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Developing Indicators for Healthy Building in Taiwan Using Fuzzy Delphi Method and Analytic Hierarchy Process

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Abstract: Healthy buildings are the future of industrial development and a global trend. This study is based on the local demand in Taiwan for the certification of healthy building assessments. It consolidates fifteen relevant assessment indicators and the literature on healthy buildings and green buildings from both domestic and international sources. Through expert questionnaires, the study investigates the importance and weight values of assessment items, selecting seven assessment indicators (air, water, light, exercise, comfort, materials, and mental well-being), seventeen assessment items, and 65 assessment sub-items. The weight values of each indicator are statistically analyzed. Based on the expert questionnaires, a rating system and scoring criteria are formulated, ultimately constructing the "Taiwan Healthy Building Assessment Indicators." The aim is for this framework to serve as a reference for the government in establishing a healthy building certification system as well as to enhance public awareness and emphasis on human health.

Keywords: healthy building; assessment; indicator; certification system; local demand in Taiwan

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1. Introduction

Following the United Nations "Stockholm Conference" in 1972, extensive discussions and research have been conducted on healthy building, green building, sustainable building, eco-building, and other projects, and the issue of healthy building has taken root internationally. People have begun to notice the impact of buildings on the environment, and under the trend of global sustainable health, circular economy and smart innovation, healthy building has become an important assessment objective internationally [1,2]. Countries have established successive index certification systems. Currently, certification systems such as LEED [3] in the US, BREEAM [4] in the UK, and EEWH [5] in Taiwan have become mature, and healthy building has been included as a basic policy strategy for adjustment in the face of aging infrastructure and climate change. More and more spaces that have been certified, and obtaining building certification can have a certain status in the construction industry, with the advantages of market brand effects, increased energy efficiency, and improved space quality [6–8]. Taiwan is facing issues such as an aging society, environmental problems, urban renewal, old building renovation, industrial economic transformation, and international links. Currently, there are green building and green building material certifications, yet there is no system in place for health building [9].

Healthy building certifications in different countries are developed based on different backgrounds and regions taking into account the standards most suitable for their respective local conditions. Therefore, Taiwan needs to construct healthy building assessment items and standards, applicable regulations, and processes based on its subtropical hot and humid climate and on international healthy building trends. By adapting to local conditions, we can introduce them into our daily lives and achieve the goal of a "healthy living environment" through concrete measures and verifications [10,11].

Following the Industrial Revolution, economic growth has come at the cost of human health, leading to the rise of health consciousness. In 1972 the United Nations held the

Stockholm Conference, highlighting the seriousness of environmental pollution. In 1987 the Montreal Protocol addressed the destruction of the ozone layer and its impact on the global economy. In 1992, the Rio Declaration in Brazil proposed Agenda 21 for the twenty-first century, calling for solutions to global issues [12–14]. From 1990 to 2000 various green building certification systems were developed worldwide, such as BREEAM in the UK, LEED in the US, EEWH in Taiwan, and CASBEE in Japan [15]. These certifications consider the indoor environment quality and human comfort, and have a connection to healthy building frameworks [16,17].

Fitwel is a certification system for healthy buildings developed by the Center for Disease Control and Prevention (CDC), the General Services Administration (GSA), and public health and design experts. It was launched with a five-year pilot program that tested 89 different building types in urban, suburban, and rural areas across the United States. The results were used to evaluate Fitwel's strategies, certification standards, and scoring formulas. In 2019, Fitwel was updated to version 2.1, which includes twelve strategies, covering issues such as building location, indoor environment, work spaces, shared spaces, food service, and emergency procedures [18–20].

Currently, there are approximately 38 green building assessment systems worldwide. Taiwan's EEWH is the fourth largest green building assessment system in the world after the UK, US, and Canada [21]. It is the only independent assessment system that is suitable for tropical and subtropical climates [22]. EEWH was established in 1999 to assess local subtropical high-temperature and high-humidity climates, and covers the four categories of ecology, energy efficiency, waste reduction, and health [23]. It has nine indicators and various versions, such as EEWH-BC, EEWH-RS, EEWH-GF, EEWH-RN and EEWH-EC, EEWH-OS. The system uses a single five-level grading system to encourage sustainability and reduce resource consumption and waste production [24,25]. Green building mainly focuses on the quantification of limited resources, and does not yet include non-material factors such as spiritual factors [26].

Healthy building was defined at the Healthy Buildings 2000 international conference in Helsinki, Finland in 2000 as "a way of experiencing the indoor environment of a building, which not only includes physical measurement values such as temperature, humidity, ventilation, noise, light, and air quality, but also includes subjective psychological factors such as layout, environmental color, lighting, space, and materials used; in addition to items such as job satisfaction and interpersonal relationships, and a healthy building must contain all of the above" [27,28]. In 2001, the World Health Organization carried out a cross-border "Housing and Health Plan" and categorized the abstract and concrete factors affecting healthy housing into four categories: physical (light environment, thermal environment, air environment, radiation environment, etc.), social, physiological, and chemical factors, laying the foundation for healthy building [29,30].

After 2004, health issues became a major global trend. In 2015, UN member states adopted the "2030 Agenda for Sustainable Development", which includes seventeen sustainable development goals (SDGs) aimed at achieving global sustainable development by 2030. These goals encompass a range of issues, including eradicating poverty, promoting health and well-being, achieving gender equality, ensuring education, fostering economic growth, reducing inequalities, addressing climate change, and preserving ocean and land resources, among others. The SDGs aim to promote sustainable development in the economic, social, and environmental dimensions, realizing global prosperity, equality, and sustainability [31]. In 2014, the International WELL Building Institute (IWBI) extended the development of the LEED green building label and created the "WELL Building Standard v1" [32], which included seven assessment indicators and 105 assessment items. Both contained quantifiable and non-quantifiable indicators. Version 2 was introduced in 2018 [33], and in 2019 the alignment between the UN Sustainable Development Goals (SDGs) and the WELL Building Standard was completed, making it a health building rating system with more emphasis on the impact of the building environment on human health [33–35].

In 2017, China released an assessment standard for healthy building [36] consisting of six categories of indicators, including air, water, comfort, fitness, humanities, and services, with additional bonus indicators for improvement and innovation. This aims to enhance and prioritize human health in building design [31,37,38]. In Taiwan, the private construction company JanDa has emphasized health in building design, developing their own assessment standards with nine indicators [39], The development of sustainable building assessment systems is shown in Figure 1.

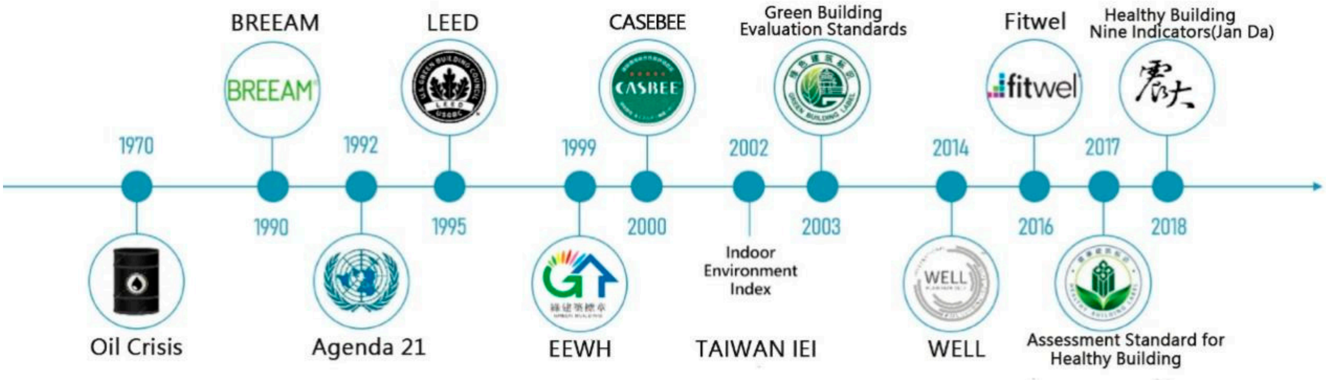

Figure 1. Timeline of sustainable building assessment systems.

Therefore, this study aims to build upon existing global health and green building assessment frameworks and to examine the evaluation indicators within each system. The content, requirements, and scoring criteria of these indicators will be investigated using research methods such as expert questionnaires, taking into account the specific social, environmental, and climatic conditions in Taiwan. Through this comparative analysis, overlapping indicators will be identified, any missing indicators will be supplemented, and appropriate weights will be assigned to each indicator based on local regulations, policies, and objectives. This process will ensure that the assessment system is tailored to meet the specific needs of Taiwan.

2. Materials and Methods

This study aims to develop the "Taiwan Health Building Assessment Indicators" by consolidating domestic and international health building assessment standards and tools, focusing on the aspects most relevant to the architectural field. Through literature review and analysis, in this study we have identified the assessment background and criteria for healthy buildings. These findings serve as the basis and direction for establishing the assessment indicators for healthy buildings in Taiwan while taking into account the local context [11]. Then, we employ the Fuzzy Delphi Method and Analytic Hierarchy Process through the medium of expert questionnaires to analyze the importance of the assessment items and determine their weights, as shown in Figure 2. This process helps to define the framework and individual items and to analyze the importance of the healthy building assessment indicators. Furthermore, we formulate a rating system and scoring principles, resulting in the creation of the "Taiwan Health Building Assessment Indicators". The objective is to provide a basis and direction for building industry policy development, align with international standards, promote the spirit of human-centric health, and encourage society to pay attention to and value the health aspects of the built environment.

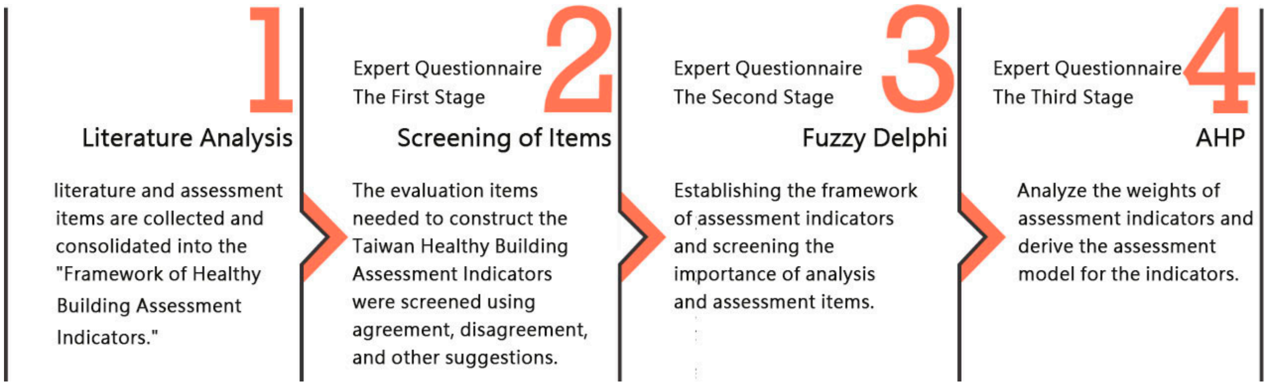

Figure 2. Flowchart of the research process.

2.1. Literature Analysis

This study aims to explore the scope of healthy building assessment indicators by collecting and analyzing domestic and international green building and healthy building certification documents. The evaluation scopes, indicators, rating criteria, and methods of these systems are summarized and compared to identify similarities and differences. This study identifies recurring indicators across multiple assessment systems which are considered important for integration. The rating criteria and requirements for these overlapping indicators are determined. The indicators from different systems are combined, modified, or innovated to ensure their feasibility and applicability in the context of Taiwan while considering local regulations, policies, and goals.

The green building assessment tools analyzed in this paper include Taiwan's EEWH [5], Taiwan's Green Building Material Certification [40], the USA's LEED [3], the UK's BREEAM [4], Japan's CASBEE [15,41], the International SBTOOL [42], China's Assessment Standard for Green Buildings [43], and others. These tools mainly focus on the sustainable use of resources, while the present research specifically discusses the health-related aspects of these tools with a particular emphasis on indoor environmental quality, including air, light, thermal comfort, acoustic environment, and building materials.

