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Abstract

Background. The recent pursuit of energy conservation, emission reduction, and sustainable development are the demanding aspect in green building construction. Green building concept becomes important in the current building life cycle to mitigate environmental issues. In this way, a strategy for surveying the performance of a green structure is attractive. Consequently, this investigation intends to build up a methodical methodology for distinguishing the elements that decide the effective development and activity of a green structure and makes a technique for assessing green building execution.

Methods. To accomplish these objectives, a comprehensive literature review was first conducted, followed by determining the performance of a green building to create a qualitative fuzzy set of performance metrics. A cloud model was used to analyze the factor hierarchy using weighted entropy to quantify the performance of a green building. Ultimately, an inside and out contextual analysis was led to check the exact discoveries.

Results. A green building performance index that was created based on expert evaluations and weighted the indexes subjectively and objectively. Likewise, a standard cloud yardstick was also created in the comprehensive cloud. The sustainability of the building was qualified and assessed by comparing cloud images with the standard cloud. It has been analyzed that, the execution measurements and persuasive components make appraisal models for a green building. This investigation can help the development business to distinguish and manage issues that emerge in building green buildings. The coherent framework that the researchers have developed for assessing green buildings provides a solid foundation for further research into sustainability and green building operation. The result indicates that the industry acquires benefit by suggesting effective measures that can be implemented in all stages of green building construction.

Conclusion. The analysis results demonstrated that this investigation builds up a novel exhibition appraisal of a green building which makes a target establishment for assessing building execution. Additionally, the findings are helpful for industry specialists to improve green building construction. Besides, the outcomes give significant data to governments and other invested individuals to create target models for green building development programs.

Keywords: green building; cloud model; uncertainty; performance assessment.

1.0 Introduction

The global construction industry is the greatest industrial energy consumed and the greatest polluter of the natural environment. Raw materials consumed annually by the construction industry account for about 44% of global raw material use [1]. The consumption of this huge quantity of natural resources degrades natural environmental degradation [2]. At the time of 2018, 70% of the world's energy is devoured by developed countries, which represent just 22% of the total populace. In Canada, the United Kingdom, and the United States, buildings are responsible for 30–50% of the country's energy needs [1, 3], and construction produces 25–48% of carbon dioxide emissions.

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The interest for energy utilized in building development and use in developing nations; carbon outflows and the utilization of power are expanding quickly [4]. For instance, the development represents 33% of India's energy consumption, which is developing by 8% consistently [5]. Chaturvedi et al. [6] anticipated that energy consumption in India's construction sector would expanding over 500% by 2100 without explicit industry approaches to limit the utilization of building energy. The development business should move toward green and sustainable development to reduce the adverse impact of buildings on the environment [7]. Green buildings are buildings that augment the utilization of assets and space, decrease ecological contamination, and live in harmony with nature [8]. Green structure idea is the idea with benevolent condition structures that obliged the interests of ecological, social, and financial joining parts of structures as indicated by guidelines that it has been resolved from the structure life cycle plan. Some proponents of green building concepts walk with the owner's needs of the building, rating tools and knowledge, government aid, and government regulations. A worthwhile green building assessment tool should enable us to assess the lifetime sustainability of a green building during the planning, construction, operation, and destruction of the building. It will indicate if best practices, which reduce the adverse impacts of construction on the natural environment, were included in the building life cycle.

2.0 Latest Developments on Green Building Performance Assessment

With the introduction of green building, the first green building performance assessment method to have been developed was the Building Research Establishment Environmental Assessment Method (BREEAM) created by building research institutions in 1990. It contains several specific evaluation systems, each of which was intended for a particular kind of building, consequently, BREEAM applies to structures. It likewise contains conventions for explicit nations, such as the Netherlands, Norway, Sweden, and Spain. Different nations have created frameworks to assess the impacts of green buildings on the natural environment, such as the Green Building Tool (GB Tool) in 1996, the Leadership in Energy and Environmental Design Scheme (LEED) in 1998, and the Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) in 2001.

