International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 13 Issue: 06 | Jun 2026 www.irjet.net p-ISSN: 2395-0072

Applicability and Effectiveness of Green Building Certification Systems in Iraqi Universities and Commercial Buildings: A Comparative Case Study of the University of Baghdad and Al-Harithiya Mall

Balsam S. AL-Samarrie[1], Assist. Prof. Dr. Tugbay B. Gumus[2], Prof. Fairs H. Al-Ani[3]

[1] *Ministry of Higher Education and Scientific Research, Baghdad, Iraq*
[2] *Department of Industrial Engineering, Faculty of Engineering, Istanbul Gedik University, Istanbul, Türkiye*
[3] *Civil Engineering Department ,University of Technology, Baghdad, Iraq*

Abstract - *In recent years, the concept of sustainability has become increasingly central to global construction practices, particularly in response to growing environmental challenges and the need for efficient resource management. Green Building Certification Systems (GBCS), such as Leadership in Energy and Environmental Design Method (LEED), Building Research Establishment Environmental Assessment Method (BREEAM), and the Global Sustainability Assessment System (GSAS), have emerged as essential frameworks to evaluate and promote sustainable design, construction, and operation of buildings. These systems provide measurable criteria for energy efficiency, water conservation, indoor environmental quality, and overall environmental impact.*

This study investigates the applicability, effectiveness, and management of Green Building Certification Systems in Iraqi universities and construction projects. It focuses on developing suitable frameworks for calibrating green building characteristics in the construction and university sectors, aiming to improve the sustainable performance of buildings with limited resources and examine the feasibility, application, and effectiveness of green building certification systems (LEED, BREEAM, CASBEE, Green Star, Globes Green, Estidama, QSAS), and clarifying the effectiveness and suitability of these systems in an environment like Iraq.

A comprehensive analysis of various aspects and indicators, such as the availability of sustainable design, suitable infrastructure, energy and water efficiency in buildings, the provision of green spaces, and access to sustainable transportation, was conducted to improve residents' quality of life and reduce the negative environmental impact of buildings. To achieve the aims, two buildings were selected in Baghdad City: the Al-Harithiya Commercial Mall Complex and the University of Baghdad.

The results of the study indicate that Al-Harithiya Mall gets an average of (54.5%) moderate applicability when using the Research Hypothesis. A locally adapted sustainability assessment framework, based on LEED principles and Benchmarking techniques, can effectively assess the applicability and performance of green building certification systems in Iraqi universities and commercial buildings, which need significant improvements.
The results show that even when some pillars achieve average performance, their overall contribution remains consistent with national priorities, thereby reinforcing the applicability of the modified assessment model. The energy pillar demonstrates the highest contribution due to its greater relative weight, while the social pillar contributes the least, reflecting its lower weight within the assessment framework. Based on the weighted results, the research hypothesis was accepted, as the proposed sustainability assessment model proved its ability to measure the applicability of s sustainability principles in an existing Iraqi commercial building.

The University of Baghdad received a rating of (51.85%) which is considered average in implementation but requires significant improvement. Regarding the hypothesis, the proposed recommendations confirm that the University of Baghdad demonstrates a moderate level of sustainability implementation with significant potential for future improvement.

However, the lack of integration between technical and administrative aspects limits the achievement of comprehensive, sustainable performance. This disparity is attributed to the limited application of renewable energy technologies and the absence of dedicated institutional management. In contrast, the University of Baghdad's assessment revealed that despite possessing significant spatial and functional potential to become a sustainable campus. This supports the research hypothesis regarding the potential to develop Iraqi public universities within a locally adapted sustainable assessment framework.

Key Words: Sustainability, Green Building Certification Systems, LEED, Sustainability Assessment, Iraqi Universities.

1. INTRODUCTION

Since the Industrial Revolution, the world has witnessed tremendous technological advancements, rapid population growth, and a corresponding increase in resource

consumption. Our awareness of the side effects of our activities is growing pollution, overflowing landfills, toxic waste, global warming, resource depletion, ozone layer damage, and deforestation (Hanley & Spash, 1993).

As the world's population continues to grow, implementing resource conservation measures in all areas of human activity becomes crucial. The built environment is a prime example of how human activity affects resources. Buildings have a significant environmental impact, consuming one-sixth of the world's freshwater, one-quarter of harvested timber, and two-fifths of material and energy flows **(Hanley & Spash, 1993).**

Green building is a fundamental practice for achieving sustainability and sustainable development, and greater attention has been paid to the environmental, social, and economic impacts associated with building construction and operation. Hence, the importance of adopting a more integrated approach to green building design with cost effectiveness has gained wide momentum **(Silvius et al., 2012; Bergman, 2012)**.

Sustainability is of great importance in the design and management of residential projects and complexes, as assessing their sustainability can help improve residents' quality of life while reducing environmental impact. Despite its importance, many challenges affect sustainability in Iraq, including unsustainable urban planning of residential complexes, old traditional designs, the cost of environmental technology, consumer culture, social and cultural challenges, and waste and pollution management **(Rogers, 2013).**

The growing sustainability ethic in the construction sector is based on the principles of resource efficiency, health, and productivity. Achieving these principles requires an integrated, multidisciplinary approach in which the construction project and its components are viewed as a whole **(National Science & Technology Council, 1993).**

Applying sustainability principles remains a major challenge for developing countries, including Iraq, as they seek to integrate sustainable development into various infrastructure projects. Among these challenges, the construction of educational facilities such as schools and universities is critical **(Elizabeth & Adams, 2015).**

Various methodologies for environmental assessment and green building measurement have emerged, developed by teams of experts, specialists, and experienced practitioners through organizations known as Green Building Councils, which have been established in various countries worldwide **(U.S. Green Building Council, 2005).**

The Green Architecture Evaluation System is an objective tool and method for measuring, evaluating, and comparing building performance It is usually done in the form of lists containing categories **(International Code Council, 2021).**

These categories are carefully selected to cover all aspects of the building's green architecture. Each element is evaluated using a specific methodology, and the results are combined to obtain a total value that reflects the building's performance from a green architecture perspective. These steps may be carried out on paper or automatically using digital form and specialized software **(Al-Adwy & Saeed, 2019).**

