Tikrit Journal of Engineering Sciences (2024); 31(4): 25-33
DOI: http://doi.org/10.25130/tjes.31.4.3

IRAQI Academic Scientific Journals

ISSN: 1813-162X (Print); 2312-7589 (Online)
Tikrit Journal of Engineering Sciences
available online at: http://www.tj-es.com

TJES Tikrit Journal of Engineering Sciences

Developing a Sustainability Assessment System for an Educational Building in the Iraqi Environment

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Keywords:
Sustainability; Educational buildings; Assessment system; Analytical Hierarchal Process (AHP).

Highlights:

- *Develop a system for a sustainability assessment for an educational buildings in the Iraqi environment.*
- *Combined of the closed questionnaire and the software program AHP has been used to identify the importance of the categories for sustainable educational buildings.*
- *The most importance factors and credits have been identified for all categories of sustainable educational buildings.*
- *Proposed the certification levels for sustainable educational buildings rating indicates to determine their sustainability rate.*

ARTICLE INFO
Article history:

Received	25 June	2023
Received in revised form	24 Nov.	2023
Accepted	04 Jan.	2024
Final Proofreading	02 Mar.	2024
Available online	15 Sep.	2024

Citation: Mohammed HA, Aswed GK, Ahmed MN. **Developing a Sustainability Assessment System for an Educational Building in the Iraqi Environment**. *Tikrit Journal of Engineering Sciences* 2024; **31**(4): 25-33.
http://doi.org/10.25130/tjes.31.4.3

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Abstract: Sustainability principles are considered one of the vital challenges facing developing countries (including Iraq), which are trying vigorously to implement sustainable development in most of their development projects. The projects of constructing educational buildings, such as schools and universities, are among the most important development projects to be established in Iraq. This study aims to develop standards to help improve the understanding of the sustainability requirements of educational buildings in Iraq. Through a series of studies, this study has developed a system that can be used to measure the sustainability of these buildings. First, information about sustainability assessment systems was gathered from the literature and references. Second, personal interviews with specialists, field questionnaires, and the software Analytical Hierarchal Process (AHP) to identify the weights of the main categories and factors for sustainable educational buildings. The results showed that the criteria of Energy Efficiency received the greatest weight (29.6%). On the other hand, less weight was obtained from the Precious Water and Waste (3.6%). Finally, the study developed a rating system model, "Educational Building Sustainability Rate (EBSR)," under Iraqi environmental conditions.

تطوير نظام تقييم الاستدامة للأبنية التعليمية في البيئة العراقية

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الخلاصة
تعتبر مبادئ الاستدامة من التحديات الحيوية التي تواجه البلدان النامية (بما في ذلك العراق)، والتي تحاول بقوة تنفيذ التنمية المستدامة في معظم مشاريعها التنموية. تعتبر مشاريع إنشاء المباني التعليمية (كالمدارس / الجامعات) من أهم المشاريع التنموية التي سيتم إنشاؤها في العراق. تهدف هذه الدراسة إلى تطوير معايير تساعد على تحسين فهم متطلبات الاستدامة للمباني التعليمية في العراق. من خلال سلسلة من الدراسات، تمكن هذه الدراسة من تطوير نظام يمكن استخدامه لقياس استدامة هذه المباني: أولاً: تم جمع معلومات حول أنظمة تقييم الاستدامة من المؤلفات والمراجع. ثانيًا: المقابلات الشخصية مع المختصين، والاستبيانات الميدانية، والعملية التحليلية الهرمية الحاسوبية (AHP) للتعرف على أوزان الفئات والعوامل الرئيسية للمباني التعليمية المستدامة. أظهرت النتائج أن معيار كفاءة الطاقة حصل على الوزن الأكبر (٢٩,٦٪)، في حين حصل معيار المياه الثمينة والنفايات على وزن أقل (٣,٦٪). أخيرًا / تطوير نموذج نظام التقييم، "معدل استدامة البناء التعليمي"(EBSR) ، في ظل ظروف البيئة العراقية.