GB Tool, developed by the International Framework Committee for Green Building Challenge, is utilized in 25 countries. The tool evaluates project location, project planning and development, environmental load, energy and resource consumption, indoor environmental quality, function, long-term performance, and social and economic aspects of a green building. LEED is an agreement based building rating framework for a new advertisement, institutional, and skyscraper private buildings, and significant redesign anticipates for existing buildings. It was developed by the U.S. Green Building Council. Green Globe is a green building evaluation tool adopted by the Building Owners and Managers Association (BOMA) in Canada to evaluate the environmental performance and interior design of new and existing buildings. This evaluation tool is crucial to Canada's national environmental planning [4, 8, 9]. China, following different nations, has presented development philosophies and far-reaching green building appraisal norms to oversee the improvement of green buildings in China as in Table 1. Widespread green building construction transforms the construction industry economics and technology. Cultural change is required to normalize the concept of sustainable development. There has been minimal green building construction in China to date. Thus, there is no regular understanding of green buildings. However, there are some terrible instances of green buildings that pursue the commercial interest in the name of green buildings. The reasons for this are a) limited understanding, b) lack of support, and c) unsatisfied assessment. Numerous individuals in China don't have a good comprehension of a green building [10]. They couldn't characterize what a green building is and would not perceive the standards and norms pertinent to green building development. Measures that encourage the construction of green buildings should be reinforced. Currently, there

is little support in China for green technology in building design, and most green technology research is at an early stage of development. Conventional building design and construction have historically failed to consider environmental protection, and architectural technology; thus, thinking has modified little [11]. Although some attention has been given to environmental protection, architects and designers still favour the traditional building technologies and construction methods utilized by their antecedents. Deficient consideration is given to specialized estimates that would reduce the effect of a structure on nature. [12]. Green building assessment methodologies in China are still in its initial stage than those used abroad. There is no unified green building code. Evaluation criteria must be standardized. The adoption of existing assessment methods has increased the use of environmental indicators, while economic and social indicators are ignored [10]. Environmental indicators in current green building standards mainly consider the impact of green buildings on people's material living conditions [12]. However, no indicators directly evaluate the economic and social consequences of green building construction; thus, they are not considered in the assessment of a green building [13].

Table 1: China green building evaluation system.

Year	Development area	System	Assessment type	Range of application
1996	Hong Kong	HK-BREEAM	New and existing buildings	Site materials, indoor environment, energy and water resources, quality improvement, and performance creation
2001	Taiwan	EMGB	All types	Water conservation index, greening index, daily energy-saving index, water resources index, waste reduction index, CO2 reduction index, sewage, and waste reduction index
2005	China Housing Chamber of Commerce	Industry eco-housing technology assessment handbook	Residence	Environmental planning and design of the community, energy, and environment, indoor environment quality, residential water use, materials and resources
2006	School of Architecture, Tsinghua University	Green building assessment system	Communal residence	Energy reuse, energy consumption, local environment, building interior
2008	Tsinghua University	Green Olympics assessment system	Olympic construction and park construction	The Japanese Q/L criteria are used for process management; planning and design, construction, building acceptance and operation management can be assessed
2008	China Academy of Building Sciences, China Academy of Building Materials, Tsinghua University Construction Research Institute	Green building technical guidance	Civilian use	Green building design and planning, technical requirements for design, construction, and operational management
2014	Ministry of Housing Urban-Rural Development of	Housing and Assessment standard for green the building	Public building	Divided from high to low into Samsung, two stars and one star; include the following six indicators:

Numerous methodologies and strategies have been utilized by analysts to make green structure appraisal models: green probability analysis, comprehensive fuzzy analysis, hierarchical analysis, clustering analysis, fuzzy analytic hierarchy processes, and gray theory [14]. These procedures express to subjective, halfway subjective, and mostly quantitative ways to deal with evaluating green building plans and development. They are superior to obsolete strategies in thinking about vulnerability and distinguishing directional indexes. However, they do not evaluate randomness or uncertainty [15].