In assessing the current situation, the application of the LEED scale certification with its five indicators (energy, water, materials, resource, indoor environmental quality and site selection) is very useful, and the research will address the possibility of applying green building certification systems (LEED, BREEAM, etc.) and their effectiveness in Iraq **(Tucker, 2010).**

Most LEED subsystems are based on a 100-point scale, plus 10 bonus points; points are distributed across multiple domains according to the certification type. All LEED building systems are based on six main areas: Sustainable Site, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, and Innovation in Design (or Operations). The LEED certification for buildings is divided into four levels, with points awarded for Certified, Silver, Gold, and Platinum **(U.S. Green Building Council, 2005; McLennan, 2004).**

The LEED building system was adopted in this study to evaluate the selected projects. From an economic perspective, LEED certification offers owners financial savings through reduced energy and water consumption costs, lower operating and maintenance expenses, increased building value, higher occupancy rates, and higher rental income, thanks to the environmental services it provides (**U.S. Green Building Council, 2005).**

The aim of this study is to focuses on the certification processes, local building standards and implementation challenges in some Iraqi construction projects and universities, developing a set of criteria aimed at enhancing the understanding and application of sustainability requirements, and presents a framework designed to assess the sustainability performance of these buildings, and calibrating green building attributes in construction so that the sustainable performance of the building is improved with limited funds. This requires a comprehensive analysis of different aspects and indicators, such as the availability of sustainable design, appropriate infrastructure, energy and water efficiency in buildings, and the provision of green spaces.

Research Hypothesis (H1): A locally adapted sustainability assessment framework, based on LEED principles and Benchmarking techniques, can effectively assess the applicability and performance of green building certification systems in Iraqi universities and commercial buildings. The current study aims to address the following questions, considering the research challenges and the gaps found in previous studies.

- What are the key factors affecting the applicability of green building certification systems in Iraq?
- How effective are international green building certification systems when applied to Iraqi projects?
- What are the major barriers and enablers in implementation?

1.1 Research Methodology and Data Collection

This study aimed to evaluate the sustainability performance of educational and service buildings. A comparative case study, supported by a performance measurement methodology, was designed to assess the applicability, effectiveness, and management of green building certification systems within the context of Iraqi universities and construction projects. Given the limited maturity of sustainability practices in Iraq and the scarcity of data based on expert experience, the study adopted a context-adapted normative framework and a weighted performance evaluation model. This approach was deemed more suitable for evaluating operational projects in emerging sustainability environments.

These included the limited number of sustainability projects in Iraq, the relatively recent adoption of green building concepts in the Iraqi construction sector, the scarcity of specialists with sufficient experience in green building certification systems, and climatic challenges such as high temperatures and water scarcity and logistical obstacles also existed, including the limited recycling facilities in Iraq, which make it difficult to recover materials for use in construction due to the lack of dedicated recycling centers **(Alwan et al., 2017).** Also, economic constraints, which include transportation and processing costs, and the potential economic benefits are often diminished because the cost of transporting recycled materials to a processing plant or a low-quality site exceeds the cost of the raw materials (UN-Habitat, 2020).

Furthermore, legal and regulatory challenges existed, particularly regarding public awareness and community acceptance. Project owners faced difficulty in convincing stakeholders, including contractors and designers, to adopt recycled materials due to a lack of awareness of sustainability benefits **(UNEP, 2016).**

Due to these restrictions, primary data was not gathered in an expert survey that could be relied upon and represented. Hence, the research method was adapted to a comparative case study using performance measurement. The theoretical basis for structuring the assessment criteria and assigning their weights, however, was the conceptual approach of the Analytic Hierarchy Process (AHP).

The LEED BD+C: Core and Shell framework is also used as the main assessment tool in this study. This internationally recognized rating system is tailored to projects in which the developer owns the building structure, its building envelope, and shared systems, while the tenant completes interior finishes. This is especially appropriate for large facilities such as universities and shopping malls.

The study compares a few selected conventional and sustainable projects from Iraq and Egypt, chosen as regional benchmarks because their environments and climates are similar to those of Iraq, and they have documented sustainability initiatives. The study compares the current state of sustainability implementation, identifies weaknesses, and recommends modifications to green building certification systems in the context of Iraq.

The LEED system was combined with a Benchmarking technique as a management and strategic tool to gauge relative performance and strengthen the study's analytical component. By examining the difference between the existing situation and the desired level. Benchmarking is a management and strategic tool used to measure the performance of an organization or project against best practices in similar or comparable sectors, with the goal of continuous improvement and development. In other words, it is the process of identifying gaps between reality and expectations by comparing the performance of an organization, system, or process with that of other leading or distinguished organizations in a particular field, analyzing the reasons for their superiority, and then using this information to achieve desired improvements, in the context of evaluating sustainable architecture or green building **(Camp, 1989).**

The study relies exclusively on secondary data obtained from publicly available and authoritative sources. These sources include official project websites, university websites, published sustainability reports, technical documentation, and references to international green building certifications.

Data was collected for four representative case studies:

- City Center Almaza, Cairo, Egypt (sustainable commercial project)
- Al-Harithiya Mall, Baghdad, Iraq (conventional commercial project)

- American University in Cairo (sustainable university campus)
- University of Baghdad (conventional university campus)

Thus, the City Center Mall project and the American University project in Cairo were selected, and a Comparative assessment was prepared.

was performed on them along with the Grand Harthiya Mall and the University of Baghdad in Baghdad. The information gathered covered many sustainability metrics, including site selection, water efficiency, energy performance, materials and resources, indoor environmental quality, management and operations, and social aspects.

Secondary data was deemed suitable, as real, operational projects with publicly documented characteristics were selected. The information on official websites and sustainability disclosures is sufficiently reliable for comparative assessment and Benchmarking. Wherever possible, information was cross-referenced with multiple sources to enhance data reliability, including LEED documentation, technical reports, academic publications, and institutional records.

The sources included data on environmental sustainability and green buildings provided by the United Nations Environment Program (UNEP) and World Bank, as well as an analysis of laws and regulations related to construction and environmental sustainability, and their application to projects based on the pillars of the system and the appropriate mathematical equations, which will be explained later. The selected case studies were chosen for their reliability, accessibility, and relevance to real-world project data, and for being representative examples of both conventional and sustainable projects, enabling comparison within the Iraqi and regional contexts.

