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Assessing the Sustainability of Adaptive Reuse Methods for Traditional Buildings

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Abstract
The aim is to arrive at a thorough comprehension of the potential of “adaptive reuse” methods in promoting the sustainability of buildings and maintaining an architectural identity. Adaptive reuse is reviving the abandoned heritage buildings that might otherwise fall into disrepair and decay, and eventually be dilapidated. The role of architectural design is crucial in the adaptive reuse method because it changes the original use of the building to another. The paper utilizes the rating system LEED (Leadership in Energy and Environmental Design), in order to assess the validity of sustainable levels in adaptive reuse conservation buildings. The research relied on literature and theoretical analysis, as well as observations to evaluate the adaptive reuse method in terms of sustainability. Two case study buildings have been selected; one international with a LEED certificate, and another local from Erbil city, Kurdistan of Iraq. The latter has been assessed based on a LEED rating system depending on the observations and the assessment process applied in the international case study, and the results have been extrapolated. The findings showed that there are too many sustainable advantages to the adaptive reuse method in the conservation of buildings. The paper also demonstrated that there is a great opportunity to achieve a LEED rating system through the adaptive reuse method in the Kurdistan region of Iraq if there is enough awareness about the requirement of the LEED rating system. Moreover, the recommendation has been suggested in this context.

Keywords*:* LEED; Adaptive reuse; Heritage buildings; Buildings Sustainability; Sustainable materials.

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1. Introduction

Large volumes of raw materials and land that may be used in other ways are consumed while constructing new buildings. The massive increase in global energy consumption serves as a warning about the depletion of energy sources, which has a major impact on the environment (climate change and global warming, for example). Buildings use over forty percent of the world's energy, over a quarter of its water, forty percent

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of its resources, and nearly one over three of its greenhouse gas emissions, according to "The United Nation's Environment Program" (2009) (Ozdil, 2010). To address this environmental catastrophe, eco-friendly or environmentally friendly architectural design is recommended, according to the perspective of ecological architecture. Therefore, building design should ensure that today's activities and structures do not jeopardize the ability of future generations to benefit from the Earth's resources (Burton, 2012). Enhancing resource efficiency, environmental quality, energy efficiency, and innovative design are all important aspects of sustainability certification. Through this, more facilities can be provided to manage energy use and environmental, financial, and social aspects of buildings. Adaptive reuse of existing structures rather than replacing them through demolition and reconstruction can reduce the quantity of materials consumed and the amount of land used. The goal of adaptive reuse is to change the original purpose of a historic building without demolishing it or starting from scratch. This method of environmental conservation relies heavily on interior design features to create a distinctive interior environment without compromising the historical significance of the building. Generally speaking, when old buildings can be efficiently converted to new uses, maintained, and designed in an energy-efficient manner in the built environment, there is no need to demolish them.

The research tries to answer the following question: what range of 'adaptive reuse' methods is effective in reducing the impact on the environment? And how much the LEED rating system is effective to be applied as a tool for monitoring or controlling energy consumption in buildings?

The objectives of the study were to define a LEED rating system checklist for assessing the sustainability of adaptive reuse buildings and assess the sustainability validity of these buildings.

The study aims to reach a sustainable presence in adaptive reuse conservation ways for heritage buildings. To reduce the usage of natural resources, reduce greenhouse gases (GHG) in buildings, and improve the inner environment.

In this context, LEED certification is used as a tool to evaluate sustainability in terms of its three aspects, environment, economic, and social in adaptively reused buildings. Also, to evaluate the improvement in the innovation of design, and clearer image during all the processes, and on managing the buildings in a sustainable level, meantime conserves the identity of culture.