الكلمات الدالة: الاستدامة، المباني التعليمية، نظام التقييم، العملية التحليلية الهرمية (AHP).

1.INTRODUCTION

Sustainable development is an important goal in human development since sustainability is becoming an increasingly crucial prerequisite for human activities. Technology and engineering, economics, environmental stewardship, the health and welfare of individuals, the communities, work, social demands, government tactics, processes, and regulations make development generally sustainable [1]. Many nations have created their grading systems to quantify and measure using sustainable building technologies in their property, architectural, and construction industries. Introducing a code to monitor the adoption of sustainable building technology establishes a standard against which companies may measure and improve their application of sustainable building principles [2]. The importance of assessing the impact of sustainable indicators, policies, and measures in large-population systems, such as hospitals, universities, high schools, and educational institutions, is important because these policies and measures are a critical component of society and the economic development of nations in the face of the difficult task of stimulating education, scientific research, and social impact [3]. The programs of safety management, training of workers and the requirements of safety in construction projects are the important factors in sustainability categories [4]. This study presents a literature evaluation of the most memorable lines of research on assessing sustainable indicators in Iraqi schools and other academic institutions. This study aims to develop standards to help improve the understanding of the sustainability requirements and proposes a sustainability assessment system for educational buildings in Iraq.

2.RESEARCH METHODOLOGY

The scientific methodology followed in this study includes the following stages:

- Theoretical study phase: This phase includes reviewing the literature and scientific references, e.g., books, engineering journals, research, and periodicals, which deal with the sustainability assessment systems in general and the principles available in sustainable educational buildings.
- Application research phase: This phase entails completing a closed questionnaire and conducting organized and unstructured personal interviews with certain professionals and authorities in Iraq's educational sector with expertise in sustainable structures, such as academic lecturers and professional engineers.
- The software program AHP has been used to identify the importance (weights) of the main categories for sustainable educational buildings in the Iraqi environment.
- The results of a closed questionnaire and the statistical means were used to identify the importance and credits for all categories of factors.
- Developing a sustainability assessment system for educational buildings, a rating system model, "Educational Building Sustainability Rate (EBSR)," was established as the most sustainable rating system applicable to educational buildings in Iraq.

List recommendations to be presented to the relevant persons, entities, and institutions.

3.PREVIOUS STUDIES

Mahmoud et al. [5] developed a global sustainability rating tool for existing buildings, considering the regional variations by proposing sustainability assessment attributes and determining their weights utilizing fuzzy logic. Yigitcanlar and Dur [6] conducted a study measuring the comparative sustainability levels of cities, regions, institutions, and projects, an essential procedure in creating sustainable urban futures. This study introduced a new urban sustainability assessment model: “The Sustainable Infrastructure, Land-use, Environment and Transport Model (SILENT)”. Poveda and Lipsett [7] developed a new assessment tool in sustainable development that requires a strategic methodology for a cohesive and logical framework incorporating relevant theory and practical experience, building on a critical analysis of the state of the art. Moldavska and Welo [8] suggested system thinking as an alternative to the reductionist approach, commonly applied to sustainability assessment. This study focused on a practical application of systems thinking to developing a sustainability assessment system for a manufacturing organization. Devuyst [9] studied the impact assessment systems introduced by local authorities and linked them to the sustainable development debate. Adapting existing impact assessment systems to their new role as sustainability assessment tools leads to the search for so-called sustainability assessment systems. Lazar and Chithra [10] revealed that Multi-Criteria Decision-Making (MCDM) is the most widely used method for developing Building Sustainability Assessment Systems (BSAS). This study reviewed and summarized the published literature on BSAS developed using MCDM methods. From the above studies, it is clear that there is no study concerned with evaluating educational buildings for sustainability indicators, which is done in this study in the Iraqi environment.