Benchmarking helps compare international university projects or buildings in terms of energy and water use, efficiency, indoor environmental quality, and environmental, social, and economic impacts and benefits. The model was chosen in collaboration with construction companies and consulting firms working in sustainable construction in Iraq and Cairo to obtain field data.

As a result, the suggested model's function goes beyond merely gauging performance; it is a tool to aid decision-making and the creation of plans grounded in practical, validated criteria. Therefore, the model adopted in this study represents an applied framework that combines the theoretical foundations of sustainability, international rating systems, and Benchmarking analysis.

Therefore, the City Center Mall project and the American University project in Cairo were chosen, and an Applied assessment was performed on them along with the Grand Harthiya Mall and the University of Baghdad in Baghdad City. This enhances understanding of sustainability requirements in Iraqi educational buildings and provides a scientific basis for future studies and the development of sustainable institutional policies.

1.2 The method:

The method is based on 3 main elements for each axis:

- Actual Project Score
- Maximum Achievement Score
- Axis Weight of the Final Total (Weight%)

The final score is calculated in just 3 steps:

Step 1: Calculate the percentage of completion for each axis. Axis completion percentage = (Project points/ Maximum) × 100
Step 2: Calculate the weighted points for each axis.
Weighted points = (Percentage of completion / 100) × Axis weight
Step 3: Calculating the Project's Final Score
Final Score = (Weighted points for each axis)

The assessment scale used to evaluate a project's acceptability under the Green Building Certification Systems (GBCS) is shown in Table 1, which indicates the project's application level according to the final score.

Table1. Final Score for the Projects (Camp, 1989)

Result Score	Application Level
85–100	Excellent – Fully Applicable
70–84	Very Good – Needs Minor Improvements
50–69	Average – Needs Significant Improvements
Below 50	Poor – Not Applicable Without Substantial Modifications

Based on the final assessment results, the scores are divided into four levels, from low to excellent as follows:
Each LEED category is linked to one or more pillars:

- Sustainable Sites (SS) → Pillar: Sustainable Site and Planning
- Water Efficiency (WE) → Pillar: Water Use Efficiency
- Energy and Atmosphere (EA) → Pillar: Energy and Environment

- Materials and Resources (MR) → Pillar: Materials and Resources
- Indoor Environmental Quality (EQ) → Pillar: Indoor Environmental Quality

Innovation (ID) + Regional Priority + Measurement and Verification → Considered within management and operation (in relation to innovative design, monitoring, and the presence of a certified specialist). Community behavior elements (such as connectivity and alternative transportation) are included within the socio-economic pillar. The percentage for each axis is calculated as follows: (Scores achieved / Highest LEED score) × 100.

This paragraph presents an applied model for assessing the sustainability suitability of a project implemented in the Iraqi context, based on the integration of the LEED BD+C: Core & Shell v3 system. This model is an internationally recognized sustainability assessment system for evaluating new buildings, which are built with the structural frame, facade, and public systems, but the interior finishes for tenants are not supervised in the building. This system can be used to assess Mixed-use Office Buildings and shopping malls.

This system meets the environmental needs and standards in Iraq.

Weight is given to each sustainability pillar. Project performance within this pillar is then measured, and the results are combined to produce a final score out of 100%. To enhance the project's practicality, the Almaza City Center project in Cairo was adopted as a reference model, and the feasibility of using its LEED indicators to develop a modified assessment model for Al-Harithiya Mall in Baghdad was explored.

2. RESULTS AND DISCUSSIONS

First – Building a Sustainability Applicability Model
Detailed calculation of the Almaza City Center project in Cairo is shown below:

The final performance is calculated using the following equation:

Final Score = ∑ (Expected Axis Scores / Maximum Score × Relative Weight)
City Center Almaza Case Analysis – Performance Measurement Model

The City Center Almaza project's LEED score summary is presented in Table 2, based on **(Majid Al Futtaim Properties, n.d), (City Center Almaza, n.d., and Occupi, n.d).**

Table 2. City Center Almaza Calculation

Category (LEED)	Points Achieved	Total Points	Percentage of Achievement (%)
Site and Layout	22	28	78.57
Water Efficiency	6	10	60.00
Energy and Environment	18	55	32.73
Materials and Resources	6	13	46.15
Indoor Environmental Quality	8	12	66.67
Management and Operation	6	6	100.00
Socio-Economic	4	4	100.00
Final Total	70	128	**54.69**

LEED metrics derived from data to calculate percentage of achievement (%):
Sustainable sites = 22/28 → 78.57%
Water efficiency = 6/10 → 60.0%
Energy & Atmosphere = 18/55 → 32.73%
Materials & Resources = 6/13 → 46.15%
Indoor environmental quality = 8/12 → 66.66%
Innovation = 6/6 → 100% (calculated within management)
Regional priority = 4/4 → 100% (calculated within management)

The sustainability assessment results for City Center Almaza Mall in Cairo demonstrated a high level of sustainability performance, with the project achieving LEED Gold certification under the LEED BD+C: Core and Shell v3 (LEED, 2009) system, scoring 70 out of 110 points. This high performance is attributed to the clear integration of the various sustainability pillars, particularly the sustainable site pillar, which scored the highest. This was due to the excellent selection of sites, its connection to public transportation networks, and the adoption of effective solutions to mitigate the urban heat island effect.

Second – Data Collection from the Benchmark Project:
Data Collection from Project Al-Harithiya Mall:
A. Defining the core pillars (the same LEED pillars adapted for Iraq) is shown in Table 3. This table was created by researchers based on research theory, calculations, and axes.

Table 3. Relative Weights of LEED Categories Used in Project Assessment

Category (LEED)	Relative Weight (%)
Site and Layout	10
Water Efficiency	15
Energy and Environment	30
Materials and Resources	15
Indoor Environmental Quality	15
Management and Operation	10
Socio-Economic	5
Total	**100**

The energy and atmosphere axis receives the highest percentage due to energy shortages and rising temperatures, increasing its share to 30%.

The water efficiency axis comes in second in importance due to water scarcity, increasing its share to 15%. Iraq's operating, infrastructure, and environmental conditions were taken into consideration when developing the distribution of sustainability axis weights.