2. Literature Review

2.1 Adaptive reuse

It can be defined as the process of reusing old buildings for work other than that which was designed or built for it previously (Ball, 2002). Adaptive reuse is an important way to preserve the value of old buildings and their neighborhoods, where the building's age is increased by using another or similar function to avoid demolition or dilapidation of the building (Abdulrahman, 2022; Bulen and Love, 2010; Jokilehto, 2006). Adaptive reuse is a standout amongst the most utilized techniques for the survival of heritage buildings (Cascal, 2007). Researchers tended to versatile reuse as a type of historical and traditional conservation of buildings (Bromley et al., 2005). For the development of society, the change of historic buildings' occupations to a new one is very important (Latham, 2000, Wilkinson et al., 2009). As indicated by Akhtarkavan, et al., (2008), the benefits of adaptive reuse adjustment for sustainability can be recorded as; Lessened energy utilization b. Re-cycling the existing construction materials c. Lessen environmental effects d. Lessen as far as possible utilizing land use e. Decrease construction squanders f. provide human needs g. providing the performance demands h. Keep up building authentic elements. Urban Revival J. Improvement of economic attributes k. save time compared with new construction. L. protects the conventional identity.

2.2 Sustainability

Because of the urgent need to overcome the problems of climate change and global warming facing the world in the twenty-first century, action towards sustainability is a critical issue at present. Population growth and urbanization affect the increment in the construction of the building. In the same context, the need for a safe and good life for future generations is also important. To achieve this goal, there is a vital requirement to control urban planning, design, and construction. Thus, sustainability in design and construction has become crucial for future generations for the storage of natural resources. According to the UNWCED sustainability can be defined as achieving the present needs of the world without conflicting the needs of future generations to be able to meet their needs (Al-Surf, 1987).

However, the construction of buildings is an important factor in harming environmental damage through the exhaustion of traditional sources, damage to natural and environmental areas, increased pollution, and use the materials in the building will be harmful to human health. Sustainability has been divided into three main interlinked levels to shape sustainability. Sustainable development has been recognized in three terms:

social development, environmental protection, and economic growth (Adams, 2006). These three conditions must be available to achieve sustainability in any area, as seen in Figure ‘1’.

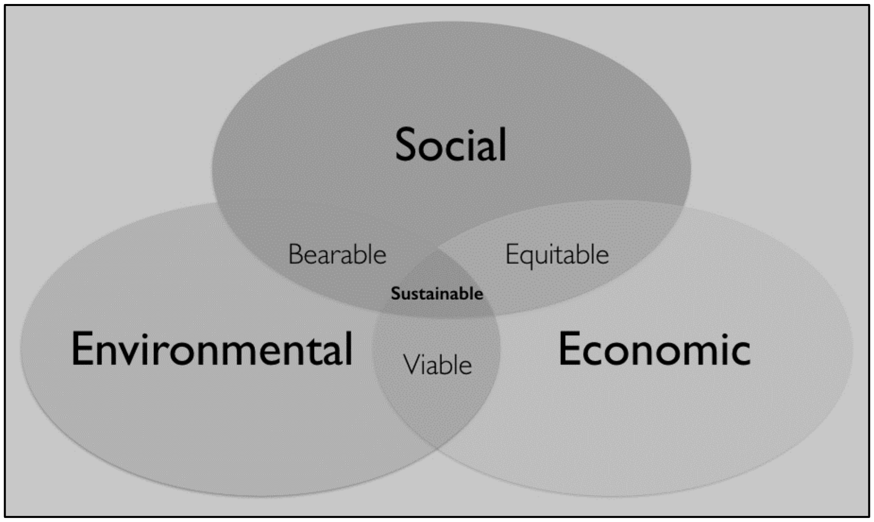

Figure 1. The three terms constitute the concept of sustainability (Shawkat, et al., 2017).

2.2.1 Sustainable Principles in buildings

The principles of sustainability aim at preserving the rights of new generations without violating the rights of present generations. Where the main principles of sustainable buildings are the provision of comfort to the inhabitants and it should not interfere and disturb the ecosystem and the negative impact on the community system (Zainul Abidin and Pasquire, 2005; Asif et al., 2005).