4.SUSTAINABLE EDUCATIONAL BUILDING (SEB)

When developing a long-term educational structure, the overarching goal is to keep the physical school/energy university's consumption low and its environmental quality high in perpetuity. Pollutants and solid trash are produced in large quantities during the construction and demolition of buildings. Existing schools/universities are demolished, resulting in vast garbage dumped in landfills. Due to new construction, communities may face habitat degradation, air quality concerns, pollution, and water quality difficulties [11]. Sustainable design encourages resource conservation (reducing water, energy, materials, and waste). It assesses the school's/whole university's footprint and the lifetime of the materials used in construction. Alternative design solutions for heating and cooling, energy-efficient design, and energy consumption monitoring are all being investigated by school/university districts. Using locally produced alternative energy, e.g., solar and wind, that does not pollute the environment, and universities and schools become more sustainable the less they rely on traditional fossil fuels [12]. Affordable, accessible, efficient, climate-friendly, and sustainable university accommodations are vital for quality academic output and ensuring students have a positive and successful learning experience [13].

5.EXISTING SUSTAINABILITY ASSESSMENT SYSTEMS

Different grading systems have been devised to define what is and is not sustainable and standardize its measurement. Several sustainable project rating systems exist worldwide, including LEED in the United States, BREEAM in the United Kingdom, Green Star in Australia, CASBEE in Japan, GeSBC in Germany, Estidama in the United Arab Emirates, and others [2]. These instruments have quickly received international acclaim, and numerous other countries have begun to use them. However, it should be emphasized that these methods and grading systems were created to assess sustainable buildings in specific locations based on local sustainability standards. As a result, due to differences in geography, climate, cultural attitudes, and possible natural resource availability, a system designed for one location may not be suitable for another [14].

6.IDENTIFYING THE SUSTAINABLE CATEGORIES

Identifying sustainability categories has been observed as the first important step to developing a sustainable assessment system for an educational building [15]. The following sustainability criteria were grouped into ten major categories and 69 elements (factors) based on theoretical research, personal interviews, expert opinion, and the researcher's practical experience, as shown in Table 1 [11, 13, 15, 16].

7.ASSESSMENT OF SUSTAINABLE CATEGORIES' IMPORTANCE (WEIGHTS)

A field questionnaire was employed to establish the importance (weights) of categories, and the AHP program (Analytic Hierarchy Process) technique was used to calculate the weight of different sustainable categories. Through pairwise comparisons across categories, the algorithm will find these crucial categories. The survey instrument was a closed questionnaire issued to several professionals with experience in sustainability and disciplines working in Iraq. Table 2 shows the characteristics of respondents for the closed questionnaire. The final relative weights and category rankings were computed using the AHP algorithm, as shown in Fig. 1 and Table 3. Based on an inconsistency value of 0.09395 (less than 0.1), which suggests the potential of relying on the pairwise comparisons' conclusions.

Table 1 The Main Categories and Factors for SEB.

No.	Categories	Factors
1	Transportation	Easy access to the site
		Reduced parking footprint
		Use of sustainable modes of transport
		Bicycle facilities
		Green vehicles
2	Sustainable Sites	Reuse of brownfield sites
		Promotes the reduction of erosion
		Habitat protection and creation
		Sustainable land use
		Management of rainwater
		Reduction of heat island
		Reduction of light pollution
		Open space
		Development community connectivity
		Sensitive land protection
3	Precious Water	Outdoor water use reduction
		Indoor water use reduction
		Water metering
		Sustainable water use in the building operation
		Alternative water sources
		Minimizing losses through leakage
4	Energy Efficiency	Fundamental commissioning and verification
		Minimum performance of energy
		Metering of building-level energy
		Fundamental refrigerant management
		Optimize the performance of energy
		Demand response
		Production of renewable energy
		Green power and carbon offsets
5	Materials and Resources	Collection and storage of recyclables
		Waste management of construction and demolition
		Reduction of building life-cycle impact
		Raw materials sourcing
		Use of environmentally friendly materials
		Use of local materials
6	Indoor Environmental Quality	Minimum indoor air quality performance
		Environmental tobacco smoke control
		Minimum acoustic performance
		Health and safety of building occupants
		Low-emitting from materials
		Management plan of construction indoor air quality
		Assessment of indoor air quality
		Thermal comfort
		Interior lighting
		Daylight
		Quality views
		Adequate ventilation and humidification
7	Management	Sustainable management practices
		Construction management plan
		Sustainability objectives in the operation of the building
		Overall management policy
		Extent of communication
		Assurance of safety and security
		Assurance of durability and reliability
		Maintenance and good implementation
8	Pollution	Prevention and control of pollution
		CO2 emissions
		Noise, light pollution, flooding and emissions to land, water, and air
		Leak detection systems
		Renewable energy sources
		Avoid the use of ozone-depleting and global warming
9	Waste	Waste management
		Reuse of construction, operational waste
		Waste reduction from the construction and operation
		Diversion encouragement from landfill
		Solid waste treatment
10	Innovation	Innovation
		Sustainable professional in the team
		School /university as an educational tool