The healthy building assessment tools we examined included the Taiwan Healthy Building Nine Indicators (JanDa Construction) [39], Taiwan Wellness Architecture (Wanze Construction) [44], Taiwan Simplified Green Buildings (AGHOUSE) [45], Taiwan Green Design Decoration Certification [46], US WELL [33], US Fitwel [18], China Assessment Standard for Healthy Buildings [36], and others. These tools cover both nationally established and privately researched standards. While Taiwan's private standards focus on specific assessment items, others are mainly conceptual and descriptive. Nevertheless, they can reflect the emphasis of Taiwan's industry on health-related issues such as air, water, light, thermal comfort, acoustic environment, and building materials. International health building certifications have broader coverage, including nutrition, community, and innovation, which receive less attention in the industry.

To conduct this research, the relevant literature was searched using keywords such as Healthy Building Assessment, Healthy Building Standards, Green Building Assessment, Sustainable Building Certification, Indoor Environmental Quality, Thermal Comfort, Indoor Air Quality, Lighting Design, Acoustic Performance, Water Efficiency, Material Selection, Indoor Fitness Facilities, Biophilic Design, Community Engagement, Innovation in Building Design, Electromagnetic Fields, Healthy Building Design Guidelines, Health and Well-being in Buildings, Building Performance Evaluation, Evidence-based Design, etc.. The literature was carefully screened and selected, excluding irrelevant or duplicate documents. A thorough reading and excerpting of selected literature was conducted to compile and analyze relevant information on assessment indicators, including strategies for creating a healthy environment, preventive measures, and checking methods, as shown in Table 1. The main conclusions and significant findings were extracted and combined with the organization of the evaluation standards system based on Taiwan's specific needs, culture, and regulatory environment, and the objectives and scope of expert questionnaire screening for healthy building evaluation standards were clearly defined. This process resulted in the identification of twelve assessment indicators (air, water, nutrition, lighting, physical activity, thermal comfort, acoustic environment, materials, mental well-being, community, innovation, and electromagnetic environment) and 130 assessment items, which are presented in a detailed table (see Appendix A). These research findings served as the basis for the content of the expert questionnaire in the first phase [40].

Table 1. Evaluation indicators in domestic and international healthy building assessment tools.

Indicator Certification (Assessment Tool)	**Evaluation Indicators**											
	Air	**Water**	**Nourishment**	**Light**	**Movement**	**Thermal Comfort**	**Sound**	**Materials**	**Mind**	**Comminity**	**Innovation**	**EMF**
LEED	◎			◎		◎	◎	◎				
BREEAM				◎	◎							
CASBEE	◎			◎		◎	◎					
SBTOOL	◎			◎		◎	◎					◎
Assessment standard for green building (China)	◎			◎	◎	◎	◎					
EEWH	◎			◎			◎	◎				
Green Building Material (Taiwan)								◎				
WELL	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	
Fitwel	◎	◎	◎	◎	◎			◎	◎	◎		
Assessment standard for healthy building (China)	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	
RESET	◎											
Taiwan Healthy Building Nine Indicators (JanDa Construction)	◎	◎		◎	◎	◎	◎	◎	◎			◎
Taiwan Wellness Architecture (Wanze Construction)	◎	◎		◎		◎						
Taiwan Simplified Green Buildings (AGHOUSE)	◎					◎		◎				
Taiwan Green Design Decoration Certification	◎	◎		◎			◎	◎				

2.2. *Assessment of Project Importance Screening and Weight Analysis*

In this study, we conducted a three-stage expert opinion survey questionnaire to assess the importance of the project items. In the first stage, a preliminary assessment was made to screen the appropriate assessment items based on agreement, disagreement, and other suggested criteria. The second stage involved the use of a Fuzzy Delphi Method questionnaire to analyze the importance screening of assessment items, facilitate comprehensive discussions, and perform cross-comparisons. In the third stage, an Analytic Hierarchy Process expert questionnaire was used to analyze the weight values of each assessment item [41]. Through the expert questionnaires from these three stages, the "Taiwan Healthy Building Assessment Framework" was established to serve as the basis for subsequent scoring criteria.

2.2.1. Expert Selection

This study utilized the Fuzzy Delphi Method and Analytic Hierarchy Process (AHP) expert questionnaire methods to gather the opinions of relevant experts in the field of healthy building assessment indicators in Taiwan. In light of the specialized nature of the indicators, respondents were required to possess professional background knowledge in order to understand the terminology and concepts involved. Therefore, the selected survey participants needed to meet at least one of the following criteria: (1) engaged in the field of healthy building practices, (2) involved in teaching and research related to the study topic, (3) possessing a professional background related to the study topic, (4) having previously published articles or reports related to the study topic, (5) engaged in a certification-related industry, and (6) having demonstrated a certain level of interest and sufficient professional knowledge in the study topic. To ensure comprehensive consideration of multiple perspectives and enhance objectivity, the survey participants were divided into three groups based on their professional fields: architecture, building materials, equipment, and civil engineering/construction. These groups consisted of experts from government agencies, academic institutions, and industry. The background and field of experts from the three stages are shown in Figures 3 and 4, respectively. Through this approach, we aimed to gather diverse professional opinions and ensure the credibility of the questionnaire.

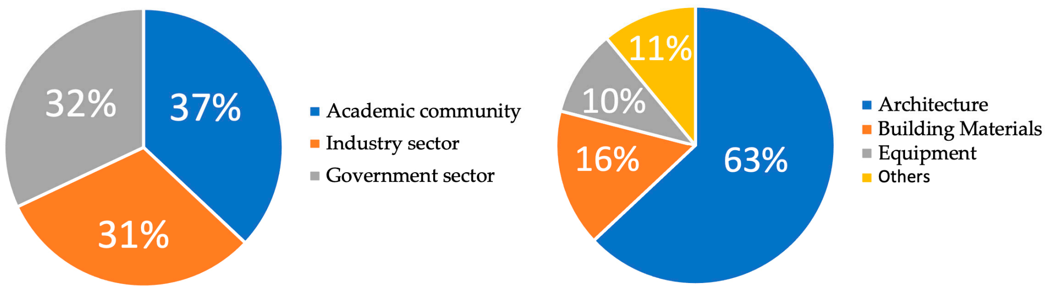

Figure 3. Statistical graph of expert background and field in the first and second stages.

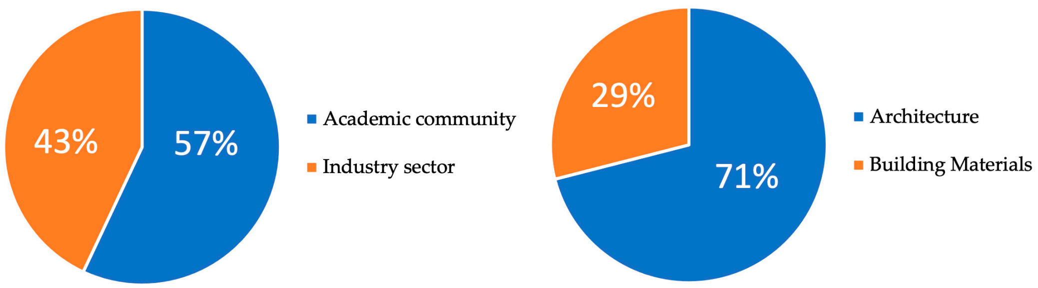

Figure 4. Statistical graph of expert background and field in the third stage.

For the first stage (expert questionnaire) and the second stage (Fuzzy Delphi Method) surveys, a minimum of ten participants was necessary to minimize group errors and maximize reliability. When the group members are homogeneous, the ideal range is 15 to 30 members. For heterogeneous groups, the ideal range is 5 to 10 members. Considering the high homogeneity (69%) in the distribution of professional fields in the architecture category for the first and second phase questionnaires, a total of nineteen questionnaires were distributed. These questionnaires were distributed among seven participants from the academic sector, six participants from the industry sector, and six participants from government agencies. In terms of professional fields, there were twelve participants from architecture, three from building materials, two from equipment, and two from other fields, including civil engineering and certification-related areas.

Regarding expert selection for the third phase (AHP questionnaire) survey, the number of experts was associated with the complexity of the decision problem; generally, a suitable range is 5 to 15 participants. There were a total of seven respondents in the third phase, including four from the academic sector and three from the industry sector.

2.2.2. The First Stage

In the first stage, a preliminary assessment of the importance of factors was conducted using the expert questionnaire method. Experts were asked to indicate their agreement or disagreement with the twelve assessment indicators and 130 assessment items compiled for this study. In order to allow experts to fully express their opinions, an additional section for suggestions was included, providing them with a space for written descriptions. This allowed the experts to select more appropriate assessment items and fully articulate their views.

A total of nineteen experts were invited to participate in the questionnaire survey. The survey was conducted using a combination of paper-based responses (fourteen questionnaires) and online responses (five questionnaires), resulting in a total of nineteen completed questionnaires. The response rate was 100%, and all nineteen received questionnaires were deemed valid.

The total number of respondents with differing opinions in the first-stage questionnaire was 302, yielding an arithmetic mean of 2.32. This figure represents approximately 12% of all participating experts. To ensure impartiality in selecting the health building assessment items deemed relatively significant by the entire expert panel, an unconditional inclusion approach was employed. A threshold value of 3, denoting disagreement, was utilized to eliminate assessment items with disagreement scores surpassing the established threshold.

The final result of the first-stage expert questionnaire yielded twelve assessment indicators and 82 assessment items.

2.2.3. The Second Stage

The second stage involved the use of the Fuzzy Delphi method with double triangular fuzzy numbers to screen the importance of assessment items. This method aims to reduce the number of repeated surveys. The key feature of this method is the application of double triangular fuzzy numbers to integrate expert opinions, with the "gray zone detection method" effectively checking whether there is convergence and consensus among the experts, as shown in Figure 5. The steps involved in this method are as follows [42]:

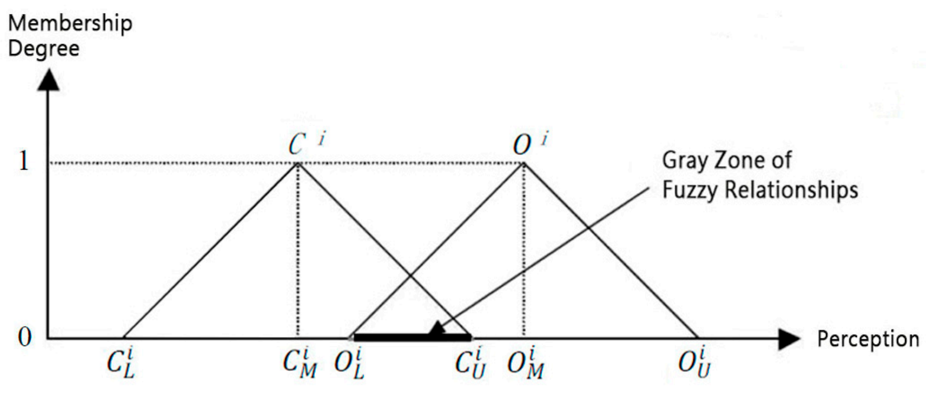

Figure 5. Dual triangular fuzzy number graph.

(1) Step 1. Continuing from the first stage, each expert is asked to assess the importance of each assessment item based on their professional expertise and experience. They need to select a possible range value between 0 and 10 to indicate the importance level, with a higher value indicating higher importance. The "minimum value" of this range represents the expert's "most conservative perception" of the assessment item, expressed as a triangular fuzzy number $C^i = \left(C_L^i,\ C_M^i, C_U^i,\right)$. The "maximum value" of this range represents the expert's "most optimistic perception" of the assessment item, expressed as a triangular fuzzy number $O^i = \left(O_L^i,\ O_M^i, O_U^i,\right)$.

(2) Step 2. For each assessment item i, statistical analysis is performed on the "most conservative perception" and "most optimistic perception" values provided by all experts. Extreme values outside of "two times the standard deviation" are excluded. The minimum value $\left(C_L^i\right)$, geometric mean $\left(C_M^i\right)$, and maximum value $\left(C_U^i\right)$ are then calculated from the remaining "most conservative perception" values, as well as the minimum value $\left(O_L^i\right)$, geometric mean $\left(O_M^i\right)$, and maximum value $\left(O_U^i\right)$ from the remaining "most optimistic perception" values.