There are a few standards of a sustainable building considered internationally, in the environmental measurement, namely; Guarantee great indoor air quality with performing thermal, visual, and acoustic comfort, this will incorporate low volatile compounds usage with good filtration, and appropriate moistness; Utilizing orientation of the buildings for better sun radiation entrance inside the building for heating in necessary seasons, and better daylight, and better natural ventilation; Water collecting, reusing the water and water framework system; Choosing an appropriate site with the easy access to public utilities (transport and services) and entertainment zones; Picking materials that have less effect on the human being and environment. In other measurements, for example, at social and economic levels, guaranteeing social value and reasonability in buildings are the central matters to accomplishing sustainability standards in buildings (Sani and Chi Munaaim, 2012).

2.2.2 Sustainable Building Material

There are some special features in building materials, to make the building sustainable. A few of these characteristics will be described in this section.

1. The material's inherent energy is the total amount of energy needed to transform it from its unprocessed state. This includes all types of energy used to control the entire process including transporting raw materials to the preparation place. This energy is classified as non-renewable energy sources, which are already unsustainable and hurt nature and climate through the discharge of gases into the air, increased atmospheric temperature, and climate change (Mink, 2006). For example, brick blocks (mud-dyed and naturally dried clay) produce less energy and, therefore, less pollution will be produced compared with the production of hollow concrete blocks.
2. The portions of the materials that are non-poisonous or less toxic have less of an impact on the works. And tenant's well-being. Where poisonous materials influence IAQ (indoor air quality) and let the building's occupants face a well-being risk. Some building materials like glues are spreading the risk immediately after a short time of the establishment. However, other kinds of materials as some sort of building materials (Asbestos pipes) may influence the well-being of tenants throughout the building's life (Jin Kim, 1998).
3. Energy effectiveness of a material is a critical component to adding sustainability to a building. The reason is to lessen the energy utilization of a building site. The energy productivity of building materials can be estimated utilizing elements, for example, U-value. The energy costs in the long haul are intensely reliant on the materials utilized in building development. (Koenigsberger, et al., 2010). Measure a building material's efficiency can help in the determination of building materials' properties and deciding the ideal for building.

4. A durable or long-lasting material needs less replacement., at that point decreases the expense of substitution and re-establishment. These sorts of materials are supportable because, will require fewer crude materials and will deliver less landfill squander during the building's lifetime (American Institute of Architects, 1992).
5. Cost-effective materials applications are helping to perform the economic dimension. This will let the total cost of the building be cheaper, and then implement economic sustainability (Ilberg, and Rollins, 2007).

2.3 LEED Rating System

LEED is an assessment of green buildings used in the US and is not the first of its kind. However, this program is the only one used by private organizations and government agencies in the US. The USGBC, established in 1993 established an appropriate system for United States buildings. Where it produced the LEED 1.0 pilot program in 1998. At present, many countries have adopted it either as it is or have made some adjustments to their climate and system of construction. LEED is an environmental assessment framework executed in structures amid all the life of the working, to assess the 'green building' grade (DOE, 2001). Dependence on USGBC, the need behind discovering LEED was (Kirk and Dell'Isola, 1995); 1) Give a positive impact on the condition, tenants' wellbeing and decrease the everyday cost; 2) Detail the rules for evaluation of the significance of "green"; 3) Abstain from "washing of green"; 4) Advance plan process in structures.
The sixth effect, titled "Innovation and Design Process (ID)," is added to the five primary environmental impact areas that make up the LEED green grading system. There are five distinct environmental effect areas as seen in Table ‘1’. The scores of the LEED system total 69. They are divided into six areas, as mentioned in Table ‘1’. Four out of six areas have prerequisites, which are compulsory and should be present in each structure, (DOE, 2001).

Table 1. LEED Green Rating System checklist and credit system.