Table 2 The characteristics of respondents for the closed questionnaire.

	Functional Position			Educational Level			Experience Level(years)		
	Engineer	Consultant	Academic	B.Sc.	M.Sc.	Ph.D.	5-15	15-25	>25
Frequency	6	14	12	7	10	15	10	13	9

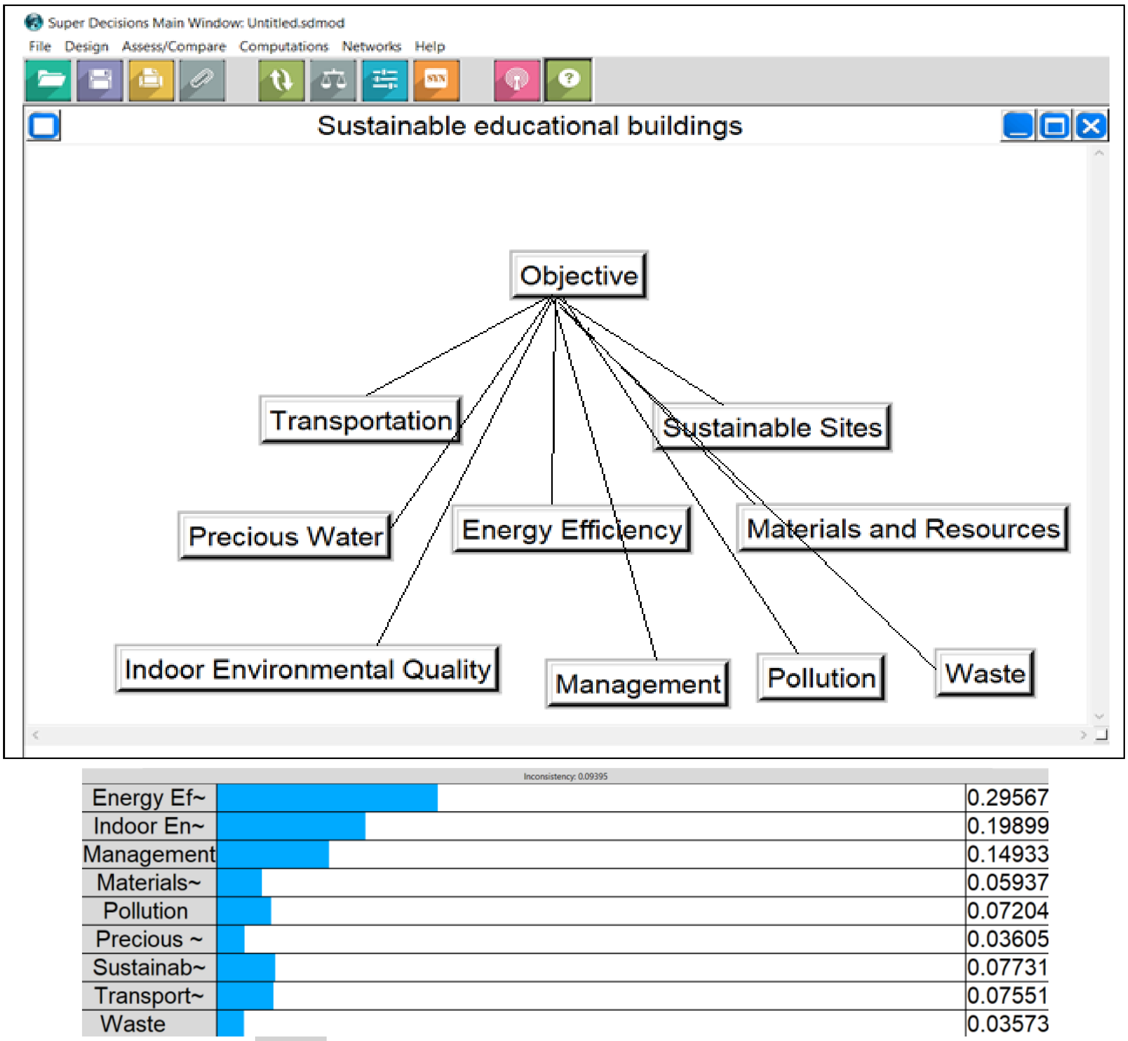

Fig. 1 AHP and Weights of Main Categories for SEB.

Table 3 Weights of Main Categories for SEB.

Weight (%)	Criteria (Inconsistency = 0.09395)	No.
29.6%	Energy Efficiency	1
19.9 %	Indoor Environmental Quality	2
14.9 %	Management	3
7.8 %	Sustainable Site	4
7.5 %	Transportation	5
7.2 %	Pollution	6
5.9 %	Materials and Resources	7
3.6 %	Precious Water	8
3.6 %	Waste	9
100%		Total
4 Extra Bonus	Innovation	10

From the results above, it can be concluded that the highest weight is received by the criterion of energy efficiency and criterion of indoor environmental quality, which got 29.6% and 19.9 %, respectively, implying that these criteria are of great importance in SEB. Also, less weight was obtained by the criterion of precious water and criterion of waste, which received 3.6% since these criteria have little impact on SEB, according to the experts' opinion under the Iraqi environmental conditions. The researchers believe that the weight percentage of the above criteria are logical for the educational environment in Iraq, as the criteria of energy efficiency and indoor environmental quality are considered among the most important criteria because of their significant impact on sustainability indicators. While the criterion of water use is of little importance because this criterion is not considered a real problem in Iraq at present.

8.ASSESSMENT OF FACTORS OF SUSTAINABILITY CATEGORIES

A closed questionnaire was conducted for the same previous sample to assess the factors of sustainability categories for educational buildings and determine their credits. The respondents were requested to rank these factors for main categories according to a five-point Likert scale, the most broadly used method for scaling responses in survey research; in the Likert scale, (1 = least important and 5 = most important). The SPSS software program was used to find the mean and standard deviation for all factors of the sustainability categories. The Likert scale rating evaluation acquired for each component and achieved by consensus of the closed questionnaire will be used to distribute credits in the assessment system. According to experts, the component that surpasses 50 percent of the Likert scale range or 2.5/5 is suitable for sustainable educational buildings in Iraq, and credits will be granted based on the characteristics presented in Table 4.

Table 4 Credits assigning.

Importance According to the Likert scale	Credit Receivable
< 2.5	0
≥ 2.5 and < 3.5	1
≥ 3.5 and < 4.5	2
≥ 4.5 and ≤ 5.0	3

Table 5 shows the results of determining the importance and credits for all categories of factors.

Table 5 Importance and Credits for All Categories of Factors.