(3) Step 3. The consensus among the experts is examined to determine if it has been achieved. Whether the expert opinions have reached a consensus can be determined using the following approach:

A. If there is no overlapping between the two triangular fuzzy numbers, that is, $C_U^i \leq O_L^i$, it indicates that the opinion intervals of the experts have a consensus zone and their opinions tend to fall within this consensus zone. Therefore, the "consensus importance value" G^i for assessment item i is defined as the arithmetic mean of C_M^i and O_M^i, expressed as:

$$G^i = \left(C_M^i + O_M^i\right)/2$$

B. If there is an overlap between the two triangular fuzzy numbers, that is, $C_U^i > O_L^i$, and the gray zone of the fuzzy relationship $Z^i = \left(C_U^i - O_L^i\right)$ is smaller than the interval range $M^i = \left(O_M^i - C_M^i\right)$ between the geometric means of optimistic and conservative opinions, this indicates that although there is no consensus zone in the opinion intervals of the experts, the two experts who provided extreme values (the most conservative O_L^i and the most optimistic C_U^i) do not differ significantly from the opinions of other experts, avoiding a divergence in opinions. Therefore, the "consensus importance value" G^i for assessment item i is defined as the fuzzy set obtained by intersecting the two triangular fuzzy numbers and then quantifying the maximum membership degree value of that fuzzy set.

$$G^i = O_L^i + \frac{\left(O_M^i - O_L^i\right) \times \left(C_U^i - O_L^i\right)}{\left(C_U^i - C_M^i\right) + \left(O_M^i - O_L^i\right)}$$

C. If there is an overlap between the two triangular fuzzy numbers, that is, $C_U^i > O_L^i$ and the gray zone of the fuzzy relationship $Z^i = \left(C_U^i - O_L^i\right)$ is greater than the interval range $M^i = \left(O_M^i - C_M^i\right)$ between the geometric means of optimistic and conservative opinions (specifically, $M^i - Z^i < 0$), this indicates that there is no consensus zone in the opinion intervals of the experts, and the two experts who provided extreme values (the most conservative in the optimistic opinion and the most optimistic in the conservative opinion) differ significantly from the opinions of other experts. This implies a divergence of opinions. Therefore, the geometric means of optimistic and conservative opinions, which did not converge, are provided to the experts as reference values and steps one to three are repeated by conducting another round of questionnaire surveys until convergence is achieved for all assessment items and the "consensus importance value" G^i is obtained. However, due to time constraints, in this study the importance values provided by the experts were examined and discussed with the research team for potential deletion or further investigation for those assessment items where significant divergence in opinions occurred.

This stage of the questionnaire survey aims to gather valuable opinions from experts and scholars in different fields as a basis for the third-stage Analytic Hierarchy Process (AHP) expert questionnaire. To ensure that the experts could fully express their opinions, flexibility was provided for experts and scholars to add additional items in order to compensate for any deficiencies in the initial literature-based list of indicators. A total of nineteen questionnaires were distributed to the experts from the first stage, and all nineteen questionnaires were collected. However, two questionnaires were deemed invalid, leaving seventeen valid questionnaires for statistical analysis.

The selection criteria were based on the expert consensus value (G^i) and the criterion value ($M^i - Z^i$). The setting of the threshold value directly affects the indicators. The determination of the threshold value can be done in various ways: (1) setting the threshold value within the range of 6 to 8, (2) subjective judgment by decision-makers, (3) consultation with experts to reach a consensus, (4) arithmetic mean, and (5) using a line graph, among others. The determination of the threshold value should be based on the researchers' research philosophy. To avoid excessive deletion of decision factors that might affect the overall framework, in this study we set the threshold value for screening items at 6 ($G^i = 6$).

2.2.4. The Third Stage

In the third stage, the Analytic Hierarchy Process (AHP) was used to integrate the opinions of relevant experts and scholars. AHP is a method for assessing the relative weights of evaluation indicators. Experts are asked to compare each pair of indicators, criteria, and sub-criteria to establish a hierarchical structure for the evaluation. This process helps to evaluate and statistically analyze the overall weights of indicators, criteria, and sub-criteria.

When experts fill out the AHP questionnaire, logical consistency among indicators within the same group is a necessary condition. For example, if there are indicators X, Y, and Z, and if X > Y and X < Z, then Y must be ranked lower than Z, otherwise the questionnaire is considered invalid.

For example, assuming that there are criteria related to "health" and that the evaluation indicators are 1. Food, 2. Exercise, and 3. Sleep, if the order in the ranking part is (3) $\geq$ (2) $\geq$ (1) this indicates that the importance is Sleep $\geq$ Exercise $\geq$ Food.

In the part involving relative importance, experts need to compare the relative importance of factors. The more they lean towards one side, the greater the importance of that factor. The closer they are to the middle, the closer the importance of the two factors. The relative importance assigned to the criteria varies from 1 to 9. Table 2 shows the Saaty's scale of relative importance [43].

Table 2. Saaty's scale of relative importance.

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Demonstrated importance	An activity is strongly favored and its dominance demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation

The questionnaire content for the third level, focusing on air quality standards, is provided as an example shown in Figure 6:

1.Sub-items of Air Quality Standards

Assessment Item		Sub-items		Content
A-1	Air Quality Standards	A-1-1	Basic Air Quality	Ensure basic air quality standards for $PM_{2.5}$, PM_{10}, Formaldehyde, VOCs, CO, O_3, etc.
		A-1-2	VOCs Control	Utilize equipment to filter VOCs.
		A-1-3	Microorganism and Mold Control	Prevent moisture and mold issues and use equipment for disinfection and sterilization.
		A-1-4	Air Quality Monitoring and Awareness	Provide monitoring displays for real-time air quality improvement.

A. Please rank the following in order of their importance (by filling in the numbers):

( ) ≥( ) ≥( ) ≥( )

B. Please compare and select the relative importance by ticking (V) below:

Figure 6. *Cont.*

Sub-items	9	7	5	3	1	3	5	7	9	Sub-items
A-1-1 Basic Air Quality										A-1-2 VOCs Control
										A-1-3 Microorganism and Mold Control
										A-1-4 Air Quality Monitoring and Awareness
A-1-2 VOCs Control										A-1-3 Microorganism and Mold Control
										A-1-4 Air Quality Monitoring and Awareness
A-1-3 Microorganism and Mold Control										A-1-4 Air Quality Monitoring and Awareness

Figure 6. Graph of non-overlapping dual triangular fuzzy numbers.

A total of seven experts were surveyed, with two paper-based responses and five online responses. The response rate was 100%, and seven questionnaires were deemed valid.

3. Results and Discussion

3.1. Results of the Fuzzy Delphi Method

In the second stage, the screening results from the first stage were applied using the fuzzy Delphi method questionnaire. A total of twelve assessment indicators and 82 assessment items were included. The analysis of importance yielded the following results.

(1) Air Indicators.

According to the analysis using double triangular fuzzy numbers, the assessment item with the highest expert consensus value (Gi) is "A-1 Basic Air Quality" (Gi = 7.51), and all other items meet the expert consensus threshold (Gi = 6). However, two items do not meet the testing value threshold (Mi-Zi > 0); these are "A-12 Natural Ventilation Potential" (Mi-Zi = −2.6) and "A-14 Operable Windows" (Mi-Zi = −2.6). This makes it impossible to calculate the expert consensus value (see Table 3).

The experts provided feedback with regard to several assessment items. For "A-3 Active Control of Volatile Organic Compounds (VOCs)", it was suggested that the use of activated carbon to filter VOCs is limited to specific treatment techniques, and that the focus should be on controlling organic pollutants. Several of the experts suggested considering whether existing technologies can provide complete control. For "A-4 Microbial and Fungal Control", it was mentioned that while prevention of dampness and mold issues and the use of ultraviolet disinfection are important, it is not necessary to specify specific techniques such as ultraviolet light. Considering the above, this item could be revised to "Prevention and Resolution of Dampness and Mold Issues". For "A-6 Enhanced Ventilation", the suggestion was to adjust indoor carbon dioxide levels by increasing outdoor air supply. Several of the experts also recommended incorporating new air devices to increase the intake of outdoor air. Lastly, for "A-15 Smoke-Free Environment", it was proposed that this item be combined with "A-10 Source Separation", as tobacco hazards can be included among other pollution sources.

Table 3. Air indicator importance analysis.

Indicator		Assessment Item	Most Conservative Cognition		Most Optimistic Cognition		Geometric Mean		M_i	Z_i	M_i-Z_i	G_i
			C^i_L	C^i_U	O^i_L	O^i_U	C^i_M	O^i_M				
Air	A-1	Basic Air Quality	4	8	8	10	5.8	9.2	3.5	0.0	3.5	7.51
	A-3	VOCs Control	3	8	7	10	4.8	8.3	3.5	1.0	2.5	7.29
	A-4	Microbe and Mold Control	1	8	5	10	4.1	7.9	3.7	3.0	0.7	6.28
	A-5	Ventilation Efficiency	2	8	6	10	5.3	8.7	3.4	2.0	1.4	7.01
	A-6	Enhanced Ventilation	2	8	5	10	5.3	8.3	3.0	3.0	0.0	6.67
	A-8	Air Quality Monitoring and Awareness	3	8	6	10	4.9	8.1	3.2	2.0	1.2	6.81
	A-10	Pollutant Source Separation	2	7	6	10	4.5	7.7	3.2	1.0	2.2	6.40
	A-11	Air Filtration	2	8	6	10	5.0	8.1	3.1	2.0	1.1	6.82
	A-12	Natural Ventilation Potential	1	9	3	10	4.3	7.8	3.4	6.0	−2.6	
	A-14	Operable Windows	1	10	5	10	5.5	8.6	3.2	5.0	−1.8	
	A-15	Smoke-Free Environment	3	8	6	10	6.0	8.9	2.9	2.0	0.9	7.19

(2) Water Indicators.

Based on the analysis using the double triangular fuzzy numbers, the assessment item with the highest expert consensus value (Gi) is "W-2 Water Pollution" (Gi = 7.30). One item does not meet the expert consensus value (Gi), namely, "W-7 Drinking Water Promotion" (Gi = 5.50), while the rest of the items meet the expert consensus threshold (Gi = 6). Among them, one item does not meet the test value threshold (Mi-Zi > 0), namely, "W-6 Moisture Management" (Mi-Zi = −0.1); therefore, the expert consensus value cannot be calculated. (See Table 4 for details).

Table 4. Water indicator importance analysis.

Indicator		Assessment Item	Most Conservative Cognition		Most Optimistic Cognition		Geometric Mean		M_i	Z_i	M_i-Z_i	G_i
			C^i_L	C^i_U	O^i_L	O^i_U	C^i_M	O^i_M				
Water	W-1	Basic Water Quality	3	8	8	10	5.6	8.9	3.3	0.0	3.3	7.27
	W-2	Water Pollutants	3	8	8	10	5.6	9.0	3.3	0.0	3.3	7.30
	W-3	Legionella Control	3	7	6	10	4.7	8.2	3.4	1.0	2.4	6.49
	W-4	Enhanced Water Quality	3	7	6	9	4.6	7.6	3.0	1.0	2.0	6.40
	W-5	Water Consistency	3	8	6	10	5.0	8.0	3.0	2.0	1.0	6.81
	W-6	Moisture Management	3	8	5	10	4.9	7.7	2.9	3.0	−0.1	
	W-7	Drinking Water Promotion	2	6	5	9	3.9	7.1	3.2	1.0	2.2	5.50
	W-8	Handwashing	3	8	6	10	5.5	8.6	3.0	2.0	1.0	7.02
	W-10	Backflow Prevention System	2	8	5	10	4.0	7.3	3.3	3.0	0.3	6.09

Regarding certain assessment items, experts suggested that "W-3 Veteran Microorganism Control" could be merged into the assessment item "W-2 Water Pollution". The explanation for "W-4 Enhancing Water Quality" should clarify the definitions of "interfering substances" and "taste characteristics", as they are not clear enough. The explanation for "W-6 Moisture Management" should include the term "indoor" to better describe its content, and several experts believed that the need for this item was not very high. For "W-7 Drinking Water Promotion", the original description mentioned having at least one water dispenser within a 30 m walking distance. The experts proposed relaxing this to a 50 m walking distance, and suggested revising the description to emphasize providing an adequate number of water dispensers, which should vary depending on the function of the building. "W-8 Handwashing" could include providing antibacterial cleansers. Moreover, in the explanation it mentions providing disposable hand towels; this could be revised to include providing reusable hand towels or replacing them with hand dryers. Additionally, the experts suggested adding "provision of shower facilities" as part of the commuting or post-exercise requirements, which could be included under the exercise indicator.

(3) Nourishment Indicators.

Based on the analysis using the double triangular fuzzy numbers, the assessment item with the highest expert consensus value (Gi) is "N-4 Nutritional Information Transparency" (Gi = 6.79), while the rest of the items meet the expert consensus threshold (Gi = 6). All items meet the test value threshold (Mi-Zi > 0), indicating that all experts agreed on the assessment items of this indicator and there was a significant level of consensus (see Table 5).