The scorching weather, the lack of electricity, the growing need for cooling, the scarcity of water, and the constraints of the local infrastructure were all given special attention. Because of their direct impact on the operational and environmental performance of buildings in the Iraqi context, the energy and water axes were assigned greater weights.

This weight distribution will be used for the axes in Iraq projects because it is suitable for comparing projects in service-oriented operational environments, such as malls:

Table 4. Rationale for the Selected Sustainability Axis Weights in the Iraqi Context

Category (LEED)	Relative Weight (%)	Rationale for the Selected Sustainability Axis Weights
Energy and Environment	30	Iraq's hot climate, frequent power outages, and growing reliance on cooling systems in commercial and educational buildings justify the high weighting of the energy axis. Energy consumption represents the most significant operational and environmental challenge facing Iraqi buildings.
Water Efficiency	15	Iraq's water scarcity, combined with increasing pressure on water resources and high consumption rates in large-scale buildings, necessitates prioritizing water efficiency and sustainable water management practices.
Materials and Resources	15	Due to the limited availability of sustainable building materials in the Iraqi market, this category was assigned a moderate weight to emphasize resource management, waste reduction, and sustainable material selection.
Indoor Environmental Quality	15	Indoor environmental quality is essential for improving occupant comfort, health, and productivity, particularly in educational and commercial buildings that rely heavily on artificial ventilation and cooling systems.
Site and Layout	10	Although site sustainability contributes to urban integration and environmental protection, its practical influence in current Iraqi developments is considered less significant than operational aspects such as energy and water performance.
Management and Operation	10	This category highlights the importance of maintenance systems, operational efficiency, and institutional sustainability practices in improving building performance without requiring major structural modifications.
Socio-Economic	5	Despite its importance in enhancing accessibility and community engagement, the socio-economic dimension was assigned a lower weight because its impact is generally supportive rather

Category (LEED)	Relative Weight (%)	Rationale for the Selected Sustainability Axis Weights
		than directly measurable in environmental performance.

B- Measuring the indicators for each pillar:

Each indicator is assigned a score from 1 to 0, the average of the axis indicators is then calculated as shown in Table 5. The table in this study was created based on the source provided by **Camp (1989).**

Table 5. Standardized Numerical Scale Used for Evaluating Each Indicator

Value	Meaning
1.00	**Fully Applied**
0.75	**Highly Applied**
0.50	**Partially Applied**
0.25	**Weakly Applied**
0.00	**Not Applied**

This scale allows for the conversion of a qualitative description into a quantitative value.
Each indicator is assigned a score from 1 to 0
1 = Fully implemented
0.5 = Partially implemented
0 = Not implemented

1- Energy & Atmosphere (EA) Axis:

The energy and atmosphere indicator, its status in Al-Harithiya Mall, and its grade are shown in Table 6, based on the research theory, calculations, and axes of Baghdad Mall.

Table 6. Energy & Atmosphere (EA) Axis Assessment for Al-Harithiya Mall

Symbol	Indicator	Status in Al-Harithiya Mall	Grade
EA1	Air Conditioning System Efficiency	Partially Achieved	0.55
EA2	Thermal Insulation	Partially Achieved	0.50
EA3	Energy-Efficient Lighting	Partially Achieved	0.40
Total Score	–	–	**1.45 / 3 = 0.48**

Result before weighing EA = 0.48

Given its crucial role in the Iraqi environment, both economically and environmentally, the energy axis was given a high relative weight of 30% in the sustainability evaluation for both Al-Harithiya Mall and the University of Baghdad. Due to the heavy reliance on air conditioning, lighting, and continuous operation, especially in Baghdad's hot, dry climate, energy is one of the most-used resources in commercial and educational facilities.

Therefore, assigning greater weight to the energy axis reflects the assessment's realism and appropriateness for the local context. It also confirms that improving energy performance is the fundamental starting point for increasing the efficiency of existing buildings and reducing emissions and operating costs, whether in major educational projects, such as government universities, or commercial projects, such as shopping centers.

2- Sustainable Sites (SS) Axis:

The Sustainable Sites Axis for Al-Harithiya Mall, along with its grade, is shown in Table 7, based on the research theory, calculations, and axes.

Table 7. Sustainable Sites (SS) Axis Assessment for Al-Harithiya Mall

Symbol	Indicator	Status in Al-Harithiya Mall	Grade
SS1	Location Selection	Achieved (Central Location)	0.60
SS2	Public Transport Accessibility	Achieved	0.60
SS3	Heat Island Reduction	Partially Achieved	0.55
SS4	Rainwater Management	Partially Achieved	0.50
Total Score	–	–	**2.25 / 4 = 0.56**

Result before weighing SS = 0.56

Due to practical factors pertaining to the project's nature and the surrounding urban environment, the Site axis received a comparatively low weight in the sustainability evaluation for Al Harthiya Mall. The mall is an existing project in the Al Harthiya region, which has a fully developed urban fabric with several pharmacies, medical centers, labs, and clinics.
This restricts the ability to make changes to important site components, such as land selection, urban orientation, or the rearrangement of the surrounding urban structure.

3- Water Efficiency (WE) Axis: The Water Efficiency Axis for Al-Harithiya Mall, with its grade, is shown in Table 8, based on research theory, calculations, and axes.

Table 8. Water Efficiency (WE) Axis Assessment for Al-Harithiya Mall

Symbol	Indicator	Status in Al-Harithiya Mall	Grade
WE1	Reduce Internal Water Consumption	Achieved	0.60
WE2	Reduce External Water Consumption	Partially Achieved	0.55
WE3	Water Reuse	Achieved	0.65
Total Score	–	–	**1.8 / 3 = 0.60**

Result before weighing WE=0.60

Based on Iraq's climate and water conditions, the water-efficiency axis of the sustainability evaluation model for Al-Harithiya Mall was assigned a relative weight of 15%. Due to climate change, high consumption rates, and insufficient reuse systems in most current projects, water resources are among the most stressed. Due to the extensive use of restaurants, sanitary facilities, cleaning systems, and service areas, large commercial buildings like malls are among the most water-intensive building types. As a result, improving water efficiency significantly impacts the project's overall environmental performance.