No	Area	No. of Credits	prerequisites
1	Sustainable Sites (SS)	14	1 required
2	Water Efficiency (WE)	5	
3	Energy and Atmosphere (EA)	17	3 requires
4	Materials and Resources (MR)	13	1 required
5	Indoor Environmental Quality (IEQ).	15	2 requires
6	‘Innovation and Design Process (ID)’	5	
		Total= 69	Total= 7

Some of the credits are multi-layered to increase performance. 26 points should be earned to get a LEED certification, and the prerequisites must be present. We can brief LEED rating as follows; (33 to 38) credits, earns ‘Silver rating’; ‘Gold rating’. (39 to 51) credits earn a ‘Gold rating’; and (52 to 69) credits earn a ‘Platinum rating’. See appendix ‘A’.

3. Methodology

This research collected information from many sources into an incorporated set of practical guidelines for integrating adaptive reuse buildings. The evaluation analysis based on the LEED rating system will be applied in adaptive reuse buildings to determine sustainability.

1. Two adaptive reuse buildings will be selected as case studies; first in Erbil City (not evaluated based on the LEED rating System), and another internationally (Holding LEED rating).

2. The LEED rating system for the international case study will be analyzed based on the literature.

2. The LEED rating system will be applied to evaluate the elements of sustainability in the local case study in Erbil, based on site observation and documentary analysis.

3. Comparison between the external case study (LEED-rated adaptive reuse building), and the Erbil case study will demonstrate, and the result will be extrapolated.

LEED has the most dominant rating system recently in the world, (Appleby, 2011). The analysis based on this rating system will be approached through a literature review of; library sources as books, and internet-valid sources, such as articles, papers, and research to understand the characteristics of this rating system.

3.1 Case Studies

3.1.1 "4240" Architecture, Inc., Denver Studio (International Case study)

Since 1903 has been Built as the Weigele Pipe Foundry, and today the 4240 Architecture, Inc. building. The building's previous function was as a warehouse close to downtown Denver. Worked before 1920, this is a model adaptive reuse project that jams numerous innately proficient highlights of a historical building, including operable bay windows, brick masonry usage, and sufficient common lighting. See Figure '2'.

Figure 2. 4240 Architecture, Studio, in Denver, USA. (Boschmann and Gabriel, 2013)

The building was constructed of timber and brick in 1895 as a warehouse for the J. McCracken Company. This project took extraordinary pride in its commitment to making architectural, Interior, and planning that incorporate social, aesthetic, and technological concerns (BuildingGreen 2009).

The project utilized the Commercial Interiors (CI) certificate framework in contrast to Operations and Management of Existing Buildings (EB: OM). LEED launched its EB: OM certification framework in 2004 for use in building activities and administration, as well as small-scale restorations. Rather, as befitting 4240 Architecture, Inc., the project investigated certification under the CI system, which 'grants the power to make sustainable decisions to tenants and designers, who do not always have control over full building operations' (USGBC 2011). The project intended to keep up as many of the building components of the foundry as could be expected under the circumstances, consolidating pillars, vents, sky-facing windows, and cranes into the texture of the inner space. See Figure '3'.

Figure 3. Using old interior elements for furniture 4240 Architecture, Inc., Denver Studio, Colorado, USA. (4240architecture, 2024)

The project's reuse of at least 40% of the foundry's interior components in addition to the building's shell infrastructure was recognized with one point for "Building reuse: keep up 40% inside non-structural," which is the most obvious credit obtained about the building's foundation. The proposal also received one point for "Sunshine and perspectives: sunlight 75% of spaces," which implicitly recognized the 28 movable bay windows that allow natural light to flood the structure and reduce the need for artificial lighting. These operable bay windows likewise take into consideration normal ventilation and decrease HVAC system use; however, credit was not explicitly given for this vernacular component. See Figure ‘4’.

Figure 4. Using old interior elements for furniture 4240 Architecture, Inc., Denver Studio, Colorado, USA. (4240architecture, 2024)

Finally, the foundry received recognition for its "Innovation in Design, regional materials," which pertains to the project's overall layout and its commitment to employing locally produced materials. We have thus linked this credit with the adaptive reuse portions of the project, even if the foundry's reuse was not the only design element for which the project received recognition. The historical building's usage was undoubtedly a significant component of the project overall. Operable windows and local timber were employed as vernacular elements in the project, but external window treatments, shading mechanisms, overhanging rooftops, and covered porches were not combined.

