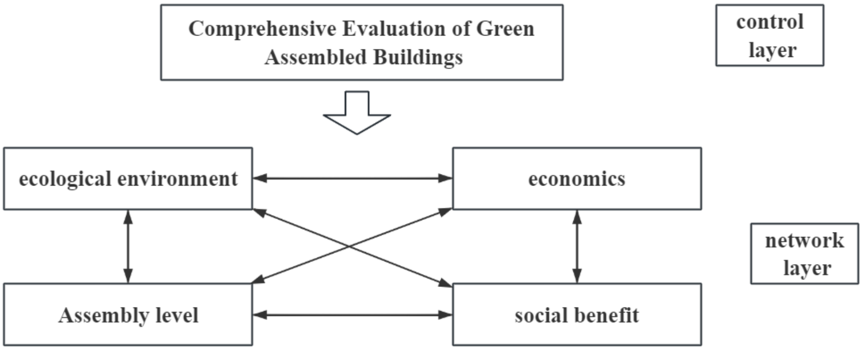

Fig. 2. Green Building Comprehensive Evaluation Network Hierarchy Diagram

6 Conclusion

With more and more green buildings in China, people are paying more attention to energy consumption, and it is believed that with the continuous penetration of big data technology, people will use big data technology to mine the valuable data generated in the operation of green buildings, such as user behaviour data, energy consumption data, climate and regional differences, etc., which will be more scientific and perfect, and it will provide a more scientific and perfect idea for the future use of big data technology in the areas of energy consumption prediction, optimization of design, energy scheduling, user comfort, and other aspects of the proposed more scientific and perfect ideas to achieve the real meaning of green building.

The comprehensive evaluation index system and index analysis of green assembly established in this paper, for the complex correlation between the indexes, combined with the fuzzy comprehensive evaluation method to construct a comprehensive evaluation model of green building, which improves the operability of the model for practical projects. With more and more green buildings, people pay more and more attention to energy consumption, and it is believed that with the continuous penetration of big data technology, people use big data technology to mine the valuable data generated in the operation of green buildings, such as user behavior data, energy consumption data, climate and regional differences, etc. will be more scientifically sound, so as to put forward more scientific and perfect ideas for the future big data technology in the aspects of energy consumption prediction, optimal design, energy scheduling, user comfort and so on, in order to realize the real meaning of the green building [9]. The research in this paper is based on the contemporary big data foundation and provides a comprehensive study on the development of the green building industry, which provides some innovative research for the development of the green building industry [10].

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