Table 5. Nourishment indicator importance analysis.

Indicator	**Assessment Item**		**Most Conservative Cognition**		**Most Optimistic Cognition**		**Geometric Mean**		**M_i**	**Z_i**	**M_i-Z_i**	**G_i**
			$C^i{}_L$	**$C^i{}_U$**	**$O^i{}_L$**	**$O^i{}_U$**	**$C^i{}_M$**	**$O^i{}_M$**				
Nourishment	N-4	Nutritional Transparency	2	8	6	10	4.7	8.1	3.4	2.0	1.4	6.79
	N-10	Mindful Eating	2	8	6	10	4.3	7.7	3.4	2.0	1.4	6.62

(4) Light Indicators.

Based on the analysis using the double triangular fuzzy numbers, the assessment item with the highest expert consensus value (Gi) is "L-2 Visual Lighting Design" (Gi = 7.43), while the rest of the items meet the expert consensus threshold (Gi = 6). However, two items do not meet the test value threshold (Mi-Zi > 0), namely, "L-6 Enhancing Daylight Access" (Mi-Zi = −0.9) and "L-7 Natural Lighting Performance" (Mi-Zi = −1.7), meaning that the expert consensus value cannot be calculated for these items (see Table 6).

Regarding certain assessment items, experts suggested that the description of "L-3 Visual Balance" should include the requirement for adequate brightness in all spaces when they are in use as a way to avoid energy waste. For "L-4 Day-Night Lighting Design", it was recommended to adopt an environmentally friendly, energy-saving, and sustainable lighting system that adapts to the day-night rhythm.

(5) Movement Indicators.

Based on the analysis using the double triangular fuzzy numbers, the assessment item with the highest expert consensus value (Gi) is "V-10 Site Planning and Selection" (Gi = 6.95), while the rest of the items meet the expert consensus threshold (Gi = 6). All items meet the test value threshold (Mi-Zi > 0), indicating that all experts agreed on the assessment items of this indicator to a considerable degree (see Table 7).

Table 6. Light indicator importance analysis.

Indicator		Assessment Item	Most Conservative Cognition		Most Optimistic Cognition		Geometric Mean		M_i	Z_i	M_i-Z_i	G_i
			C^i_L	C^i_U	O^i_L	O^i_U	C^i_M	O^i_M				
Light	L-1	Light Exposure and Education	2	8	6	10	4.9	8.0	3.1	2.0	1.1	6.79
	L-2	Visual Lighting Design	3	8	7	10	5.7	8.7	2.9	1.0	1.9	7.43
	L-3	Visual Balance	4	8	7	10	6.0	8.5	2.5	1.0	1.5	7.42
	L-4	Circadian Lighting Design	3	7	7	9	4.9	8.0	3.2	0.0	3.2	6.44
	L-5	Glare Control	3	8	7	10	5.2	8.3	3.1	1.0	2.1	7.31
	L-6	Enhanced Daylight Access	1	9	5	10	4.7	7.8	3.1	4.0	−0.9	
	L-7	Natural Daylight Performance	1	10	5	10	4.5	7.8	3.3	5.0	−1.7	
	L-8	Electric Light Quality	3	8	6	10	5.2	8.3	3.2	2.0	1.2	6.90
	L-9	Occupant Lighting Control	3	7	6	9	4.8	7.9	3.1	1.0	2.1	6.46

Table 7. Movement indicator importance analysis.

Indicator		Assessment Item	Most Conservative Cognition		Most Optimistic Cognition		Geometric Mean		M_i	Z_i	M_i-Z_i	G_i
			C^i_L	C^i_U	O^i_L	O^i_U	C^i_M	O^i_M				
Movement	V-1	Visual and Physiological Ergonomics	2	8	6	10	4.8	8.2	3.4	2.0	1.4	6.82
	V-2	Fitness Furniture	3	7	7	10	5.2	8.3	3.0	0.0	3.0	6.75
	V-4	Sports Network and Pathways	2	9	6	10	4.6	7.7	3.1	3.0	0.1	6.82
	V-8	Active Architecture and Communities	2	8	6	10	4.4	7.8	3.3	2.0	1.3	6.66
	V-9	Support for Commuters and Residents	1	7	5	10	4.3	7.8	3.5	2.0	1.5	6.01
	V-10	Site Planning and Selection	2	8	6	10	5.3	8.4	3.1	2.0	1.1	6.95

Regarding certain assessment items, experts suggested that "V-8 Active Buildings and Communities" is more suitable for newly constructed buildings. Additionally, several experts recommended adding the item "provision of Shower Facilities" to the assessment, allowing users to shower after commuting or engaging in physical activities. This suggestion could be considered under the water indicator as well.

(6) Thermal Comfort Indicators.

Based on the analysis using the double triangular fuzzy numbers, the assessment item with the highest expert consensus value (Gi) is "T-7 Humidity Control" (Gi = 6.90), while the rest of the items meet the expert consensus threshold (Gi = 6). All items meet the test value threshold (Mi-Zi > 0), indicating that all experts agreed on the assessment items of this indicator to a considerable degree (see Table 8).

Table 8. Thermal comfort indicator importance analysis.

Indicator	Assessment Item		Most Conservative Cognition		Most Optimistic Cognition		Geometric Mean		M_i	Z_i	M_i-Z_i	G_i
			C^i_L	C^i_U	O^i_L	O^i_U	C^i_M	O^i_M				
Thermal Comfort	T-3	Individual Thermal Control	2	7	5	10	4.5	7.7	3.2	2.0	1.2	6.04
	T-4	Radiant Thermal Comfort	2	8	6	10	4.6	7.8	3.2	2.0	1.2	6.69
	T-5	Thermal Zoning	2	8	6	10	4.4	7.5	3.1	2.0	1.1	6.58
	T-6	Thermal Comfort Monitoring	2	8	6	10	4.9	8.1	3.2	2.0	1.2	6.80
	T-7	Humidity Control	2	8	6	10	5.2	8.3	3.1	2.0	1.1	6.90

Regarding certain assessment items, experts suggested that "T-3 Personal Thermal Comfort Control" could prioritize cost-effective personal fans. Two additional assessment items were recommended: "promotion of natural ventilation" to address the subtropical climate and actively reduce heat load through natural ventilation, and "outdoor air cooling" to address the subtropical climate, where outdoor air cooling can be used to reduce heat load during the comfortable seasons.

(7) Sound Comfort Indicators.

Based on the analysis using the double triangular fuzzy numbers, the assessment item with the highest expert consensus value (Gi) is "S-5 Floor Sound Insulation" (Gi = 8.03), while the rest of the items meet the expert consensus threshold (Gi = 6). However, one item does not meet the test value threshold (Mi-Zi > 0), namely, "S-3 Sound Absorption" (Mi-Zi = −0.6), meaning that the expert consensus value cannot be calculated (see Table 9).

Table 9. Sound indicator importance analysis.

Indicator	Assessment Item		Most Conservative Cognition		Most Optimistic Cognition		Geometric Mean		M_i	Z_i	M_i-Z_i	G_i
			C^i_L	C^i_U	O^i_L	O^i_U	C^i_M	O^i_M				
Sound	S-1	Maximum Noise Levels	2	9	6	10	4.8	8.2	3.3	3.0	0.3	7.02
	S-2	Sound Barriers	2	8	7	10	5.1	8.6	3.5	1.0	2.5	7.35
	S-3	Sound Absorption	1	8	4	10	4.3	7.6	3.4	4.0	−0.6	
	S-5	Floor Sound Insulation	2	10	7	10	5.8	9.2	3.3	3.0	0.3	8.03

Regarding certain assessment items, experts suggested that "S-2 Sound Barrier" could be revised to the term "Sound Insulation", which is more commonly used in Taiwan. Furthermore, it was suggested that the definition of this assessment item is not clear and needs further examination and discussion as to its purpose and content. Two experts recommended revising the content of "S-3 Sound Absorption" by replacing the term "reverberation time", which is not commonly used in Taiwan, with "echo time", "residual time", or "lingering time". For "S-5 Floor Sound Insulation", as current building floors in Taiwan are generally thicker than 15 cm, it seems to have no significant difference from the standard. Several experts suggest that it could be revised to indicate the implementation of impact sound insulation measures in the floors or to refer to Article 46 of the "Architectural Technology Standards–Building Design and Construction".

(8) Materials Comfort Indicators.

Based on the analysis using the double triangular fuzzy numbers, the assessment item with the highest expert consensus value (Gi) is "X-1 Prevention of Basic Materials" (Gi = 8.59), while the rest of the items meet the expert consensus threshold (Gi = 6). However, one item does not meet the test value threshold (Mi-Zi > 0), namely, "X-9 Reduction of Volatile Components" (Mi-Zi = −0.1), meaning that the expert consensus value cannot be calculated (see Table 10).

Table 10. Materials indicator importance analysis.

Indicator	Assessment Item		Most Conservative Cognition		Most Optimistic Cognition		Geometric Mean		M_i	Z_i	M_i-Z_i	G_i
			C^i_L	C^i_U	O^i_L	O^i_U	C^i_M	O^i_M				
Materials	X-1	Basic Material Prevention	3	10	8	10	6.4	9.5	3.0	2.0	1.0	8.59
	X-2	Hazardous Material Reduction	3	10	8	10	6.6	9.3	2.8	2.0	0.8	8.56
	X-3	On-Site Management	5	10	8	10	6.9	9.3	2.4	2.0	0.4	8.58
	X-4	Hazardous Material Reduction	4	8	8	10	6.7	9.3	2.6	0.0	2.6	8.01
	X-5	Enhanced Material Prevention	3	8	6	10	5.7	8.7	3.0	2.0	1.0	7.08
	X-6	Waste Management	3	8	6	10	5.1	8.3	3.2	2.0	1.2	6.87
	X-7	Pesticide Use	2	7	6	9	4.4	7.7	3.3	1.0	2.3	6.40
	X-8	Cleaning Products and Standards	3	8	6	10	5.0	7.8	2.8	2.0	0.8	6.74
	X-9	Reduction of Volatile Compounds	2	9	6	10	5.4	8.3	2.9	3.0	−0.1	
	X-10	Long-Term Volatile Control	3	8	6	10	5.3	8.4	3.1	2.0	1.1	6.94
	X-11	Short-Term Volatile Control	2	8	5	10	5.0	8.2	3.1	3.0	0.1	6.55
	X-12	Material Transparency	2	9	6	10	4.9	8.1	3.2	3.0	0.2	7.03
	X-13	Exterior Structures	2	7	6	9	4.4	7.3	2.9	1.0	1.9	6.34

Regarding certain assessment items, experts suggested that "X-8 Cleaning Products and Specifications" could emphasize its application in public areas. For "X-10 Long-Term Volatile Control" and "X-11 Short-Term Volatile Control", it was recommended that these be merged into a single assessment item, "X-9 Reduction of Volatile Components".

(9) Mind Comfort Indicators.

Based on the analysis using the double triangular fuzzy numbers, the assessment item with the highest expert consensus value (Gi) is "M-7 Opportunity for Recovery" (Gi = 6.62), while the rest of the items meet the expert consensus threshold (Gi = 6). However, four items do not meet the test value threshold (Mi-Zi > 0); these are "M-5 Contact with Nature" (Mi-Zi = −1.0), "M-8 Spaces that Support Recovery" (Mi-Zi = −0.9), "M-10 Sleep Support" (Mi-Zi = −0.9), and "M-13 Tobacco Prevention and Cessation" (Mi-Zi = −0.9), and their expert consensus value cannot be calculated. Regarding certain assessment items, experts suggested that "M-6 More Contact with Nature" is difficult to implement in urban environments (see Table 11).

Table 11. Mind indicator importance analysis.

Indicator	Assessment Item		Most Conservative Cognition		Most Optimistic Cognition		Geometric Mean		M_i	Z_i	M_i-Z_i	G_i
			$C^i{}_L$	$C^i{}_U$	$O^i{}_L$	$O^i{}_U$	$C^i{}_M$	$O^i{}_M$				
Mind	M-1	Mental Health Promotion	3	7	6	10	5.2	8.2	3.0	1.0	2.0	6.54
	M-5	Enhanced Access to Nature	2	8	4	10	4.5	7.5	3.0	4.0	−1.0	
	M-6	More Nature Exposure	1	8	5	10	4.5	7.5	3.0	3.0	0.0	6.27
	M-7	Restorative Opportunities	3	8	5	10	5.2	8.3	3.0	3.0	0.0	6.62
	M-8	Restorative Spaces	1	8	4	10	4.1	7.3	3.1	4.0	−0.9	
	M-10	Sleep Support	1	7	3	10	3.8	6.9	3.1	4.0	−0.9	
	M-13	Tobacco Use Prevention and Cessation	2	8	4	10	4.1	7.2	3.1	4.0	−0.9	

(10) Community Comfort Indicators.