No.	Transportation Factors	Mean	Standard Deviation	Credit
1	Easy access to the site	4.53	0.618	3
2	Reduced parking footprint	3.20	0.748	1
3	Use of sustainable modes of transport	4.27	1.062	2
4	Bicycle facilities	3.33	1.011	1
5	Green vehicles	4.27	0.998	2
Total				9
No.	**Sustainable Sites Factors**	**Mean**	**Standard Deviation**	**Credit**
1	Reuse of brownfield sites	4.13	0.618	2
2	Promotes the reduction of erosion	3.87	0.806	2
3	Habitat protection and creation	4.13	0.618	2
4	Sustainable land use	4.13	0.806	2
5	Management of rainwater	3.87	1.087	2
6	Reduction of heat island	4.13	0.718	2
7	Reduction of light pollution	4.07	0.772	2
8	Open space	4.20	0.653	2
9	Development community connectivity	3.87	0.884	2
10	Sensitive land protection	4.07	0.680	2
Total				20
No.	**Precious Water Factors**	**Mean**	**Standard Deviation**	**Credit**
1	Outdoor water use reduction	3.87	0.957	2
2	Indoor water use reduction	4.07	0.854	2
3	Water metering	4.67	0.596	3
4	Sustainable water used in the building operation	4.07	0.929	2
5	Alternative water sources	4.20	0.833	2
6	Minimizing losses through leakage	4.20	0.748	2
Total				13
No.	**Energy Efficiency Factors**	**Mean**	**Standard Deviation**	**Credit**
1	Fundamental commissioning and verification	4.27	0.680	2
2	Minimum performance of energy	4.20	0.748	2
3	Metering of building-level energy	4.40	0.712	2
4	Fundamental refrigerant management	4.20	0.542	2
5	Optimize the performance of energy	4.33	0.699	2
6	Demand response	4.07	0.854	2
7	Production of renewable energy	4.67	0.596	3
8	Green power and carbon offsets	4.47	0.618	2
Total				17
No.	**Materials and Resources Factors**	**Mean**	**Standard Deviation**	**Credit**
1	Collection and storage of recyclables	4.13	0.666	2
2	Waste management of construction and demolition	3.93	0.705	2
3	Reduction of building life-cycle impact	3.47	0.617	1
4	Raw materials sourcing	3.73	0.683	2
5	Use of environmentally friendly materials	4.33	0.551	2
6	Use of local materials	3.87	0.765	2
Total				11
No.	**Indoor Environmental Quality Factors**	**Mean**	**Standard Deviation**	**Credit**
1	Minimum indoor air quality performance	4.20	0.748	2
2	Environmental tobacco smoke control	4.20	0.653	2
3	Minimum acoustic performance	4.20	0.833	2
4	Health and safety of building occupants	4.73	0.442	3
5	Low-emitting from materials	4.47	0.618	2
6	Management plan of construction indoor air quality	4.07	0.573	2
7	Assessment of indoor air quality	4.13	0.618	2
8	Thermal comfort	4.47	0.618	2
9	Interior lighting	4.20	0.653	2
10	Daylight	4.73	0.442	3
11	Quality views	4.07	0.680	2
12	Adequate ventilation and humidification	4.40	0.611	2
Total				26

No.	Management Factors	Mean	Standard Deviation	Credit
1	Sustainable management practices	4.20	0.653	2
2	Construction management plan	4.07	0.680	2
3	Sustainability objectives in the operation of the building	4.07	0.772	2
4	Overall management policy	4.13	0.618	2
5	Extent of communication	3.73	0.680	2
6	Assurance of safety and security	4.40	0.712	2
7	Assurance of durability and reliability	4.07	0.573	2
8	Maintenance and good implementation	4.47	0.618	2
Total				16
No.	**Pollution Factors**	**Mean**	**Standard Deviation**	**Credit**
1	Prevention and control of pollution	4.60	0.611	3
2	CO2 emissions	4.27	0.680	2
3	Noise, light pollution, flooding and emissions to land, water, and air	4.00	0.816	2
4	Leak detection systems	3.87	0.884	2
5	Renewable energy sources	4.40	0.712	2
6	Avoid the use of ozone-depleting and global warming	4.20	0.748	2
Total				13
No.	**Waste Factors**	**Mean**	**Standard Deviation**	**Credit**
1	Waste management	4.40	0.800	2
2	Reuse of construction, operational waste	3.93	0.854	2
3	Waste reduction from the construction and operation	3.93	0.929	2
4	Diversion encouragement from landfill	3.87	0.806	2
5	Solid waste treatment	4.00	0.730	2
Total				10

For all the above factors of sustainability categories, the weights are different from one consideration to another depending on the opinion of experts in the field of educational building consultants under the conditions of the Iraqi environment.