3.1.2 Kurdish Textile Museum in Erbil Citadel (Local Case Study)

The Kurdish Textile Museum is a museum dedicated to textiles produced in Iraqi Kurdistan. It was established in 2004 and is located in a renovated mansion in the southeast neighborhood of Erbil Citadel. See Figure ‘5’.

Figure 5. Location of Kurdish Textile Museum inside Citadel of Erbil. Source: Google Earth.

The building is old and was a former home. It has been renovated with most of its interior and exterior elements preserved. See Figure '6'.

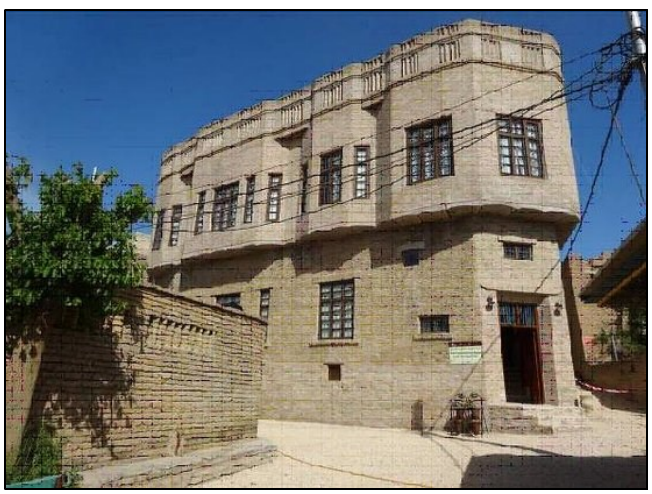

Figure 6. Kurdish Textile Museum, Building from outside. (By Author)

The process of adaptive reuse for this building was started in 2004, and the buildings were conserved while keeping the old architectural elements, and the water and electrical systems had been repaired, also the structural strengthening. A new water and sewerage system has been built for this building to avoid leakage and water penetration in the vertical elements of the buildings like walls, and the foundation. The local materials have been applied in the renovation of the building façade like burned brick, as seen in Figure '7'.