A new method was proposed by the researchers for evaluating green building construction. The cloud model is a numerical hypothesis created by Li and Shi that uses fuzzy set theory, probability, and statistical theory to quantify complex uncertainty [16]. The cloud model characterizes randomness, fuzziness, and variable correlations and it maps qualitative uncertainties to quantitative uncertainties [17]. The cloud model has been used to quantify the performance of green buildings by some researchers [18]. However, their models are not comprehensive or systematic.

An investigation has been accomplished for green building assessments by comparing the criteria used for green building assessment in China with those used in different countries. Quantitative and qualitative indexes for green building properties were consolidated to set up an evaluative model, which can be used for green building assessment. The main purpose of a green building assessment tool is to evaluate different aspects of sustainable practices during the planning, construction, and operation of a green building and to identify where and how to incorporate best practices to reduce the adverse effects of the building on the environment. A thorough comprehensive examination framework was also built up that utilizes a novel strategy to evaluate green building extends that are dependent upon uncertainty. The green building performance cloud model assessment method is shown in Figure 1.

3.0 Research Methods and Procedures

3.1 The cloud model

A cloud model transforms qualitative concepts into quantitative values [19–21]. Two key concepts of the cloud model, which creates mapping relationships, are its numerical characteristics and the cloud generators. Together, they reflect the interdependence of quality and quantity. The summary of the cloud model is as follows:

C is a quantitative domain; P is a qualitative semantic concept of U ; x is a numerical value for P ($x \in U$); $\mu P(x)$ represents the degree of certainty that the random number x represents P ; x is a random number that tends towards a stable value; and $\mu P(x) \in [0, 1]$ [22]. The distribution of x in domain C is a *cloud*, and each value of x value is a *cloud drop* ($x, \mu P(x)$) [23]. Many cloud drops converge into the cloud. Each cloud drop is represented as a point and the qualitative semantic concept P is thus mapped onto a number field. Three numerical characteristics of the cloud (the expected value Ex , entropy En , and hypertrophy He) quantify the qualitative concepts, as shown in Figure 2.

Fig. 1: Green building performance cloud model assessment method

Fig. 2: Numerical characteristics of a cloud

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3.2 Numerical characteristics of a cloud

The expected value Ex is the most representative (mean) value of the qualitative concept in C , and it is the centric value of the number field space. En quantifies the qualitative concept P and is determined by the fuzziness and randomness of the concept P . Entropy values indicate that the larger En values are, the more macroscopic P is. A concept becomes more difficult to quantify when the fuzziness and randomness are associated with the concept increase. Hypertrophy He represents the uncertainty of En and is determined by the fuzziness and randomness of En . The uncertainty of all point sets represents qualitative concepts in the number field space (i.e., the decrease in cloud cohesion). Greater cloud drop dispersion is indicated by higher He values. The more random the cloud drops are, the greater the cloud *thickness* is.

3.3 Cloud generators

There are two cloud generators: the forward cloud generator, and the reverse cloud generator [19, 20, 23, 24]. The forward cloud generator derives the range and distribution of quantitative values from qualitative information by mapping the numerical characteristics of the cloud (Ex , En , He) into cloud drops [25]. The reverse cloud generator converts the values represented by Ex , En , and He into semantically qualitative concepts (as shown in Figures 3 and 4).

Fig. 3: Forward cloud generator.

Fig. 4: Reverse cloud generator.

4.0 Data Interpretation and Analysis
4.1 Performance evaluation system for a green building project

A multi-level index of building properties can be developed, by drawing on relevant literature [26-28], and policy analysis [29, 30] and using evaluative scoring. The index can be used to assess the performance of a green building [31]. Four first-level indexes (environmental-economic balance, regional social coordination, health and comfort, and green management) and 36 second-level indexes (*D1–D36*) were identified. The green building assessment indexes and descriptions are shown in Table 2.

Table 2: Green building construction evaluation index system.