Based on the analysis using the double triangular fuzzy numbers, the assessment item with the highest expert consensus value (Gi) is "C-7 Accessibility and Universal Design" (Gi = 7.66). One item does not meet the expert consensus threshold (Gi), which is "C-3 Resident Survey" (Gi = 5.53). The rest of the items meet the expert consensus threshold (Gi = 6). However, four items do not meet the test value threshold (Mi-Zi > 0); these are "C-1 Health Awareness" (Mi-Zi = −3.4), "C-5 Support for New Mothers" (Mi-Zi = −3.6), "C-8 Emergency Preparedness" (Mi-Zi = −1.1), and "C-9 Community Openness and Engagement" (Mi-Zi = −1.0), meaning that the expert consensus value cannot be calculated (see Table 12).

Regarding certain assessment items, experts suggested that "C-7 Accessibility and Universal Design" should prioritize accessibility needs. For "C-16 Toilet Configuration", it was recommended that an adequate number of toilets should be provided based on space requirements.

(11) Innovation Comfort Indicators.

Based on the analysis using the double triangular fuzzy numbers, the assessment item with the highest expert consensus value (Gi) is "I-4 Professionals (AP)" (Gi = 6.54). The rest of the items meet the expert consensus threshold (Gi = 6). However, one item does not meet the test value threshold (Mi-Zi > 0), namely, "I-1 Innovation" (Mi-Zi = −0.6), meaning that the expert consensus value cannot be calculated (see Table 13).

Table 12. Community indicator importance analysis.

Indicator	Assessment Item		Most Conservative Cognition		Most Optimistic Cognition		Geometric Mean		M_i	Z_i	M_i-Z_i	G_i
			C^i_L	C^i_U	O^i_L	O^i_U	C^i_M	O^i_M				
Community	C-1	Health Awareness	1	7	1	10	4.3	6.9	2.6	6.0	−3.4	
	C-3	Occupant Survey	2	7	4	10	4.0	7.1	3.0	3.0	0.0	5.53
	C-4	Enhanced Occupant Survey	2	8	6	10	4.4	7.7	3.3	2.0	1.3	6.64
	C-5	New Mother Support	1	10	3	10	4.6	7.9	3.4	7.0	−3.6	
	C-7	Accessibility and Universal Design	3	8	8	10	6.1	9.2	3.1	0.0	3.1	7.66
	C-8	Emergency Preparedness	2	8	4	10	5.4	8.3	2.9	4.0	−1.1	
	C-9	Community Openness and Engagement	2	8	4	10	4.9	7.9	3.0	4.0	−1.0	
	C-11	Health Promotion	2	7	6	9	4.3	7.2	3.0	1.0	2.0	6.31
	C-16	Restroom Facilities	2	8	6	10	5.0	8.4	3.4	2.0	1.4	6.88

Table 13. Innovation indicator importance analysis.

Indicator	Assessment Item		Most Conservative Cognition		Most Optimistic Cognition		Geometric Mean		M_i	Z_i	M_i-Z_i	G_i
			C^i_L	C^i_U	O^i_L	O^i_U	C^i_M	O^i_M				
Innovation	I-1	Innovation	2	8	4	10	4.4	7.8	3.4	4.0	−0.6	
	I-3	Green Building Rating Systems	3	7	6	10	4.9	7.9	3.0	1.0	2.0	6.48
	I-4	Accredited Professional (AP)	3	7	6	9	5.3	8.0	2.8	1.0	1.8	6.54
	I-5	Health Building Education	4	6	6	10	4.9	7.7	2.7	0.0	2.7	6.28

Regarding certain assessment items, experts suggested that the "I-4 Professionals (AP)" item should include at least one team member with Accredited Professionals (AP) qualification. It was recommended that this requirement could be expanded to include "contractual cooperation with an AP".

(12) Electromagnetic Environment Comfort Indicators.

Based on the analysis using the double triangular fuzzy numbers, the assessment item with the highest expert consensus value (Gi) is "E-3 Distribution Room Protection" (Gi = 7.09). The rest of the items meet the expert consensus threshold (Gi = 6). However, one item does not meet the test value threshold (Mi-Zi > 0), namely, " E-1 Bedside Power Supply " (Mi-Zi = −0.8), meaning that the expert consensus value cannot be calculated (see Table 14).

Table 14. Electromagnetic environment indicator importance analysis.

Indicator	Assessment Item		Most Conservative Cognition		Most Optimistic Cognition		Geometric Mean		M_i	Z_i	M_i-Z_i	G_i
			$C^i{}_L$	$C^i{}_U$	$O^i{}_L$	$O^i{}_U$	$C^i{}_M$	$O^i{}_M$				
Electromagnetic Environment	E-1	Bedside Power	1	8	4	10	3.7	6.9	3.2	4.0	−0.8	
	E-3	Distribution Room Protection	4	8	6	10	5.8	8.6	2.8	2.0	0.8	7.09
	E-4	Electromagnetic Wave Protection	3	8	6	10	5.7	8.3	2.6	2.0	0.6	7.01

Regarding certain assessment criteria, experts suggested that the "E-1 Bedside Power Supply" item should be enhanced with grounding treatment to guide and release electromagnetic waves.

3.2. Integration and Consolidation of Assessment Items

After using the Fuzzy Delphi Method to determine the importance values of the twelve indicators and 82 assessment items, they were narrowed down to twelve assessment indicators and 63 assessment items. To ensure that the experts could fully express their opinions, flexibility was provided for them to add additional items to supplement the initial list of literature-based indicators. Having taken into account the suggestions from the experts on the questionnaires and compared and analyzed them with respect to existing regulations, climate conditions, and industry status in Taiwan, they can serve as references and bases for developing assessment methods, checking standards, and scoring principles.

The overall structure of the indicators and assessment items was changed by reorganizing and renumbering them. Similar indicators were merged and assigned new numbers. The original two-tier classification of "assessment indicators" and "assessment items" was merged into a three-tier classification of "assessment indicators", "assessment items", and "assessment sub-items". The comparison and integration of each indicator with the current situation in Taiwan is described below.

3.2.1. Air

The air indicators are based on expert opinions and reference the Indoor Air Quality Management Act published by the Environmental Protection Administration (EPA) of the Executive Yuan. They consider the specifications of indoor air quality standards as well as relevant content from the Ministry of the Interior's Construction and Planning Agency's "Building Technical Regulations" in the section on air conditioning and ventilation systems and the "Tobacco Hazards Prevention Act". These have been consolidated into three categories: "A-1 Air Quality Standards", "A-2 Increased Ventilation Efficiency", and "A-3 Filtration and Isolation". The detailed indicators and corresponding references are shown in Table 15.

Table 15. Consolidation of air indicators and corresponding original codes.

Indicator	Assessment Item		Sub-Items		Original Code
Air	A-1	Air Quality Standards	A-1-1	Basic Air Quality	A-1
			A-1-2	VOCs Control	A-3
			A-1-3	Microorganism and Mold Control	A-4
			A-1-4	Air Quality Monitoring and Awareness	A-8
	A-2	Increased Ventilation Efficiency	A-2-1	Ventilation Efficiency	A-5
			A-2-2	Enhanced Ventilation	A-6
	A-3	Filtration and Isolation	A-3-1	Pollutant Source Separation	A-10
			A-3-2	Air Filtration	A-11
			A-3-3	Smoke-Free Environment	A-15

3.2.2. Water

The water indicators are based on expert opinions and reference the "Drinking Water Management Act" published by the Environmental Protection Administration (EPA) of the Executive Yuan, which sets the drinking water quality standards under Article 11, Section 2. They additionally consider the "Guidelines for Legionella Control Operations for Veterans" and the "Guidelines for Legionella Environmental Testing and Related Measures in Hospitals" published by the Centers for Disease Control of the Ministry of Health and Welfare as well as the "Occupational Safety and Health Facility Regulations" and the "Taiwan Water Treatment Processes in Water Treatment Plants." These have been consolidated into two categories: "W-1 Drinking Water Quality Standards" and "W-2 Handwashing". The original community indicator "Toilet Facilities Configuration" has been included in the water indicator "W-2 Handwashing". The detailed indicators and corresponding references are shown in Table 16.

Table 16. Consolidation of water indicators and corresponding original codes.

Indicator	Assessment Item		Sub-Items		Original Code
Water	W-1	Drinking Water Quality Standards	W-1-1	Basic Water Quality	W-1
			W-1-2	Water Pollutants	W-2
			W-1-3	Enhanced Water Quality	W-4
			W-1-4	Legionella Control	W-3
			W-1-5	Water Consistency	W-5
			W-1-6	Backflow Prevention System	W-10
	W-2	Handwashing	W-2-1	Handwashing	W-8
			W-2-2	Restroom Configuration	C-16

3.2.3. Light

The light indicators are based on expert opinions and reference relevant regulations and standards such as the Taiwan EEWH Green Building Certification Indoor Environmental Indicators and energy efficiency criteria and labeling methods for indoor lighting fixtures under energy-saving certifications. Similar evaluation sub-items are consolidated into two categories: "L-1 Indoor Lighting" and "L-2 Personal Lighting and Automation Control". The detailed indicators and corresponding references are shown in Table 17.

Table 17. Consolidation of light indicators and corresponding original codes.

Indicator	Assessment Item		Sub-Items		Original Code
Light	L-1	Indoor Lighting	L-1-1	Light Exposure and Education	L-1
			L-1-2	Visual Lighting Design	L-2
			L-1-3	Visual Balance	L-3
			L-1-4	Circadian Lighting Design	L-4
			L-1-5	Electric Light Quality	L-8
	L-2	Personal Lighting and Automation Control	L-2-1	Glare Control	L-5
			L-2-2	Occupant Lighting Control	L-9

3.2.4. Movement

The movement indicators are based on expert opinions and reference relevant guidelines such as the "Reasonable Work Environment Guidelines" published by the Institute of Labor Safety and Health, Council of Labor Affairs, Executive Yuan, and the "Building Technical Regulations–Building Design and Construction" Chapter 10, "Building Accessibility Design Specifications." They are consolidated into two categories: "V-1 Ergonomics" and "V-2 Movement Support". The original community indicator "Accessibility and Universal Design" is merged into the sports indicator "V-1 Ergonomics". The detailed indicators and their references are shown in Table 18.

Table 18. Consolidation of movement indicators and corresponding original codes.

Indicator	Assessment Item		Sub-Items		Original Code
Movement	V-1	Ergonomics	V-1-1	Visual and Physiological Ergonomics	V-1
			V-1-2	Fitness Furniture	V-2
			V-1-3	Accessibility and Universal Design	C-7
	V-2	Movement Support	V-2-1	Sports Network and Pathways	V-4
			V-2-2	Active Architecture and Communities	V-8
			V-2-3	Support for Commuters and Residents	V-9
			V-2-4	Site Planning and Selection	V-10

Regarding specific sub-items, "V-2-1 Sports Network and Pathways" are regulated in Chapter 4, "Fire Evacuation Facilities and Fire Equipment" of the "Building Technical Regulations–Building Design and Construction" regarding the positioning and quantity of staircases. However, as the primary purpose of these regulations is fire safety and evacuation rather than human health and well-being, assessment based on international healthy building standards is recommended.

Regarding "V-2-3 Support for Commuters and Residents", there is currently no mandatory requirement in Taiwan for the provision of bicycle parking spaces. However, many counties and cities have implemented public bicycle rental systems, such as "YouBike" in the northern region, "T-Bike "in Tainan, and the upcoming "iBike" in Taichung.

3.2.5. Comfort

The original assessment framework had separate indicators for thermal comfort, sound environment, and electromagnetic environment. However, due to the limited number of items identified during the questionnaire screening, these three indicators are consolidated into a single category called "Comfort Indicators". The comfort indicators are based on expert opinions, and reference relevant regulations and assessment standards in Taiwan such as the "Noise Control Act", "Building Technical Regulations–Building Design and Construction", and the "Guidelines for Limiting Time-Varying Electric, Magnetic, and Electromagnetic Field Exposure." Similar sub-items within these indicators are merged, resulting in three assessment items: "C-1 Thermal Comfort", "C-2 Sound", and "C-3 Electromagnetic Environment". The detailed indicators and their references are shown in Table 19.