Thus, calculations are performed for the remaining axes, the results of which are as follows:

4. Materials & Resources (MR) Axis:
Result before weighing MR=0.60
5. Indoor Environmental Quality (IEQ) Axis:
Result before weighing IEQ =0.58
6. Management and Operations(Mo) Axis:
Result before weighing MO =0.50
7. The Social Aspect (SA)Axis:
Result before weighing SA = 0.55

C. Converting each axis score to a weighted percentage
Axis score = (Average of indicators × Axis weight).
D. Final Sustainability Assessment Table – Al_Harithiya Mall / Baghdad
The Final Sustainability Assessment for Al-Harithiya Mall is shown in Table 9.

Table9. Final Sustainability Assessment of Al-Harithiya Mall

Axis	Weight (%)	Result Before Weighting (%)	Result After Weighting (%)	City Center Mall (%)
Site and Layout	10	0.56	5.6	28
Water Efficiency	15	0.60	9.0	10
Energy and Environment	30	0.48	14.4	55
Materials and Resources	15	0.60	9.0	13
Indoor Environmental Quality	15	0.58	8.7	12
Management and Operation	10	0.50	5.0	6
Socio-Economic	5	0.55	2.75	4
Final Total	**100**	–	**54.45%**	**70%**

Al-Harithiya Mall gets 54.45% (Moderate Applicability). Average - Needs Significant Improvements.

Therefore, compared to the City Center Mall in Cairo, the local assessment results indicate that the complex has an average applicability of sustainability systems, but its actual performance still falls short of that of similar regional projects. This is primarily due to the absence of an approved sustainability assessment framework from the design stage, the limited implementation of renewable energy technologies, and the inadequacy of water and materials management systems.

This comparison confirms that the gap between the two projects is not related to function or size, but rather to the extent to which they adopt sustainability principles.

Third: Building a Sustainability Applicability Model Data Collection from the American University in Cairo:

The model is based on elements such as the weights assigned to the American University in Cairo's sustainability pillars, which were determined analytically using the university's LEED BD+C priorities and published sustainability strategies, as previously mentioned for the City Center Al Mazaha Mall.

These weights reflect the actual areas of focus implemented by the university, as shown in Table 10, which is based on research theory, calculations, and axes.

Table 10. Relative Weights of LEED Categories for the Sustainability Applicability Model

Category (LEED)	Relative Weight (%)
Site and Layout	10
Water Efficiency	20
Energy and Environment	30
Materials and Resources	10
Indoor Environmental Quality	15
Management and Operation	10
Socio-Economic	5
Total	100

The Energy & Atmosphere axis has the highest score due to a lack of energy and a hot climate, which has increased its percentage to 30%.

The Water Efficiency axis is the second priority due to water scarcity, which has increased its percentage to 20%. The mathematical equations and methodology adopted for the project are the same as those used in Center City Almaza and Al-Harithiya Mall. The calculation for American University in Cairo is shown in Table 11, based on the research theory, calculations and axes. And based on Source: (The American University in Cairo, n.d.-a).

Table 11. Sustainability Calculation for The American University in Cairo

Category (LEED)	Points Achieved (%)	Weighted Score	Percentage of Achievement (%)
Site and Layout	10	0.65	6.50
Water Efficiency	20	0.85	17.00
Energy and Environment	30	0.80	24.00
Materials and Resources	10	0.70	7.00
Indoor Environmental Quality	15	0.75	11.25
Management and Operation	10	0.75	7.50
Socio-Economic	5	0.70	3.50
Final Total	100	–	76.75%

A high degree of sustainability integration across energy, water efficiency, indoor environmental quality, and management practices was demonstrated by the American University in Cairo's final weighted sustainability score of (76.75%). According to globally accepted assessment standards, this outcome highlights the efficacy of the purpose-built sustainable campus planning. confirming its function as a standard case for evaluating the application of sustainability on conventional university campuses like Baghdad University.

Fourth – Data collection from the standardization project:

Data Collection from the University of Baghdad

A. Defining the core pillars (the same LEED pillars adapted for Iraq):

The same weight distribution for the axes in the Iraq projects because it is suitable for comparing projects in different environments, as shown in Table 12.

Table 12. Final LEED Category Weights for Project Comparison

Category (LEED)	Relative Weight (%)
Site and Layout	15
Water Efficiency	15
Energy and Environment	30
Materials and Resources	15
Indoor Environmental Quality	15
Management and Operation	10
Socio-Economic	5
Total	100

These weights reflect the importance of each pillar in Iraq (energy and water have higher weights due to electricity and water scarcity issues).
The Energy & Atmosphere axis has the highest score due to a lack of energy and a hot climate, which has led to an increase in the Energy axis's percentage to 30%
The Water Efficiency axis is the second priority due to water scarcity, which has increased its percentage to 20%.

- Weighted Sum Model (WSM) is used to calculate axis weights, University of Baghdad

The scientific function of Result Before Weighting is not to issue a final judgment, but rather to isolate the raw, true performance of each axis:

Reveal the actual degree of application without exaggeration or understatement due to weighting. Allow a fair comparison between The American University in Cairo and the University of Baghdad.

B: Indicator evaluated according to a standardized numerical scale

Evaluation of indicators is shown in Table 13. This table was created by the researcher based on the research theory, calculations, and axes

Table 13. Standardized Numerical Scale for Indicator Evaluation

Value	Meaning
1.00	**Fully Applied**
0.75	**Highly Applied**
0.50	**Partially Applied**
0.25	**Weakly Applied**
0.00	**Not Applied**

This scale allows for the conversion of a qualitative description into a quantitative value. This scale allows for the conversion of a qualitative description into a quantitative value. Each indicator is assigned a score from 1 to 0

1 = Fully implemented
0.5 = Partially implemented
0 = Not implemented

-The mathematical equations and methodology adopted for the project are the same as those used in Center City Almaza and
Al-_Harithiya Mall

1. Energy & Atmosphere (EA) Axis

The energy and atmosphere indicator, its status at the University of Baghdad, and its grade are shown in Table 14, based on the research theory, calculations, and axes.
And based on Source: (University of Baghdad, n.d.).