Green building performance evaluation	
Index	Description
<i>Environmental-economic balance</i>	
Renewable energy utilization, D1	Utilize the common states of building locales, adequately create and use sustainable power source, and diminish natural contamination and environmental damage caused by energy consumption.
Energy efficiency, D2	On the another hand, it improves the efficient use of building energy; on the other hand, choose reasonable equipment and take effective control measures. Use energy recovery technology to release energy cascading and optimize energy systems for different energy use structures.
Enclosure structure energy-saving, D3	The building enclosure has a great effect on energy conservation, including insulation technology in external walls, roofing, and ground. The utilization of various advanced building energy-saving technologies can greatly improve energy efficiency and reduce energy consumption [32].
Utilization of water-saving appliance, D4	Measures such as water-saving appliances, water-saving systems, and the recycling of water resources are used to improve building water use efficiency, to diminish water utilization in the building, and to acknowledge the goal of water-saving.
Recovery of water and rainwater, D5	Identify local use of technology and economic conditions to make use of rainwater and reclaimed water and water recovery systems; make full use of construction, water by recycling it, reduce the environmental pressure of water extracted from the natural environment, pay attention to the source and regulate the flow of water.
Sewage recovery and treatment, D6	Use rainwater and sewage diversion systems, ensure the comprehensive use of rain, sewage water, and water safety; saving water can greatly alleviate the increased demand because of water shortage.
Utilization of low energy material, D7	Green buildings use building materials of low energy, high performance, low resource consumption, and high durability, which reduces the use of non-renewable resources; uses industrially produced finished products as much as possible, and reduce construction waste.
Green roof, D8	Greening of rooftops.
The rate of green space, D9	The proportion of the green area.
<i>Regional social coordination</i>	
Effective utilization of land resources, D10	Reconstruction and redevelopment of existing land are an effective use of land resources and an effective measure to improve land utilization rate. The overall value of green building construction can be greatly increased by using

	the complete public infrastructure support on of the surrounding land.
Protect the soil from contaminated, D11	During the construction process, the soil will be polluted to some degree. A suitable selection and layout of vegetation can adjust the microclimate of the site, control soil erosion, and even remediate soil pollution.
Harmony with existing buildings, D12	Architectural design should coordinate the overall built shape, including existing buildings, spatial configuration, facade and colour, and the surrounding environment [33].
Interference with the surrounding environment, D13	The adverse effect of development exercises on the earth, for example, air contamination, water contamination, light contamination, and noise contamination, must be controlled to lessen impedance with the general condition.
Impact on surrounding public transport, D14	The architectural design is closely related to the surrounding site environment, transportation network, and urban infrastructure.
Location of amenities, D15	The location of amenities.
Free parking, D16	The effect on green buildings of free parking.
Impact on peripheral economic benefits, D17	Economic benefits to the surrounding environment.
<i>Health and comfort</i>	
Temperature comfort (°), D18	Indoor temperature and humidity controls must meet the human body temperature comfort requirements.
Indoor air quality, D19	Utilize building configuration to improve common ventilation, the circumstance of air outlets, and utilize new enlivening materials that can improve indoor air quality.
Reasonable lighting and sunshine level, D20	Toward the start of the compositional plan, natural light should be incorporated as much as possible to create a good visual field with accessible windows and to provide a comfortable indoor environment.
Acoustic performance, D21	Dynamic and static partitions can divide the layout and space of the building, and structural components of the building must be selected to reduce noise, to ensure the office and living environment are quiet.
Indoor pollution control, D22	Space layout is both logical and practical; human psychology and physiology also should be taken into account.
Indoor air quality, D23	Indoor materials can truly influence indoor air quality when they are a significant wellspring of indoor contamination.
Owner safety, D24	The architectural design should primarily consider the usability of the building to ensure the safety of owners and occupants to improve the general building design concept.
General design concept, D25	General design, also known as all-around design or universal design, is the built environment and communication systems that can be used by all building users without modification.
<i>Green management</i>	
Community waste management plan, D26	Consider the sustainability of the construction project life cycle, which is the biggest feature of green buildings. Conventional construction projects only