Table 19. Consolidation of comfort indicators and corresponding original codes.

Indicator	Assessment Item		Sub-Items		Original Code
Comfort	C-1	Thermal Comfort	C-1-1	Individual Thermal Control	T-3
			C-1-2	Radiant Thermal Comfort	T-4
			C-1-3	Thermal Zoning	T-5
			C-1-4	Thermal Comfort Monitoring	T-6
			C-1-5	Humidity Control	T-7
			C-1-6	Promotion of Natural Ventilation	Add. Items
			C-1-7	Outdoor Air Cooling	Add. Items
	C-2	Sound	C-2-1	Maximum Noise Levels	S-1
			C-2-2	Sound Insulation	S-2
			C-2-3	Floor Sound Insulation	S-5
	C-3	Electromagnetic Environment	C-3-1	Distribution Room Protection	E-3
			C-3-2	Electromagnetic Wave Protection	E-4

3.2.6. Materials

The material indicators are referenced based on expert opinions and aligned with relevant regulations and assessment standards in Taiwan, including the "Green Building Materials Explanation and Evaluation Manual", "Environmental Pesticide Management Act", "Pharmaceutical Affairs Act", "Cosmetic Hygiene Management Regulations", the 18th article, first paragraph of the "Waste Disposal Act" stipulating the "Methods and Facility Standards for Collection, Storage, Removal, and Disposal of Waste Dry Batteries", the "Methods and Facility Standards for Collection, Storage, Removal, and Disposal of Waste Containers", and the "Methods and Facility Standards for Collection, Storage, Removal, and Disposal of Waste Lighting Sources" published by the Environmental Protection Administration, Executive Yuan. Similar assessment items are consolidated into two evaluation categories: "X-1 Material Prevention" and "X-2 Material Management". The detailed indicators and corresponding references are shown in Table 20.

3.2.7. Mind

The mind indicators are referenced based on expert opinions and aligned with relevant regulations and standards in Taiwan, including the "Mental Health Act" and the "Food Safety and Sanitation Management Act" formulated by the Ministry of Health and Welfare, the "Student Counseling Act" formulated by the Ministry of Education, the "Housing Act" formulated by the Ministry of the Interior, and the "EEWH Green Building Certification", among other relevant guidelines. Similar assessment items are consolidated into three evaluation categories: "M-1 Support and Promotion of Health", "M-2 Transparency of Information", and "M-3 Organizational Management". The original community indicators of "Promotion of Health" and "Enhanced Resident Surveys" are merged into "M-1 Support and Promotion of Health". The original material indicator of "Material Transparency" is merged into the mental well-being indicator of "M-2 Information Transparency". The newly developed indicator is revised and merged into "M-3 Organizational Management". The detailed indicators and their corresponding references are shown in Table 21.

Table 20. Consolidation of materials indicators and corresponding original codes.

Indicator	Assessment Item		Sub-Items		Original Code
Materials	X-1	Material Prevention	X-1-1	Basic Material Prevention	X-1
			X-1-2	Hazardous Material Reduction	X-2
			X-1-3	Hazardous Material Reduction	X-4
			X-1-4	Long-Term Volatile Control	X-10
			X-1-5	Short-Term Volatile Control	X-11
			X-1-6	Enhanced Material Prevention	X-5
	X-2	Material Management	X-2-1	On-Site Management	X-3
			X-2-2	Waste Management	X-6
			X-2-3	Pesticide Use	X-7
			X-2-4	Cleaning Products and Standards	X-8
			X-2-5	Exterior Structures	X-13

Table 21. Consolidation of mind indicators and corresponding original codes.

Indicator	Assessment Item		Sub-Items		Original Code
Mind	M-1	Support and Promotion of Health	M-1-1	Mental Health Promotion	M-1
			M-1-2	Promotion of Health and Risk Assessment	C-11
			M-1-3	More Nature Exposure	M-6
			M-1-4	Restorative Opportunities	M-7
			M-1-5	Mindful Eating	N-10
			M-1-6	Enhanced Occupant Survey	C-4
	M-2	Information Transparency	M-2-1	Material Transparency	X-12
			M-2-2	Nutritional Transparency	N-4
	M-3	Organizational Management	M-3-1	Green Building Assessment System	I-3
			M-3-2	Accredited Professional (AP)	I-4
			M-3-3	Health Building Education	I-5

A total of seven indicators, seventeen assessment items, and 65 assessment sub-items were obtained, and served as the foundation and basis for the expert questionnaire in the third stage of the Analytic Hierarchy Process (AHP).

3.3. Results of the Analytic Hierarchy Process

In the third stage, relevant expert opinions were integrated through the Analytic Hierarchy Process (AHP) to assess and statistically determine the weights of the overall indicators, items, and sub-items. First, a consistency check was conducted to ensure the validity of the questionnaire responses. Then, the average weight values for each item were calculated based on the weights provided by the experts. This allowed for comparison and analysis of the different indicators.

(1) Consistency Check.

The survey targeted individuals primarily from industry and academia, including researchers, designers, and users involved in green building or green building materials. Their expertise covered areas such as architecture, building materials, and certification, providing a basis for subsequent statistical analysis and comparison. A total of seven experts were invited to participate in the survey, with two completing the questionnaire in writing and five completing it online. The response rate was 100%, resulting in seven valid questionnaires. By calculating the weight values for each level of the assessment items and conducting a consistency check, it was ensured that both the Consistency Index (CI) and the Consistency Ratio (CR) were less than or equal to 0.1 before including the average weight calculation. A CI value of 0 indicates complete consistency between judgments. Saaty [43,44] suggested that as long as the Random Index (RI) is less than 0.1, which is the case when the matrix dimension is below 4, there is a good level of consistency. In this study, to ensure the validity of the questionnaire, the RI for less than two items was set to 0; thus, these items were not calculated. The analysis of the seven collected questionnaires met this standard; therefore, all seven were included in the weight calculation. The analysis process is presented in Tables 22 and 23.

Table 22. Consistency testing of weighted judgments for first- and second-level assessment items by experts.

Level / Experts		Level 1 Indicator		Level 2 Air		Level 2 Water		Level 2 Light		Level 2 Movement		Level 2 Comfort		Level 2 Materials		Level 2 Mind	
		C.I.	**C.R.**	**C.I.**	**C.R.**	**C.I.**	**C.R.**	**C.I.**	**C.R.**	**C.I.**	**C.R.**	**C.I.**	**C.R.**	**C.I.**	**C.R.**	**C.I.**	**C.R.**
Industry	P1	0.10	0.08	0.00	0.00	-	-	-	-	-	-	0.00	0.00	-	-	0.00	0.00
	P2	0.10	0.08	0.03	0.06	-	-	-	-	-	-	0.00	0.00	-	-	0.00	0.00
	P3	0.10	0.08	0.02	0.03	-	-	-	-	-	-	0.02	0.03	-	-	0.00	0.00
Academia	P4	0.09	0.07	0.00	0.00	-	-	-	-	-	-	0.00	0.00	-	-	0.00	0.00
	P5	0.06	0.05	0.06	0.10	-	-	-	-	-	-	0.00	0.00	-	-	0.01	0.03
	P6	0.00	0.00	0.00	0.00	-	-	-	-	-	-	0.02	0.03	-	-	0.00	0.00
	P7	0.08	0.06	0.01	0.03	-	-	-	-	-	-	0.03	0.06	-	-	0.00	0.00

Note: "-" indicates that the matrix consists of only two factors and does not require a consistency check.

Table 23. Consistency testing of weighted judgments for third-level assessment items by experts.

Experts		Level 3 A-1 Air Quality Standards		Level 3 A-2 Increased Ventilation Efficiency		Level 3 A-3 Filtration and Isolation		Level 3 W-1 Drinking Water Quality Standards		Level 3 W-2 Handwashing		Level 3 L-1 Indoor Lighting		Level 3 L-2 Personal Lighting and Automation Control		Level 3 V-1 Ergonomics	
		C.I.	**C.R.**	**C.I.**	**C.R.**	**C.I.**	**C.R.**	**C.I.**	**C.R.**	**C.I.**	**C.R.**	**C.I.**	**C.R.**	**C.I.**	**C.R.**	**C.I.**	**C.R.**
Industry	P1	0.00	0.00	-	-	0.01	0.03	0.03	0.02	-	-	0.06	0.06	-	-	0.03	0.06
	P2	0.07	0.07	-	-	0.00	0.00	0.10	0.08	-	-	0.07	0.06	-	-	0.00	0.00
	P3	0.00	0.00	-	-	0.02	0.03	0.01	0.01	-	-	0.05	0.04	-	-	0.01	0.01
Academia	P4	0.01	0.02	-	-	0.02	0.03	0.08	0.06	-	-	0.08	0.07	-	-	0.01	0.03
	P5	0.07	0.07	-	-	0.04	0.07	0.10	0.08	-	-	0.06	0.05	-	-	0.02	0.03
	P6	0.00	0.00	-	-	0.00	0.00	0.00	0.00	-	-	0.05	0.04	-	-	0.00	0.00
	P7	0.00	0.00	-	-	0.01	0.03	0.06	0.05	-	-	0.08	0.07	-	-	0.00	0.00

Note: "-" indicates that the matrix consists of only two factors and does not require a consistency check.

(2) Weighting of Assessment Indicators.

Using the Analytic Hierarchy Process (AHP), the relevant expert and scholar opinions were integrated. After conducting consistency tests and removing questionnaires that did not meet the criteria, the weight values for each item were calculated. Comparisons and analyses were then performed for each indicator. Based on the relative weight values of the indicators, items, and sub-items, the relative weights were converted into absolute weights for each assessment sub-item, as shown in Table 24.

Table 24. Weighting and ranking of healthy building assessment indicators in Taiwan.

Indicator	Weight	Rank	Assessment Item		Relative Weight	Rank	Sub-Items		Relative Weight	Rank	Absolute Weight	Overall Rank
Air	0.34	1	A-1	Air Quality Standards	0.39	1	A-1-1	Basic Air Quality	0.35	1	0.046	3
							A-1-2	VOCs Control	0.31	2	0.041	5
							A-1-3	Microorganism and Mold Control	0.20	3	0.026	13
							A-1-4	Air Quality Monitoring and Awareness	0.14	4	0.019	19
			A-2	Increased Ventilation Efficiency	0.37	2	A-2-1	Ventilation Efficiency	0.61	1	0.076	1
							A-2-2	Enhanced Ventilation	0.39	3	0.049	2
			A-3	Filtration and Isolation	0.25	3	A-3-1	Pollutant Source Separation	0.33	4	0.028	10
							A-3-2	Air Filtration	0.50	2	0.042	4
							A-3-3	Smoke-Free Environment	0.17	5	0.014	27
Water	0.13	4	W-1	Drinking Water Quality Standards	0.68	1	W-1-1	Basic Water Quality	0.33	1	0.029	8
							W-1-2	Water Pollutants	0.27	2	0.024	14
							W-1-3	Enhanced Water Quality	0.09	5	0.008	40
							W-1-4	Legionella Control	0.11	4	0.009	34
							W-1-5	Water Consistency	0.13	3	0.011	31
							W-1-6	Backflow Prevention System	0.08	6	0.007	44
			W-2	Handwashing	0.32	2	W-2-1	Handwashing	0.65	1	0.027	9
							W-2-2	Restroom Configuration	0.35	2	0.014	26
Light	0.15	3	L-1	Indoor Lighting	0.62	1	L-1-1	Light Exposure and Education	0.12	5	0.011	32
							L-1-2	Visual Lighting Design	0.39	1	0.036	6
							L-1-3	Visual Balance	0.17	3	0.015	25
							L-1-4	Circadian Lighting Design	0.15	4	0.014	29
							L-1-5	Electric Light Quality	0.18	2	0.017	23
			L-2	Personal Lighting and Automation Control	0.38	2	L-2-1	Glare Control	0.63	1	0.036	7
							L-2-2	Occupant Lighting Control	0.37	2	0.021	18