Table 14. Energy & Atmosphere (EA) Axis Assessment for Al-Harithiya Mall

Symbol	Indicator	Status in Al-Harithiya Mall	Grade
EA1	Air Conditioning System Efficiency	Partially Achieved	0.50
EA2	Thermal Insulation	Partially Achieved	0.50
EA3	Energy-Efficient Lighting	Partially Achieved	0.50
EA4	Provision of Natural Lighting	Achieved	0.75
EA5	Renewable Energy	Weakly Achieved	0.25
EA6	Energy Control Systems	Weakly Achieved	0.25
Total Score	–	–	**2.75 / 6 = 0.45**

Result before weighing EA = 0.45

Given its crucial role in the Iraqi environment, both economically and environmentally, the energy axis was given a high relative weight of 30% in the sustainability evaluation for both Al-Harithiya Mall and the University of Baghdad. Due to the heavy reliance on air conditioning, lighting, and continuous operation, especially in Baghdad's hot, dry climate, energy is one of the most-used resources in commercial and educational facilities.

Iraq's energy infrastructure is beset by many problems, chief among them a limited electricity supply and a heavy reliance on environmentally harmful conventional generators.

To achieve true building sustainability, energy efficiency, and the usage of renewable energy sources are among the most important challenges. Therefore, assigning greater weight to the energy axis reflects the assessment's realism and appropriateness for the local context. It also confirms that improving energy performance is the fundamental starting point for increasing the efficiency of existing buildings and reducing emissions and operating costs.

whether in major educational projects, such as government universities, or in commercial projects, such as shopping centers.

2. Materials & Resources (MR) Axis:

Based on research theory, calculations, and axes, the Materials and status at the University of Baghdad and their grades are shown in Table 15.

Table 15. Materials & Resources (MR) Axis Assessment for Al-Harithiya Mall

Symbol	Indicator	Status in Al-Harithiya Mall	Grade
MR1	Recycled Materials	Partially Achieved	0.50
MR2	Waste Management	Partially Achieved	0.50
MR3	Local Materials	Achieved	0.75
MR4	Environmentally Friendly Materials	Achieved	0.65
Total Score	–	–	**2.4 / 4 = 0.60**

Result before weighing MR=0.60

The University of Baghdad's sustainability assessment assigned a relative weight to the Materials & Resources axis. The purpose of this axis is to assess how well building materials and resource management techniques are used across the course of university buildings.

This choice was made because many university buildings have been around for many years and use conventional materials and systems established before the development of sustainable architectural ideas.

Re-use, waste management, and partial modernization are therefore fundamental pillars in the evaluation process.

The choice of educational materials is a key concern for government-sponsored education projects, and for this axis, this is particularly linked to the long-term maintenance of materials, availability in the local area, and economic factors.

Thus, in addition to replacing existing structures, the analysis focuses on using local resources, the feasibility of restoring existing structures, and minimizing construction waste.

Consequently, the assessment model's Materials & Resources axis aligns with a realistic view of sustainability and the concept of the gradual construction of university facilities in the context of Iraq, based on available financial and technical resources.

3. Indoor Environmental Quality (IEQ) Axis

Table 16 shows the Indoor Environmental Quality (IEQ) Axis Status at the University of Baghdad and the prepared grade.

Table 16. Indoor Environmental Quality (IEQ) Axis Assessment for Al-Harithiya Mall

Symbol	Indicator	Status in Al-Harithiya Mall	Grade
IEQ1	Air Quality	Partially Achieved	0.50
IEQ2	Thermal Comfort	Partially Achieved	0.50
IEQ3	Natural Lighting	Achieved	0.75
IEQ4	Indoor Air Quality	Partially Achieved	0.45
Total Score	–	–	**2.2 / 4 = 0.55**

Result before weighing IEQ =0.55

In the University of Baghdad's sustainability assessment, the Indoor Environmental Quality (IEQ) axis was assigned a relative weight because it directly affects user efficiency and health in educational facilities. The indoor environment significantly affects instructor and student performance, academic achievement, and focus.

Inadequate natural ventilation, antiquated air-conditioning systems, poor thermal regulation, and a significant reliance on artificial lighting are issues that many university buildings face. This has a detrimental effect on indoor air quality, thermal comfort, and visual comfort.

In keeping with sustainability principles that emphasize people as the primary component of education, this axis is weighted to underscore the importance of improving the everyday living conditions in university buildings by increasing ventilation, reducing indoor pollutants, and enhancing natural lighting.

Thus, calculations are performed for the remaining axes, the results of which are as follows:

4. Sustainable Sites (SS) Axis:
Result before weighing SS = 0.58
5. Water Efficiency (WE) Axis:
Result before weighing WE = 0.50

6. Indoor Environmental Quality (IEQ) Axis:
Result before weighing IEQ =0.55
7. Management and Operations Axis:
Result before weighing MO =0.50
8. The Social Axis:
Result before weighing SA=0.56

C. Converting each axis score to a weighted percentage
Axis score = (Average of indicators × Axis weight).

Third: Final Sustainability Assessment Table – University of Baghdad

The final sustainability assessment for the University of Baghdad is given in Table 17, which gives the final total of (51.85) % as compared to American University, which gives a total of (76.75) %.

Table 17. Final Sustainability Assessment of the University of Baghdad

Axis	Weight (%)	Result Before Weighting (%)	University of Baghdad (%)	American University (%)
Site and Layout	10	0.58	5.8	6.5
Water Efficiency	15	0.50	7.5	17
Energy and Environment	30	0.45	13.5	24
Materials and Resources	15	0.60	9.0	7
Indoor Environmental Quality	15	0.55	8.25	11.25
Management and Operation	10	0.50	5.0	7.5
Socio-Economic	5	0.56	2.8	3.5
Final Total	**100**	–	**51.85%**	**76.75%**

University of Baghdad gets 51.85% (Moderate applicability). Average - Needs Significant Improvements.

An analysis of the two universities shows that the key difference between them lies in their approaches to sustainability as a long-term institutional policy. While the University of Baghdad's fragmented, disconnected sustainability initiatives remain in place, the American University of Cairo's clear strategy and ongoing assessment processes have helped drive improved sustainability performance.

3. CONCLUSIONS

1- Several factors were identified that influence the use of green building rating systems in Iraq, including economic, technical, legislative, and access to green building sustainability expertise factors. The study also showed that while grading systems, such as LEED, work well globally for projects in Iraq, they need to be adjusted to account for the country's unique local, environmental, and financial conditions.