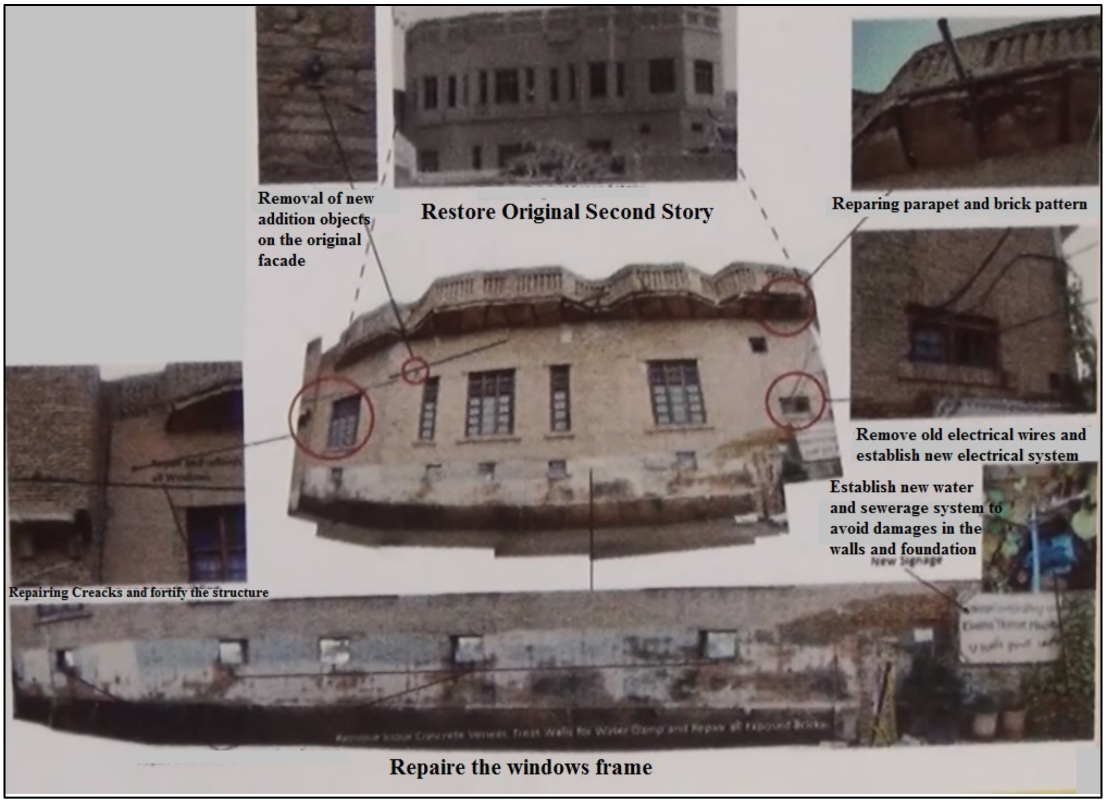

Figure 7. Renovation process in Kurdish Texture Museum inside Erbil Citadel.

The majority of the interior elements also have been conserved to be as old shape and the doors have been restored to their previous shape. The floor material has been changed to new material, and there are no recycling systems for water, or any energy efficiency system applied in this building. See Figure '8'.

Figure 8. Conservation of interior architectural elements. Wikimedia, (2024).

The application of the LEED rating system on this building will be based on the assessment checklist, as seen in Appendix 'A'. The absence or presence of this factor will be evaluated based on personal site observation, and documentary analysis of the building.

4. Analysis and Discussion

Based on the data collection regarding both case studies (International and Local), the international adaptive reuse buildings have gained a silver rating) in the LEED rating system, because it collected 36 points. The following table '2', is the Summary of LEED credits earned by 4240 Architecture, Inc., building (Boschmann and Gabriel, 2013).

Table 2. LEED credit earned by 4240 Architecture, Inc. building in Denver. (See. Appendix 'A')

No.	Area	No of Credit	Out of
1	Sustainable Site (SS)	5	14
2	Water Efficiency (WE)	1	5
3	Energy and Atmosphere (EA)	6	17
4	Materials and Resources (MR)	9	13
5	Indoor Environment Quality(IEQ)	10	15
6	Innovation and Design Process (ID)	5	5
		Total =**36**	**69**

Hence, based on the above table the total credits earned by the building is 36, which gives it a 'Silver Rating', (33 to 38 points must be earned), (DOE, 2001).

The local case study (Kurdish Textile Museum, Erbil), which has been renovated according to adaptive reuse way has been assessed based on the LEED rating system by LEED, V4. (2016)-Standards and the tables of the assessment have been taken from this standard as the following.

1. Sustainable Site (SS); the section includes 14 points one of them required, and obligatory which is (Construction activity pollution prevention), which is achieved in this building because the building was not a new construction. Therefore, the pollution is minimal. The building achieved a Sustainable Site because it implemented the required points, and gained (4) points out of (14), as seen in Table '3'.

Table 3. LEED assessment regarding Sustainable Site (SS) for Kurdish Textile Museum, Erbil.

Yes	?	No			
Yes			Sustainable Sites		14 Points
Yes			Prereq 1	**Construction Activity Pollution Prevention**	Required
1		0	Credit 1	**Site Selection**	1
1		0	Credit 2	**Development Density & Community Connectivity**	1
0		1	Credit 3	**Brownfield Redevelopment**	1
0		1	Credit 4.1	**Alternative Transportation**, Public Transportation	1
0		1	Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
1		0	Credit 4.3	**Alternative Transportation**, Low-Emitting & Fuel Efficient Vehicles	1
0		1	Credit 4.4	**Alternative Transportation**, Parking Capacity	1
1		0	Credit 5.1	**Site Development**, Protect or Restore Habitat	1
0		1	Credit 5.2	**Site Development**, Maximize Open Space	1
0		1	Credit 6.1	**Stormwater Design**, Quantity Control	1
0		1	Credit 6.2	**Stormwater Design**, Quality Control	1
0		1	Credit 7.1	**Heat Island Effect**, Non-Roof	1
0		1	Credit 7.2	**Heat Island Effect**, Roof	1
0		1	Credit 8	**Light Pollution Reduction**	1