	consider the investment in the early stages of the project and ignore the maintenance costs in the later stage to ensure minimal investment.
Waste management in construction, D27	Centralize disposal of construction waste during construction to improve the building management system.
Operational waste management, D28	Green building construction pays attention to community waste management plans and wastes treatment during building construction and operation to reduce environmental damage.
Long-term facility maintenance plan, D29	The long-term follow-up of the building operation will allow the owner to recognize and realize the benefits of building sustainable and to reduce future maintenance of the facility for subjective reasons.
Building management system, D30	At each stage of development, construction, and building use, the impact of management decisions on the project is dynamic and variable and will affect resource consumption of the building; it is also very important to maintain the indoor and outdoor environment.
Facility maintenance and operation expense management, D31	A sound and effective management mechanism will conserve energy, reduce waste and pollution, increase environmental protection, and reduce the operating cost of a green building.
Owner recognition of facility sustainability, D32	Mainly an assessment of the relationships between economic and ecological values of buildings at different stages emphasizes the management of building processes and recognizes the green performance of buildings.
The integrated design process, D33	Integrated design is the most basic step of green building construction and determines the objectives and the plan of a green building.
Trial run management, D34	Trial operation management identifies the goals of resource-saving and reducing energy consumption in building operations.
Construction management, D35	Manage construction to reduce resource use and energy consumption.
Project cost management, D36	Green building construction must control project costs, extend building life, and reduce average costs.

4.2 Green building performance in the cloud model

Expert scoring was used to determine the importance of the defined indexes. The index weightings were determined using the analytical hierarchy process (AHP) weighting and entropy weighting. Weights were combined to create the subjective and objective weights of the 36 assessment indexes, and thus the evaluation scores of the clouds for the project [34-36]. Computing the similarity between clouds enables us to determine the green building performance score.

4.3 Determination of the assessment criteria

The assessment criteria R were classified as $R = \{R_1, R_2, \dots, R_p\}$. Four-step ($P = 4$) or five-step ($P = 5$) ratings are commonly used. Experts were invited to assess the system indexes in C and to give them weights. AHP and entropy were used to assign a subjective weight and an objective weight to each index. Thus, the combined weight of the index was determined. The domain C of the index value was divided into P intervals depending on the hierarchic level. The interval $[x_i^{min}, x_i^{max}]$ was the i interval. The characteristic values for the standard cloud $Cloud_y$ corresponded to each interval. The quantifiers E_{X_i} , E_{N_i} , and H_{E_i} were calculated by [37]:

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$$\begin{cases} E_{Xi} = (\chi_i^{\max} + \chi_i^{\min}) / 2 \\ E_{Ni} = (\chi_i^{\max} - \chi_i^{\min}) / 2\sqrt{2\ln 2} \\ H_{Ei} = k \end{cases} \quad (1)$$

230 where k is a **parameterized** constant which is determined according to the ambiguous threshold in different projects.

232 4.4 Determination of green building performance for the comprehensive cloud

233 After re-screening, thirty experts were selected to score the indexes. The experts were variously from a construction unit,
234 construction management department, and green building research staff. They were approached to score the factors that
235 were checked during the green building development measure.

236 Equations (2)–(4) were used to derive the evaluation cloud for all indicators to process the expert scoring,

237 with $Y_v = (y_{v1}, y_{v2}, \dots, y_{v30})$ and $v = 1, 2, \dots, 30$. The index was $C_{UW}(E_{xw}, E_{nw}, H_{ew})$, with $w = 1, 2, \dots, 30$:

$$E_{xi} = 1/V \times (\text{Sum from } v=1 \text{ to } V \text{ of } z_{vi}) \text{ where } i = 1, 2, \dots, 30 \quad (2)$$

$$E_{ni} = \sqrt{\frac{\pi}{2}} \times \frac{1}{V} (\text{Sum from } v=1 \text{ to } V \text{ of } |z_{vi} - E_{xi}|) \text{ where } i = 1, 2, \dots, 30 \quad (3)$$

$$H_{ei} = \sqrt{\left| S_i^2 - E_{ni}^2 \right|} \text{ where } i = 1, 2, \dots, 30 \quad (4)$$