Table 24. *Cont.*

Movement	0.05	6	V-1	Ergonomics	0.76	1	V-1-1	Visual and Physiological Ergonomics	0.27	2	0.010	33
							V-1-2	Fitness Furniture	0.12	3	0.004	53
							V-1-3	Accessibility and Universal Design	0.61	1	0.023	15
			V-2	Movement Support	0.24	2	V-2-1	Sports Network and Pathways	0.26	2	0.003	61
							V-2-2	Active Architecture and Communities	0.24	3	0.003	62
							V-2-3	Support for Commuters and Residents	0.22	4	0.003	63
							V-2-4	Site Planning and Selection	0.29	1	0.003	58
Comfort	0.10	5	C-1	Thermal Comfort	0.57	1	C-1-1	Individual Thermal Control	0.12	4	0.007	45
							C-1-2	Radiant Thermal Comfort	0.11	5	0.006	48
							C-1-3	Thermal Zoning	0.11	5	0.006	46
							C-1-4	Thermal Comfort Monitoring	0.09	7	0.005	51
							C-1-5	Humidity Control	0.15	2	0.008	37
							C-1-6	Promotion of Natural Ventilation	0.29	1	0.017	21
							C-1-7	Outdoor Air Cooling	0.13	3	0.007	42
			C-2	Sound	0.27	2	C-2-1	Maximum Noise Levels	0.23	3	0.006	49
							C-2-2	Sound Insulation	0.44	1	0.012	30
							C-2-3	Floor Sound Insulation	0.34	2	0.009	35
			C-3	Electromagnetic Environment	0.17	3	C-3-1	Distribution Room Protection	0.54	1	0.009	36
							C-3-2	Electromagnetic Wave Protection	0.46	2	0.008	41
Materials	0.18	2	X-1	Material Prevention	0.71	1	X-1-1	Basic Material Prevention	0.20	1	0.026	12
							X-1-2	Hazardous Material Reduction	0.13	6	0.017	22
							X-1-3	Hazardous Material Reduction	0.16	4	0.021	17
							X-1-4	Long-Term Volatile Control	0.17	3	0.022	16
							X-1-5	Short-Term Volatile Control	0.14	5	0.018	20
							X-1-6	Enhanced Material Prevention	0.20	1	0.027	11
			X-2	Material Management	0.29	2	X-2-1	On-Site Management	0.31	1	0.016	24
							X-2-2	Waste Management	0.26	2	0.014	28
							X-2-3	Pesticide Use	0.16	3	0.008	39
							X-2-4	Cleaning Products and Standards	0.14	4	0.007	43
							X-2-5	Exterior Structures	0.13	5	0.007	47

Table 24. *Cont.*

Mind	0.04	7	M-1	Support and Promotion of Health	0.44	1	M-1-1	Mental Health Promotion	0.19	2	0.003	55
							M-1-2	Promotion of Health and Risk Assessment	0.19	2	0.003	56
							M-1-3	More Nature Exposure	0.24	1	0.004	52
							M-1-4	Restorative Opportunities	0.10	5	0.002	65
							M-1-5	Mindful Eating	0.10	5	0.002	64
							M-1-6	Enhanced Occupant Survey	0.19	2	0.003	57
			M-2	Information Transparency	0.26	3	M-2-1	Material Transparency	0.71	1	0.007	38
							M-2-2	Nutritional Transparency	0.29	2	0.003	59
			M-3	Organizational Management	0.30	2	M-3-1	Green Building Assessment System	0.46	1	0.006	50
							M-3-2	Accredited Professional (AP)	0.30	2	0.004	54
							M-3-3	Health Building Education	0.24	3	0.003	60

3.4. Summary

Through the expert questionnaire, the following two suggestions were obtained. Several experts expressed the concern that when using this method, if they consider multiple items to be equally unimportant then their weights will be close to those of equally important items. This study used a three-stage Analytic Hierarchy Process (AHP) to prioritize the items suitable for the Taiwan Healthy Building Assessment Indicators, calculate the weight values of each item, and convert the relative weight values into absolute weight values. Therefore, such a situation is less likely to occur. However, if the committee members have diverging perceptions the resulting weight values may deviate significantly from the original intent of the members. For example, if a few members consider an item to be of extremely high importance while the majority consider it slightly less important, the average weight value will be relatively high.

The relative and absolute weight values obtained through the AHP can be further expanded into specific scoring principles and evaluation methods. They can be referenced from international standards and combined with Taiwan's climate and environment to formulate and enumerate proposed scoring principles. This will establish the "Scoring Criteria for the Taiwan Healthy Building Assessment Indicators" as the basis for evaluating healthy buildings, enabling the practical application of this assessment system and serving as a basis for subsequent checking and verification cases. The specific scoring criteria are not described in detail in this study.

The verification methods for each indicator's sub-items should refer to international standards and be divided into documentary evidence and performance verification. Documentary evidence includes inspection reports, educational materials, project reports, graphic verification, and inspection of finished products, while performance verification includes instrument testing and simulation analysis. The specific verification methods are not described in detail in this study.

4. Conclusions

This study focuses on fifteen relevant evaluation indicators and the literature related to healthy buildings and green buildings from domestic and international sources. These were analyzed and consolidated into a "Health Building Evaluation Indicator Framework". By utilizing expert opinions, the study employed the Fuzzy Delphi Method and Analytic Hierarchy Process (AHP) to screen, rank, and integrate the evaluation items. The relative and absolute weights obtained through the AHP provide a foundation for establishing the "Taiwan Health Building Assessment Indicator Scoring Criteria".

In the academic field, these evaluation indicators can serve as a basis for future research and improvement aiming to establish content and evaluation models that align with Taiwan's local characteristics while considering international healthy building trends. This promotes international alignment and facilitates the adoption of specific evaluation items, reducing costs and difficulties for applicants while increasing their understanding and willingness to apply.

In industry, the application of these evaluation indicators can promote the importance of human health in Taiwan's construction industry. This in turn can enhance building quality and employee work efficiency, leading to increased productivity. For users, they can incorporate the concept of a healthy environment as a factor in decisions and considerations such as choosing a home, rental property, or employment, thereby reducing the frequency of illness, improving physical and mental well-being, and enhancing quality of life and happiness.

Based on our research findings, the following conclusions can be drawn.

(1) International Health Building Certification Evaluation Background and Projects.

After comprehensive analysis of domestic and international evaluation indicators and projects, twelve evaluation indicators and 130 evaluation items were identified as the basis for the first-stage expert questionnaire. By benchmarking and comparing these with healthy building standards from different countries and regions, this study provides opportunities for international alignment and enables the use of specific universal evaluation items, potentially reducing costs and difficulties for applicants and increasing their understanding and willingness to apply.

(2) Construction of "Taiwan Health Building Assessment Indicators".

Through the first and second stages of the Fuzzy Delphi Method questionnaire, the evaluation items were further screened and compared with existing regulations in Taiwan. Ultimately, seven evaluation indicators, seventeen evaluation items, and 65 evaluation sub-items were obtained. The Analytic Hierarchy Process results allocated weight values to each indicator and item, as shown in Figure 7.

Figure 7. Graph of evaluation item stage screening process results.

(3) Results of the third-stage weight investigation.

According to the ranking of absolute weight values, five sub-items related to air indicators (ventilation efficiency, enhanced ventilation, basic air quality, air filtration, and active control of volatile organic compounds) were considered the most important.

These research findings can serve as a reference for future studies, and lead to the following recommendations.

(1) Enhancement and revision of the Taiwan Health Building Assessment Indicator Framework and content.

Regarding the framework and content of evaluation indicators, recommendations include further refining the classification of evaluation types, integrating evaluation stages, classifying evaluation conditions, and benchmarking and comparison with international standards. As several of the items excluded through expert questionnaire screening are specific to certain stages, it is suggested that these be integrated in a phased, classified, and staged manner based on their importance in order to enhance the comprehensiveness of these indicators.

(2) Comparison of different rating methods.

It is recommended that future research explore different rating methods or establish corresponding rating principles based on different application types. Through comparative analysis, the most suitable rating method for these evaluation indicators can be identified.

(3) Validation and comparison of cases.

Future research could select and statistically analyze cases of different types, periods, and regions. Validation methods could include design drawings, architectural certifications, material documentation, interior performance simulations, building performance testing, and on-site assessments, all of which could be used to obtain comprehensive validation and evaluation results for subsequent inspections and rating levels.

(4) Improving public awareness of healthy buildings.

Creating high-quality environments that are healthy, safe, comfortable, and environmentally friendly for users is the goal of healthy building standards. Therefore, it is recommended that future research promote the concept of healthy buildings through workshops, seminars, or other educational programs to increase awareness and acceptance among the general public. This will enhance the willingness of businesses to apply healthy building practices and to promote healthy buildings as a distinctive feature, forming a positive cycle.

In conclusion, this study successfully established the "Taiwan Health Building Evaluation Indicator Framework" by analyzing and consolidating evaluation indicators and the literature related to healthy buildings and green buildings from both domestic and international sources. These research findings provide important references for both academy and industry, helping the construction industry in Taiwan to prioritize human health, improve building quality and employee work efficiency, and enhance public awareness, resulting in improved quality of life and happiness through healthy building standards. Future research can further explore and develop specific scoring criteria and evaluation methods based on international standards and Taiwan's climate and environmental conditions, further promoting the practice and application of healthy buildings in Taiwan.

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Appendix A

Table A1. Preliminary list of air indicators for Taiwan Healthy Building Assessment.

Indicator	Code	Assessment Item	Explanation of Assessment Item
	A-1	Basic Air Quality	Ensure basic air quality standards for $PM_{2.5}$, PM_{10}, Formaldehyde, VOCs, CO, O_3, etc.
	A-2	Enhanced Air Quality	Higher standards for strengthening $PM_{2.5}$, PM_{10}, Formaldehyde, benzene, CO, CO_2, and O_3.
	A-3	VOCs Control	Utilize activated carbon filtration for VOCs.
	A-4	Microbe and Mold Control	Prevent moisture and mold issues and use ultraviolet disinfection.

Table A1. *Cont.*

Air	A-5	Ventilation Efficiency	Mechanical and natural ventilation spaces must meet specified supply and exhaust rates.
	A-6	Enhanced Ventilation	Increase outdoor air supply to maintain indoor CO_2 concentration.
	A-7	Construction Pollution Management	Reduce construction pollution.
	A-8	Air Quality Monitoring and Awareness	Provide monitoring displays for real-time air quality improvement.
	A-9	Pollution Infiltration Management	Establish entrance channel systems with outdoor cleaning mats to isolate pollutants.
	A-10	Pollutant Source Separation	Isolate indoor pollutant sources and set up independent exhaust systems for copy rooms, chemical storage areas, etc.
	A-11	Air Filtration	Filter particulate matter in ventilation systems.
	A-12	Natural Ventilation Potential	Natural ventilation potential in public areas and residential spaces.
	A-13	Ventilation and Airflow	Utilize the principle of thermal buoyancy for vertical ventilation and airflow.
	A-14	Operable Windows	Install outward-opening windows that can be opened to the outdoors.
	A-15	Smoke-Free Environment	Prohibit smoking indoors and outdoors.
	A-16	Combustion Minimization	Avoid using combustion-based fireplaces, stoves, etc., in commonly used spaces to reduce indoor pollutants.

Table A2. Preliminary list of water and nourishment indicators for Taiwan Healthy Building Assessment.

Indicator	Code	Assessment Item	Explanation of Assessment Item
Water	W-1	Basic Water Quality	Monitoring and controlling turbidity and coliform counts in drinking water, handwashing water, and shower water.
	W-2	Water Pollutants	Monitoring and controlling concentrations of metals, organic pollutants, pesticides, disinfectants, etc., in drinking water.
	W-3	Legionella Control	Implementing Legionella prevention programs to prevent Legionnaires' disease.
	W-4	Enhanced Water Quality	Treating interfering chemicals to meet taste characteristics in drinking water.
	W-5	Water Consistency	Requiring the use of filters capable of removing suspended solids with a pore size of 1.5 μm or smaller for drinking water and quarterly testing to ensure compliance.
	W-6	Moisture Management	Using porous, moisture-resistant materials and installing water leak detection systems.
	W-7	Drinking Water Promotion	Providing at least one drinking fountain within a 30-m walking distance.
	W-8	Handwashing	Providing an adequate number of sinks, disposable soap, and disposable hand towels.
	W-9	High-Temperature Disinfection	Centralized domestic hot water systems supplying water at a temperature not lower than 55 °C while implementing disinfection measures.
	W-10	Backflow Prevention System	Installing reservoir backflow prevention systems.
	W-11	Promoting Health with Hot Springs	Providing carbonated hot springs for bathing and health promotion.