2. Water Efficiency: this part did not achieve success in the building, because it gained only (2) points over (5). The only reduction in water usage was achieved through reducing the water used in new construction processes, as well as the water usage in the materials manufacturing process. See table '4'.

Table 4. LEED assessment regarding Water Efficiency (WE) for Kurdish Textile Museum, Erbil.

Yes	?	No			
Yes			Water Efficiency		5 Points
0		1	Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
0		1	Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
0		1	Credit 2	**Innovative Wastewater Technologies**	1
1		0	Credit 3.1	**Water Use Reduction**, 20% Reduction	1
1		0	Credit 3.2	**Water Use Reduction**, 30% Reduction	1

3. Energy and Atmosphere (EA): in this area, three required points should be achieved, at least 2 of them for the projects after 2007. But, because the Kurdish Textile Museum was established before 2007, then the requirements will be considered not obligated. Optimization energy performance had been evaluated by 10 points because the building is only renovated, the majority is existing, and small parts only are new. The observation showed that there is no on-site renewable energy, therefore, the building did not score any points. In the same context, the commissioning is not achieved which is the requirement of the owner, and here it could be considered green building requirements because the building was not designed originally to meet the LEED rating system evaluation. There are no measurements and verifications in the building system and also there is no refrigerant management and no green power design. Based on the previous analysis, the total scores were (10) points out of (17). See Table '5'.

Table 5. LEED assessment regarding Energy & Atmosphere (EA) for Kurdish Textile Museum, Erbil.

Yes	?	No			
Yes			Energy & Atmosphere		17 Points
Yes			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
Yes			Prereq 1	**Minimum Energy Performance**	Required
Yes			Prereq 1	**Fundamental Refrigerant Management**	Required
*Note for EAc1: All LEED for New Construction projects registered after June 26, 2007 are required to achieve at least two (2) points.					
10		0	Credit 1	**Optimize Energy Performance**	1 to 10
			Credit 1.1	10.5% New Buildings / 3.5% Existing Building Renovations	1
			Credit 1.2	14% New Buildings / 7% Existing Building Renovations	2
			Credit 1.3	17.5% New Buildings / 10.5% Existing Building Renovations	3
			Credit 1.4	21% New Buildings / 14% Existing Building Renovations	4
			Credit 1.5	24.5% New Buildings / 17.5% Existing Building Renovations	5
			Credit 1.6	28% New Buildings / 21% Existing Building Renovations	6
			Credit 1.7	31.5% New Buildings / 24.5% Existing Building Renovations	7
			Credit 1.8	35% New Buildings / 28% Existing Building Renovations	8
			Credit 1.9	38.5% New Buildings / 31.5% Existing Building Renovations	9
			Credit 1.10	42% New Buildings / 35% Existing Building Renovations	10
0		3	Credit 2	**On-Site Renewable Energy**	1 to 3
			Credit 2.1	2.5% Renewable Energy	1
			Credit 2.2	7.5% Renewable Energy	2
			Credit 2.3	12.5% Renewable Energy	3
0		1	Credit 3	**Enhanced Commissioning**	1
0		1	Credit 4	**Enhanced Refrigerant Management**	1
0		1	Credit 5	**Measurement & Verification**	1
0		1	Credit 6	**Green Power**	1

4. Materials and Resources: this area consists of 13 points, one of these points is required and obligatory which is 'Storage & Collection of Recyclables', which belongs to the building occupants how they can reduce the waste materials (LEED V4, 2016). The building of the Kurdish Textile Museum in Erbil Citadel is missing this feature, hence, this area, according to the requirements, is not achieved. However, (11) points were gained out of (13), but the requirements were not achieved. See Table '6'.