244 The combined weight γ_w was substituted into C_{uw} , and the comprehensive green building performance cloud $C(E_X,$
245 $E_N, H_E)$ was given by:

$$\begin{cases} E_X = \sum_{w=1}^{24} (E_{xw} \cdot \gamma_w) \\ E_N = \sqrt{\sum_{w=1}^{24} (E_{nw}^2 \cdot \gamma_w)} \\ H_E = \sum_{w=1}^{24} (E_{ew} \cdot \gamma_w) \end{cases} \quad (5)$$

251 4.5 Calculating Cloud similarity

252 Finally, calculate cloud similarity and determine the performance assessment grade of green buildings. Cloud similarity
253 can be calculated by the steps shown in Table 3. By comparing the similarity of the comprehensive cloud and the
254 standard cloud, the greater the similarity, the closer the safety performance level of the prefabricated construction project
255 is the evaluation level.

256 Table 3: The steps for calculating cloud similarity

Step	Solution content	Description
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1	$E_{Xk} = Norm(E_N, H_E^2)$	E_{Xk} is a normalized random number, E_N is the expected value and H_E^2 is the variance.
2	$x_k = Norm(E_x, E_{Xk}^2)$	x_k is a normalized random number, E_X is the expected value, and E_{Xk}^2 is the variance.
3	$\mu_k = \exp\left(-\left(x_k - E_{Xi}\right)^2 / 2E_{Ni}^2\right)$	x_k is put into the standard cloud $Cloud_v$ with score i .
4	$\delta = \frac{1}{n} \sum_{k=1}^n \mu_k$	Repeat steps 2 and 3 to obtain cloud similarity until n μ_k values are generated. Normally, n is in the range 10–20.

5.0 Case Study Results and Findings

5.1 Case study project overview

The XiTi project is located in Shatoujiao, Yantian District, Shenzhen city. The project is bounded by Dongpu Haijing garden in the east, Palm Bay in the south, Waterfront Road in the west, and Financial Road in the north. The built land area is 0.81 ha while the total construction area is about 5.9 ha. The mainland use indicators are shown in Table 4.

Table 4: Technical and economic indicators.

Used land location	Quantity
Total area of used land (m ²)	8052.87
Total covered area (m ²)	58766.24
Green area (m ²)	2415.9
Plot ratio (%)	4.50
Density of building (fraction of coverage) (%)	25.00
Land area for roads and squares (m ²)	1809.84
Public area (m ²)	5050
Total parking spaces	300
Underground parking spaces	25
Ground parking spaces	275

5.2 Determine the assessment criteria R and calculate the evaluation criteria cloud

Due to the project assessment grade difference, the project assessment is on a six-point scale: $R = \{\text{very poor, poor, qualified, moderate, good, and excellent}\}$. The scores are in the interval [0, 100]. The characteristic parameters of each level of assessment for the standard cloud model $Cloud_v$ are given in Table 5.

Table 5: Standard scoring categories and the corresponding cloud models.

Performance rating standard	Interval partition	Cloud model characteristic parameters (En, Ex, He)
Very poor, $Cloud_1$	[0.0, 20.0]	(10, 8.4932, 0.5)
Poor, $Cloud_2$	(20.0, 40.0]	(30, 8.4932, 0.5)
Qualified, $Cloud_3$	(40.0, 60.0]	(50, 8.4932, 0.5)
Moderate, $Cloud_4$	(60.0, 80.0]	(70, 8.4932, 0.5)
Good, $Cloud_5$	(80.0, 90.0]	(85, 4.2466, 0.5)
Excellent, $Cloud_6$	(90.0, 100.0]	(95, 4.2466, 0.5)

276 Table 5 gives the six performance ratings of the green building performance in a standard cloud. The cloud
277 representation was obtained using Matlab 7.0 (Figure 5).

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279 Fig. 5: Six-point evaluation standard cloud chart.

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281 **5.3 Analysis of expert evaluation data and calculation of combined weights**
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283 Thirty experts, engaged in the green building industry or research, were invited to evaluate the project's green
284 performance. The experts calculate the subjective weight of the importance of the index and collect data of 30 similar
285 projects to calculate the objective weight. Accordingly, a blend consolidated load of each list was acquired in Table 6.