9.DEVELOPING A SUSTAINABILITY ASSESSMENT SYSTEM FOR EDUCATIONAL BUILDING

A basic framework for the comprehensive system of sustainability assessment in Iraqi educational buildings has been proposed, and its criteria have been developed and established by the informed consensus of international and local experts, based on the previous determining that included the assessment categories, assessment factors, and their weighting coefficient. The framework of the assessment system is composed of 10 categories, nine of which are mandatory (Transportation, Sustainable Sites, Precious Water, Energy Efficiency, Materials and Resources, Indoor Environmental Quality, Management, Pollution, and Waste) and one encouraging category (Innovation), with a total of 69 factors. The experts agree that the proposed approach for assessing sustainable educational buildings is thorough.

10.EDUCATIONAL BUILDING SUSTAINABILITY RATE (EBSR)

It is possible to reflect the rate or the sustainability level in the Iraqi educational building using the following procedure: Using the weights previously determined for the main sustainability criteria for educational buildings and the credits obtained by each of the main criteria factors, it is possible to reflect the rate or the sustainability level in the Iraqi educational building using the following procedure:

1- Find the number of credits available in each category.
2- Calculate the total number of credits earned for each category component.
3- Using Eq. (1), compute each category score; the EBSR has nine categories. Thus, nine distinct rating scores will be produced.
4- Adding any points for innovation that have been earned.

$$\mathbf{SCD} = \frac{Co}{Cc} * \mathbf{Wc} * \mathbf{100} \qquad (1)$$

where:
SCD: Sustainable Category Degrees
Co: Credits Obtained
Cc: Credits Certified
Wc: Weighting of Categories

To determine the Educational Building Sustainability Rate (EBSR), Eq. (2) is as follows: the overall rating degree will be obtained from the summation of these 10 rating degrees.

$$\mathbf{EBSR} = \sum_{n=1}^{10} \mathbf{SCDn} \qquad (2)$$

where:
EBSR: Educational Building Sustainability Rate
n: Number of categories included in the category of innovation.

11.SEB CERTIFICATION LEVELS

A proposed target SEB rating indicates that the educational building program in Iraq (certification levels) is divided into five levels as follows:

EBSR classification starts from 40 as a baseline; it is the level of meeting the minimum requirements; therefore, any educational building rated less than 40 will be considered "Un Certified,"

Level 1: EBSR = 40 ≤ 50 is considered " Certified”.

Level 2: EBSR = 51≤ 60 is considered "Good".

Level 3: EBSR = 61 ≤ 70 is considered "Very Good".

Level 4: EBSR = 71 ≤ 80 is considered "Excellent".

Level 5: EBSR = 81≤ 100 is considered "Wonderful"

12.CONCLUSIONS

The major conclusions drawn based on the present research can be abridged as follows:

- Different rating systems have been developed worldwide There are several sustainable project rating systems. Still, in Iraq, no classification system grants a certificate of accreditation for applying sustainability criteria in educational buildings.
- Based on the findings of the closed questionnaire and the software Analytic Hierarchy Process (AHP), the criteria of Energy Efficiency received the greatest weight (29.6%), indicating that this criterion is very important in the construction of sustainable educational buildings in Iraq.
- On the other hand, less weight was obtained from the Precious Water and Waste (3.6%), showing that these criteria have little impact on sustainable educational buildings in Iraq.
- Several supplementary variables were removed or merged in the proposed grading system, including some key categories and criteria, in Iraq's suggested evaluation for a sustainable educational building.
- Iraq lacks knowledge and awareness about applying sustainability principles in educational buildings, such as schools and universities.
- It is possible to use the system proposed in the present study (EBSR) to evaluate the sustainability of educational buildings in Iraq.
- Applying sustainable categories in educational buildings in Iraq provides a good environment for students, teachers, and the educational system in terms of efficient energy use and good indoor and outdoor comfort for the building's occupants.

ACKNOWLEDGEMENTS

The authors are thankful for the support toward this research by the Civil Engineering Department, College of Engineering, Kerbala University.

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