2- The findings also revealed several obstacles to the implementation of these systems, the most important of which are high upfront costs, a lack of supportive legislation, and a lack of understanding of sustainability ideas. The establishment of government legislation, raising awareness, and encouraging the use of sustainable technologies in the building and construction industry were the most significant supporting elements.

3- This study makes a substantial academic addition to the subject of evaluating and using sustainable systems in Iraqi Universities and construction projects.

4- There is a lack of research in sustainability and environmental assessment systems, whether in terms of scientific depth, analytical depth, comprehensiveness, or relevance to the Iraqi context. Most of the earlier studies were theoretical and/or superficial, with little or no scientific basis to encourage the building industry to adopt more sustainable practices.

5- This study creates an academic base that will help Iraq's transition to sustainable development and modern urban development and act as a reference for further research. It also promotes the adoption of sustainability principles in building projects, academic institutions, and other investment projects.

6- Due to the different nature, function, and operational objectives of the projects, the difference in the relative Harithiya -weights of the sustainability axes between Al l and the University of Baghdad reflects the different Mal nature and function of the two projects, not a difference in the evaluation methodology. Al-Harithiya Mall is a commercial investment project. In contrast, the University of Baghdad is a long-term institutional educational project whose priorities and objectives are different from those of the City Center.

7- The sustainability assessment results for Almaza Mall in Cairo demonstrated a high level of sustainability performance, with the project achieving LEED Gold

certification under the LEED BD+C: Core and Shell v3 (LEED, 2009) system, scoring 70 out of 110 points. The project also demonstrated strong performance in the energy efficiency pillar through improved energy efficiency, the implementation of on-site renewable energy systems, and the use of monitoring and measurement systems. This positively impacted long-term operational efficiency. While some pillars, such as storm water management and outdoor lighting, scored lower, this did not significantly affect the overall project evaluation.

8- Al-Harithiya Mall has Moderate Applicability (Average) compared to Almaza Mall, which needs significant improvements. This is predominantly due to the lack of a verified sustainability assessment system for the design process, renewable energy technologies, and water and materials management. It demonstrates that even if some pillars perform at an average level, the overall performance does not deviate significantly from the national priorities, so the modified assessment model remains applicable.

The energy pillar has the highest absolute value; however, because it has a higher relative weight, it contributes the most to the assessment, whereas the social pillar contributes the least, as it has the lowest relative weight in the assessment framework. The difference confirms the effectiveness of the proposed model in differentiating actual performance from contextual priorities, thus substantiating the research hypothesis.

9- A local weighting methodology was followed, which fits the specificities of the Iraqi context and the needs of each type of project, thus ensuring the realism and accuracy of the results and increasing the applicability of the resulting recommendations.

Weighted results and graphical representations for Al-Harithiya Mall confirmed the research hypothesis: the proposed sustainability assessment model can evaluate the suitability of sustainability principles for existing commercial buildings in Iraq.

10- The sustainability assessment (76.75%) from 10-The American University in Cairo (AUC) showed that its campus is a trailblazer in the region in terms of practicing sustainability at the university level. It has adopted an integrative institutional strategy towards sustainability (planning, design, operation, and management). It is demonstrated through its high levels of achievement in energy, water, materials, and resources, and its indoor environment, the existence of a sustainability office, and through monitoring and measurement programs. The University of Baghdad has a Moderate Applicability Average (51.85%), indicating it needs improvement.

Therefore,

11-The results revealed that integrated campus planning has helped the American University in Cairo implement effective solutions, including solar energy systems, water reuse, waste management, and an improved learning environment. This led to a high rating for the university in most of the areas assessed.

12 - The University of Baghdad assessment revealed that the university has strong spatial and functional potential to become a sustainable campus; however, its current sustainability performance is average compared with the AUC. This difference has been attributed to the underutilization of renewable energy technologies, the lack of a specific institutional management framework for sustainability, and the use of traditional operational solutions for buildings and resource management. However, it has the potential to become a sustainable campus in the future, both spatially and functionally.

13- When comparing the two universities, the significant difference is not whether they could do it or not, or the size of the project, but that they have a policy of sustainability as being the long-term approach.

The American University in Cairo has a clear vision and regular assessment mechanisms, which have contributed to improving the University's sustainability performance, whereas the University of Baghdad continues to use individual, uncoordinated strategies.

14. The conceptual framework is consistent with the research hypothesis as it highlights that the weighting of priorities and gaps in the implementation of sustainability issues in Iraqi public universities is the main factor affecting sustainability performance, while sustainability indicators are not.

15. The hypothesis indicates that the University of Baghdad has a partial implementation level of integration into sustainability systems. Yet the lack of integration between technical and administrative aspects hampers the achievement of holistic, sustainable performance. This confirms the study's hypothesis that Iraqi public universities can be developed through a locally adapted sustainable assessment system.

LIMITATIONS OF THE STUDY

This study suffers from a limited supply of publicly available secondary data and a small number of sustainable projects operating in Iraq. Furthermore, the evaluation framework relies on weighted performance assessment rather than real-time operational measurements. Future studies may benefit from field measurements, larger datasets, and multi-criteria decision-making approaches based on expert experience.

Several limitations should be considered when interpreting the results of this study.

a. Thestudy relies on secondary data from publicly bsites and technical available sources. While official we documentation are generally reliable, some project details may not be fully disclosed.

b. The certifications of projects with sustainabilit er numb in Iraq is very limited. This restricted the selection of local ced opportunities for a broader case studies and redu empirical comparison.

c. The study was initially designed to include questionnaires from experts using the Analysis Hierarchy Process (AHP). However, due to the scarcity of specialists ding certification with extensive knowledge of green buil systems in Iraq, it was not possible to collect sufficient and reliable primary data. Consequently, the study adopted a king methodology, retainrbenchmaAHP's weighting principlesas its conceptual framework .

d. The pproach focuses on a limited number ofcase study a projects, which may limit the statistical generalizability of the findings. Nevertheless, the study aims for analytical generalization, offering insights and recommendations simply applicable to similar contexts, rather than providinga statistical representation.

e. Sustainability performance assessment is primarily based on the LEED BD+C: Core and Shell framework. While this system is internationally recognized, certain tional criteria local conditions in Iraq may necessitate addi or modifications for its future implementation.

f. Climate challenges: Rising temperatures and water scarcity.

g. Logistical Limitations : Poor Recycling Facility: In most developing countries, such as Iraq, it is difficult to retrieve materials to use in building work, as there are no special facilities to reuse.