286
287 Table 6: Index weight and cloud characteristics.

Index	Subjective weight	Objective weight	Combined weight	Cloud characteristics (<i>Ex, En, He</i>)
D ₁	0.07098	0.05985	0.14613	(82.42, 2.62, 1.37)
D ₂	0.05672	0.02793	0.05449	(91.92, 4.32, 0.65)
D ₃	0.00992	0.04102	0.01397	(88.09, 3.62, 1.36)
D ₄	0.02267	0.01743	0.01358	(87.92, 4.32, 1.26)
D ₅	0.02772	0.01642	0.01565	(82.47, 4.63, 0.56)
D ₆	0.04153	0.02842	0.04057	(89.02, 3.89, 1.16)
D ₇	0.03124	0.02932	0.03148	(83.93, 4.05, 0.97)
D ₈	0.02146	0.03922	0.02893	(89.82, 2.48, 1.55)
D ₉	0.06703	0.02038	0.04701	(90.33, 4.03, 1.36)
D ₁₀	0.00993	0.01934	0.00662	(91.23, 3.42, 0.75)
D ₁₁	0.02062	0.03795	0.02687	(86.77, 4.99, 1.01)
D ₁₂	0.01376	0.03974	0.01883	(81.25, 2.32, 0.92)
D ₁₃	0.00826	0.03582	0.01018	(83.42, 2.02, 0.91)
D ₁₄	0.01278	0.01083	0.00476	(93.71, 2.83, 0.91)
D ₁₅	0.00858	0.03662	0.01078	(82.28, 1.76, 0.61)
D ₁₆	0.01812	0.00995	0.00618	(92.38, 2.56, 1.16)
D ₁₇	0.04353	0.04922	0.07367	(84.68, 5.09, 1.47)
D ₁₈	0.02268	0.01074	0.00838	(94.95, 2.28, 1.02)
D ₁₉	0.01207	0.01403	0.00583	(81.16, 3.52, 0.46)
D ₂₀	0.03029	0.02015	0.02098	(86.65, 3.58, 1.72)
D ₂₁	0.01392	0.04052	0.01937	(81.26, 4.62, 1.07)

D_{22}	0.04025	0.03752	0.05193	(86.01, 3.52, 1.28)
D_{23}	0.04247	0.03075	0.04491	(83.91, 4.07, 1.66)
D_{24}	0.02252	0.02015	0.01558	(92.01, 4.08, 0.71)
D_{25}	0.03346	0.03076	0.03537	(92.96, 3.52, 0.59)
D_{26}	0.04103	0.01433	0.02021	(81.13, 5.52, 1.47)
D_{27}	0.03637	0.03098	0.03876	(80.82, 3.52, 1.36)
D_{28}	0.02376	0.02931	0.02395	(87.97, 1.52, 0.08)
D_{29}	0.01128	0.01853	0.00717	(91.68, 3.42, 0.77)
D_{30}	0.02146	0.03222	0.02377	(94.02, 4.11, 1.22)
D_{31}	0.02564	0.03802	0.03351	(81.96, 2.56, 1.07)
D_{32}	0.03037	0.03070	0.03205	(88.52, 4.77, 1.26)
D_{33}	0.02037	0.02976	0.02086	(87.03, 2.88, 1.63)
D_{34}	0.03318	0.00274	0.00313	(80.19, 3.33, 0.98)
D_{35}	0.02359	0.02976	0.02413	(85.06, 4.46, 1.38)
D_{36}	0.03032	0.01971	0.02054	(81.96, 2.96, 0.06)

5.4 Calculation of each index cloud and synthesized cloud

The expert index weightings were used to construct the evaluation matrix. Each cloud $C_{Uw}(E_{xw}, E_{nw}, H_{ew})$ was calculated by equations (1)–(4). Index D_{23} is used as an example. The 30 experts weighted *Indoor air quality*, D_{23} . The cloud $C_{D23}(83.91, 4.07, 1.66)$ for the particular index was calculated. The comprehensive green building cloud is obtained by substituting all cloud indexes and the weighted indexes into the equation (5) (Figure 6).