Table A2. *Cont.*

Nourishment	N-1	Food Production	Providing gardens, greenhouses, or landscaped areas with edible plants.
	N-2	Local Food Environment	Having supermarkets or retail stores selling agricultural products within an 800-m walking distance.
	N-3	Fruits and Vegetables	Offering at least four varieties of fruits and four varieties of vegetables with increased visibility through placement.
	N-4	Nutritional Transparency	Labeling nutritional information such as calorie and sugar content and providing detailed ingredient information.
	N-5	Refined Ingredients	Limiting the total sugar content of food sold or provided, promoting whole grains, and managing edible oils.
	N-6	Food Advertising	Not selling or promoting sugary drinks and fried foods, encouraging consumption of natural foods, and promoting water intake.
	N-7	Artificial Ingredients	Restricting and eliminating artificial additives such as colorings, sweeteners, and artificial preservatives.
	N-8	Portion Sizes	Promoting healthy portion sizes and limiting the size of plates, bowls, or cups.
	N-9	Nutrition Education	Providing free nutrition education to improve dietary habits and behaviors and increase nutritional knowledge.
	N-10	Mindful Eating	Designating dining spaces and providing opportunities for dining breaks.
	N-11	Special Diets	Managing allergenic foods, such as peanuts, gluten, lactose, eggs, etc., in meals.
	N-12	Food Preparation	Providing auxiliary facilities in dining areas, such as refrigeration space, microwave ovens, ovens, etc.
	N-13	Responsible Food Sourcing	Requiring organic certification for agricultural products.

Table A3. Preliminary list of light and movement indicators for Taiwan Healthy Building Assessment.

Indicator	Code	Assessment Item	Explanation of Assessment Item
Light	L-1	Light Exposure and Education	Ensure indoor lighting and glass visibility, and provide lighting education, such as circadian rhythms.
	L-2	Visual Lighting Design	Provide the required illuminance for visual sensitivity.
	L-3	Visual Balance	All spaces should have a certain level of brightness.
	L-4	Circadian Lighting Design	Use lighting systems that adapt to circadian
	L-5	Glare Control	Install automated shading and light fixtures to control glare.
	L-6	Enhanced Daylight Access	Specify the distance to windows or atriums and ensure a direct view of the outdoors through windows.
	L-7	Natural Daylight Performance	Natural daylighting rates in public areas and residences.
	L-8	Electric Light Quality	Specify the Color Rendering Index (CRI) and reduce artificial lighting flicker.
	L-9	Occupant Lighting Control	Residents can adjust the lighting intensity, color temperature, and lamp color.

Table A3. *Cont.*

Movement	V-1	Visual and Physiological Ergonomics	Reduce bodily harm, improve comfort and safety through ergonomic design and education, such as adjustable desks, chairs, and screens.
	V-2	Fitness Furniture	Provide fitness areas or fitness furniture, such as sit/stand desks, to prevent prolonged static and sedentary behaviors.
	V-3	Enhanced Ergonomics	Provide access to ergonomic experts.
	V-4	Sports Network and Pathways	Design aesthetically pleasing staircases and corridor spaces, such as incorporating music and artwork, and encourage the use of stairs.
	V-5	Outdoor Design that Promotes Exercise	Utilize external elements to encourage exercise and physical activity, such as street lighting and continuous sidewalks.
	V-6	Physical Exercise Opportunities	Provide free physical exercise opportunities and education.
	V-7	Sports Exercise Spaces and Equipment	Provide exercise spaces and equipment.
	V-8	Active Architecture and Communities	Promote exercise and physical activity through architectural space design.
	V-9	Support for Commuters and Residents	Provide bicycle storage facilities.
	V-10	Site Planning and Selection	Nearby sites should have multiple transportation options, diverse facilities, and pedestrian and bicycle lanes.
	V-11	Promote Physical Exercise	Encourage physical exercise and active lifestyles through subsidies or incentives.
	V-12	Self-Monitoring	Provide free or subsidized wearable devices to monitor physical activity indicators, improving awareness of healthy behaviors and health indicators.

Table A4. Preliminary list of thermal and sound comfort indicators for Taiwan Healthy Building Assessment.

Indicator	Code	Assessment Item	Explanation of Assessment Item
Thermal Comfort	T-1	Thermal Performance	Utilize simulations of air temperature, humidity, air movement, mean radiant temperature of surrounding surfaces, metabolic rate, and clothing insulation to ensure a comfortable thermal environment.
	T-2	Enhanced Thermal Comfort Performance	Utilize simulations to ensure higher and more comfortable thermal environment standards.
	T-3	Individual Thermal Control	Permanent building residents can request personal thermal comfort devices, such as personal fans, heated/cooled seats, etc.
	T-4	Radiant Thermal Comfort	Use radiant heating and cooling systems and install independent ventilation systems.
	T-5	Thermal Zoning	Common spaces can set their own temperature conditions through independent automatic temperature controllers without being limited by other areas.
	T-6	Thermal Comfort Monitoring	Monitor dry bulb temperature, relative humidity, air velocity, and average radiant temperature in the space.
	T-7	Humidity Control	Control the relative humidity in the space.
	T-8	Sunshading of Exposed Columns and Beams	Exposed columns and beams ≥90 cm are used for sunshade and heat insulation.
	T-9	Entrance Path Sunshading	Avoid uncovered or unshaded entrance paths.

Table A4. *Cont.*

Sound	S-1	Maximum Noise Levels	Limit the background noise level generated by air conditioning systems or transportation vehicles.
	S-2	Sound Barriers	Ensure appropriate sound insulation between walls and doors to enhance speech privacy in horizontal spaces.
	S-3	Sound Absorption	Design spaces with comfortable reverberation time and install sound-absorbing ceilings and vertical surfaces such as walls.
	S-4	Sound Masking	Enhance sound masking in specific areas to ensure a suitable acoustic environment for open-plan work areas and enclosed offices.
	S-5	Floor Sound Insulation	RC floor plate thickness (df) $\geq$ 15 cm.
	S-6	Sound Mapping	Manage background noise, sound privacy, and indicate zoning of acoustic environments.

Table A5. Preliminary list of materials indicators for Taiwan Healthy Building Assessment.

Indicator	Code	Assessment Item	Explanation of Assessment Item
Materials	X-1	Basic Material Prevention	Limit the content of hazardous building materials such as asbestos, mercury, lead, etc.
	X-2	Hazardous Material Reduction	Hazardous Material Reduction
	X-3	On-Site Management	Reduce or eliminate contact with hazardous building material components such as asbestos or lead through on-site management.
	X-4	Hazardous Material Reduction	Reduce heavy metals (lead, mercury, cadmium, etc.) and phthalates in building materials.
	X-5	Enhanced Material Prevention	Select certified healthy building materials.
	X-6	Waste Management	Manage hazardous waste, handle recycling of batteries, pesticides, mercury-containing equipment, etc., to reduce environmental pollution and contact with related waste.
	X-7	Pesticide Use	Reduce pests through integrated pest management (IPM) and minimize the use of pesticides.
	X-8	Cleaning Products and Standards	Limit harmful ingredients in soaps, shampoos, cleaning, disinfecting, and sanitizing products, and establish a maintenance cleaning plan.
	X-9	Reduction of Volatile Compounds	Reduce harmful volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs).
	X-10	Long-Term Volatile Control	Reduce slow-releasing volatile organic compounds (VOCs), such as limiting the proportion of newly installed furniture.
	X-11	Short-Term Volatile Control	Reduce rapidly releasing volatile organic compounds (VOCs), such as managing adhesives, paints, etc.
	X-12	Material Transparency	Provide material information for interior decoration and finishing materials.
	X-13	Exterior Structures	Minimize treated exterior structures and wood-plastic materials, control the content of wood preservatives (CCA), lead, etc.
	X-14	Site Remediation	Conduct on-site assessment and remediation for project locations with past or present industrial activities, such as hazardous waste storage, gas stations, manufacturing plants, etc., before construction.

Table A6. Preliminary list of mind indicators for Taiwan Healthy Building Assessment.

Indicator	Code	Assessment Item	Explanation of Assessment Item
Mind	M-1	Mental Health Promotion	Provide mental health management, common mental health issues, and promote mental health knowledge.
	M-2	Mental Health Support	Offer employee mental health check-ups, financial assistance, and adjustable leave options.
	M-3	Mental Health Education	Provide training and education focused on mental health to promote awareness and education on mental well-being.
	M-4	Stress Management Support	Develop stress management plans and support systems.
	M-5	Enhanced Access to Nature	Facilitate natural exposure through plants, water, lighting, natural landscapes, etc., including natural materials, patterns, colors, or images, and indirect contact with nature.
	M-6	More Nature Exposure	Enhance indoor and outdoor nature exposure, natural scenery, and the natural environment near the premises.
	M-7	Restorative Opportunities	Provide opportunities for workday breaks and paid leave policies for all regular employees.
	M-8	Restorative Spaces	Designate spaces for reflection, relaxation, and recovery (not for work purposes).
	M-9	Restorative Programming	Offer at least two relaxation and recovery-focused programs, such as mindfulness meditation or mindfulness exercises (yoga, tai chi), at no cost or at subsidized prices.
	M-10	Sleep Support	Assist employees in improving sleep health through education and resources, and provide opportunities for short daytime naps.
	M-11	Support for Concentration	Evaluate the work environment and overall space management to minimize distractions and help residents focus on their work.
	M-12	Business Travel	Provide programs to assist employees in managing stress and maintaining health during business trips.
	M-13	Tobacco Use Prevention and Cessation	Offer smoking cessation support programs for employees, such as counseling, prescription and non-prescription smoking cessation medications, or nicotine replacement therapy.
	M-14	Substance Use Education and Services	Promote prevention and education on substance abuse, as well as support services for substance use and addiction treatment.
	M-15	Opioid Emergency Response Plan	Opioid emergency toolkit and training.

Table A7. Preliminary list of community, innovation, and electromagnetic environment indicators for Taiwan Healthy Building Assessment.

Indicator	Code	Assessment Item	Explanation of Assessment Item
Community	C-1	Health Awareness	Provide guidelines for healthy buildings and promote health education.
	C-2	Integrative Design	Integrate collaborative design and development processes from certification initiation to completion, including expert workshops and the integration of aesthetics and design.
	C-3	Occupant Survey	Collect feedback on residents' experiences and health conditions.
	C-4	Enhanced Occupant Survey	Assess residents' comfort, satisfaction, behavior changes, self-reported health conditions, and other factors related to well-being.
	C-5	New Mother Support	Provide support spaces and policies for breastfeeding.
	C-6	Organizational Transparency	Require project participation in third-party certification programs to assess compliance with principles of fairness and inclusivity within the organization.
	C-7	Accessibility and Universal Design	Provide basic accessibility design and incorporate universal design principles.
	C-8	Emergency Preparedness	Develop emergency preparedness plans and provide emergency resources such as automated external defibrillators (AEDs).
	C-9	Community Openness and Engagement	Provide community public spaces, facilities, and planning to facilitate gatherings, socializing, and collaboration.
	C-10	Health Services and Benefits	Promote health benefits and provide health services as needed, offering free or subsidized health benefit coverage for all regular employees and their families.
	C-11	Health Promotion	Promote a culture of health through posters, signage, or presentations, and provide health risk assessments (HRAs).
	C-12	Community Immunization	Implement measures such as seasonal flu prevention and other vaccination programs.
	C-13	New Parent Support	Provide leave and workplace support for new fathers, such as flexible work arrangements and assistance transitioning back to work from parental leave.
	C-14	Family Support	Provide support for child and elderly care, household leave, and bereavement support.
	C-15	Civic Engagement	Promote civic participation and remind residents to register for voting.
	C-16	Restroom Facilities	Provide an adequate number of restrooms, including individual and family restrooms.
Innovation	I-1	Innovation	Offer innovative solutions not covered by existing assessment criteria.
	I-2	Gateways to Well-Being	Independent health and well-being program completed over the past three years as required by the project.
	I-3	Green Building Rating Systems	The project has obtained relevant certifications for sustainable buildings.
	I-4	Accredited Professional (AP)	At least one member of the project team is accredited as a Professional (AP).
	I-5	Health Building Education	Free visits to certified spaces.
Electromagnetic Environment	E-1	Bedside Power	No power wiring is installed on the main wall surface near the bed within 2 m high and within 50 cm on both sides of the bedside.
	E-2	Outlet Distance	Maintain distance between long-term seating positions such as desks, living rooms, sofas, and electrical appliances and power outlets.
	E-3	Distribution Room Protection	Implement protective measures for public facilities adjacent to the local power distribution room.
	E-4	Electromagnetic Wave Protection	Install electromagnetic wave protection panels in the main power switchboard inside the residence.

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