Insufficient Equipment and Technology: Some countries lack advanced technologies to improve the recycling process. Businesses require significant investments in technology and machinery to recycle materials appropriately (Alwan et al., 2017).

h. Economic Limitations: Transportation and Processing Costs: The potential economic benefits in most cases are abated due to the fact that the cost of transporting recycled materials to a processing plant or a low-quality location is higher than the cost of raw materials (UN-Habitat, 2020).

ı. Legal and Regulatory: Building Codes and Regulations: In certain developing countries, efforts to make the sector more sustainable can be hindered by ambiguous legal provisions governing the use of recycled materials in construction.

Public Awareness and Community Acceptance: The project owners might struggle to convince stakeholders, including contractors and designers, to adopt recycled materials due to limited awareness of sustainability benefits (United Nations Environment Program, 2016).

i. Governance Constraints: The study encountered several challenges related to the level of e-governance implementation in the institutions and projects under study. Many administrative and operational systems still rely more on traditional procedures than on integrated digital systems. This resulted in limited availability of accurate, up-to-date databases on sustainability indicators, energy and water consumption, and management and operational mechanisms.

Furthermore, the weak integration among different electronic systems and the limited use of smart monitoring technologies and building management systems made it difficult to obtain detailed, reliable information that could be fully used for evaluation and comparative analysis. In addition, the varying levels of digital transformation between Iraqi institutions and regional benchmark projects posed a challenge in standardizing data collection and analysis criteria.

Therefore, the limited e-governance and supporting digital infrastructure are among the constraints that partially affected the accuracy of some operational indicators in the study. This underscores the need to develop electronic systems and advance digital transformation to support the application of sustainability concepts in future Iraqi projects (United Nations Department of Economic and Social Affairs [UNDESA], 2022).

Finally, Cultural and Educational: Lack of a Sustainability Culture: In certain developing nations, there may be a lack of knowledge or enthusiasm for sustainable building principles, which can result in opposition to their adoption (Mahdi & Mahood, 2021).

ACKNOWLEDGEMENT

The authors would also like to thank Engineers, Project managers, and friends from the executive companies overseeing project implementation, as well as professors who enriched us with information and engineering resources related to building and project sustainability.

REFERENCES

1) Al-Adwy, A., & Saeed, M. (2019). The role of technology in implementing green architecture principles (Master's thesis). Faculty of Engineering, Benha University.
2) Alwan, Z., Jones, P., & Holgate, P. (2017). Strategic sustainable development in the UK construction industry through the framework for strategic sustainable development using building information modeling. Journal of Cleaner Production, 140, 349–358. https://doi.org/10.1016/j.jclepro.2015.12.085
3) Bergman, D. (2012). Sustainable design: A critical guide. Princeton Architectural Press.
4) Camp, R. C. (1989). Benchmarking: The search for industry best practices that lead to superior performance. ASQC Quality Press.
5) City Center Almaza. (n.d.). Shopping mall and entertainment destination. https://www.citycentrealmaza.com/
6) Elizabeth, L., & Adams, C. (2015). Sustainable building materials: Principles and practice. Routledge.
7) Ferwati, M. S., Al Saeed, M., Shafaghat, A., & Keyvanfar, A. (2019). Qatar Sustainability Assessment System (QSAS)–Neighborhood Development (ND) assessment model: Coupling green urban planning and green building design. Journal of Building Engineering, 22, 171–180. https://doi.org/10.1016/j.jobe.2018.12.013
8) Hanley, N., & Spash, C. L. (1993). Cost–benefit analysis and the environment. Edward Elgar Publishing.
9) International Code Council. (2021). International green construction code (IgCC). https://codes.iccsafe.org/content/IGCC2021P2
10) Iraqi Ministry of Electricity. (n.d.). Ministry of Electricity.https://mofa.gov.iq/geneva/?page_id=1096&lang=en
11) Iraqi Ministry of Environment. (n.d.). Reports on positive feedback and initiatives related to sustainability. https://moen.gov.iq/en/national-initiatives
12) Majid Al Futtaim Properties. (n.d.). City Center Almaza. https://www.majidalfuttaim.com/ar/what-we-do/our-industries/brand/city-centre-almaza
13) McLennan, J. F. (2004). The philosophy of sustainable design. Ecotone Publishing.
14) Ministry of Housing and Construction. (n.d.). Information on real estate projects and building systems used.
15) National Science and Technology Council, Subcommittee on Construction and Buildings. (1993). Preliminary report. National Science and Technology Council.
16) Occupi. (n.d.). City Center Almaza – Cairo: Premium retail space. https://getoccupi.com/malls/city-almaza
17) Rogers, J. C. (2013). Green building law and regulations. Wolters Kluwer Law & Business.
18) Silvius, G., Schipper, R. O. N., & Planko, J. (2012). Sustainability in project management. Gower Publishing.
19) The American University in Cairo. (n.d.). Office of Sustainability.https://www.aucegypt.edu/sustainability/office
20) The American University in Cairo. (n.d.). Sustainability.https://www.aucegypt.edu/sustainability
21) Tucker, L. M. (2010). Sustainable building systems and construction for designers. Fairchild Books.
22) U.S. Green Building Council. (2005). LEED for Existing Buildings v2.0 Reference Guide. U.S. Green Building Council.
23) UN-Habitat. (2020). Waste Wise Cities tool: A practical guide for assessing waste management at the city performance level. https://unhabitat.org
24) United Nations Department of Economic and Social Affairs. (2022). E-government survey 2022: The future of digital government. United Nations. https://desa.un.org
25) United Nations Environment Program. (2016). Global material flows and resource productivity: Assessment report for the UNEP International Resource Panel. United Nations Environment Program.https://www.resourcepanel.org/reports/global-material-flows-and-resource-productivity
26) University of Baghdad. (n.d.). University of Baghdad profile. https://www.uobaghdad.edu.iq