Fig. 6: Comprehensive cloud for green building evaluation

5.5 Calculation of performance evaluation score by calculating similarity

The similarity b was calculated between the synthesized cloud $C(86.09; 3.64; 1.13)$ and used the standard cloud $Cloud_v$ (Table 7) to find that that similarity b_5 is the maximum; the corresponding performance rating for the green building project is *Good*.

Table 7: Similarity calculations.

Standard value	$Cloud_1$	$Cloud_2$	$Cloud_3$	$Cloud_4$	$Cloud_5$	$Cloud_6$
Similarity b_i	0.0001	0.0001	0.005	0.2423	0.7268	0.2115

5.6 Discussion

Figure 6 shows that building performance assessment using the cloud model takes full account of any uncertainty, ambiguity, or randomness in the construction and operation of a green building. The overall cloud rating for this undertaking was Good and Excellent. From this examination, it can infer that its green exhibition is incredible. This contextual analysis exhibits the pertinence of the technique. Quantitative qualities and subjective ideas are joined to give a goal assessment. The assessment is introduced in two different ways, by the comparability esteem and the cloud maps, which settles on it simpler for decision-makers to assimilate and assess the information they receive.

6.0 Conclusion

Evaluating the benefits of installing a comprehensive energy-saving system in a building is a complex activity. It can be difficult to determine what characteristics of the system, reduce energy usage, and it can be hard to accurately quantify any characteristic affects the system as a whole. Regularly evaluation can be assessed inside a specific range (vulnerability and absence of exactness), or impacts can be portrayed semantically (unclearness and fluffiness). Sometimes such judgments overlap. Performance assessment of a green building is subject to temporal and spatial uncertainties. A Comprehensive green building evaluation turns into a multi-file and staggered cycle to assess these uncertainties. Consequently, a cloud model was developed to give an extensive evaluation of a green structure. This model assesses the vulnerability, fluffiness, and haphazardness inalienable in the appraisal by consolidating them into the development of cloud drops. The process of cloud drop formation transforms qualitative concepts into quantified values, making possible an objective mathematical evaluation of a building. A green building performance index that was created based on expert evaluations and weighted the indexes subjectively and objectively. Likewise, a standard cloud yardstick was also created in the comprehensive cloud. The sustainability of the building was qualified and assessed by comparing cloud images with the standard cloud. It has been analyzed that, the execution measurements and persuasive components make appraisal models for a green building. This investigation can help the development business to distinguish and manage issues that emerge in building green buildings. The coherent framework that the researchers have developed for assessing green buildings provides a solid foundation for further research into sustainability and green building operation. The result indicates that the industry acquires benefit by suggesting effective measures that can be implemented in all stages of green building construction. However, this study has a potential limitation. First, specific solutions to problems encountered in constructing green buildings must be made in collaboration with the government department. Secondly, the conclusions were drawn from considering Chinese green buildings, which makes them applicable only to China and their applicability in different nations is not yet clear. Green building construction involves many activities and many processes.

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Declarations

- Ethical Approval and Consent to participate

The Fujian agriculture and forestry university Ethical Review Board approached this study with consent to participate.

- Consent for publication

All authors have consent for publication.

- Availability of supporting data

All data generated or analysed during this study are included in this published article

- Competing interests

The authors declare that they have no competing interests

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437 - **Authors' contributions**

438 Xiao-Juan Li conducted the data collection, Chen Wang conducted the data analysis, Shilpi Bora drafted the first writing,
439 Bimenyimana Samuel was in charge of the methodology.

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444

Figures

Figure 1

Green building performance cloud model assessment method

Figure 2

Numerical characteristics of a cloud

Figure 3

Forward cloud generator.

Figure 4

Reverse cloud generator.

Figure 5

Six-point evaluation standard cloud chart.

Figure 6

Comprehensive cloud for green building evaluation