Table 6. LEED assessment regarding Materials and Resources (MR) for Kurdish Textile Museum, Erbil.

Yes	?	No			
		No	Materials & Resources		13 Points
Yes			Prereq 1	**Storage & Collection of Recyclables**	Required
1		0	Credit 1.1	**Building Reuse,** Maintain 75% of Existing Walls, Floors & Roof	1
1		0	Credit 1.2	**Building Reuse,** Maintain 95% of Existing Walls, Floors & Roof	1
1		0	Credit 1.3	**Building Reuse,** Maintain 50% of Interior Non-Structural Elements	1
1		0	Credit 2.1	**Construction Waste Management**, Divert 50% from Disposal	1
1		0	Credit 2.2	**Construction Waste Management**, Divert 75% from Disposal	1
1		0	Credit 3.1	**Materials Reuse**, 5%	1
1		0	Credit 3.2	**Materials Reuse**, 10%	1
1		0	Credit 4.1	**Recycled Content**, 10% (post-consumer + 1/2 pre-consumer)	1
1		0	Credit 4.2	**Recycled Content**, 20% (post-consumer + 1/2 pre-consumer)	1
1		0	Credit 5.1	**Regional Materials**, 10% Extracted, Processed & Manufactured	1
1		0	Credit 5.2	**Regional Materials**, 20% Extracted, Processed & Manufactured	1
0		1	Credit 6	**Rapidly Renewable Materials**	1
0		1	Credit 7	**Certified Wood**	1

5. Indoor Environment Quality: this part holds two obligatory points; the first is the minimum air quality required, and that is achieved through the vernacular design of the historical building, which contains air ventilation and a courtyard system as well as sky lighting. The second is 'Environmental Tobacco Smoke (ETS) Control', which is also achieved by preventing smoking inside the building. Other factors have been analyzed and evaluated, and the total gained points were (6) points out of (15), as seen in Table '7'.

Table 7. LEED assessment regarding Indoor Environment Quality (IEQ) for Kurdish Textile Museum, Erbil.

Yes	?	No			
Yes			Indoor Environmental Quality		15 Points
Yes			Prereq 1	**Minimum IAQ Performance**	Required
Yes			Prereq 2	**Environmental Tobacco Smoke (ETS) Control**	Required
0		1	Credit 1	**Outdoor Air Delivery Monitoring**	1
1		0	Credit 2	**Increased Ventilation**	1
1		0	Credit 3.1	**Construction IAQ Management Plan,** During Construction	1
1		0	Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
0		1	Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
0		1	Credit 4.2	**Low-Emitting Materials**, Paints & Coatings	1
1		0	Credit 4.3	**Low-Emitting Materials**, Carpet Systems	1
0		1	Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products	1
0		1	Credit 5	**Indoor Chemical & Pollutant Source Control**	1
0		1	Credit 6.1	**Controllability of Systems**, Lighting	1
0		1	Credit 6.2	**Controllability of Systems**, Thermal Comfort	1
1		0	Credit 7.1	**Thermal Comfort**, Design	1
0		1	Credit 7.2	**Thermal Comfort**, Verification	1
1		0	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
0		1	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

6. Innovation and Design Process (ID): This part concerns finding new, innovative factors for buildings, and going beyond sustainable strategies in the building. According to the observation, the building design holds one innovative factor, through the adaptive reuse method in the conservation and design process. Therefore, one point only gained out of (5) in this part and (ID) was not completely successful. See table '8'.

Table 8. LEED assessment regarding Innovation and Design Process (ID) for Kurdish Textile Museum, Erbil.

Yes	?	No			
Yes			Innovation & Design Process		5 Points
1		0	Credit 1.1	Innovation in Design: Through Adaptive reuse method application	1
		1	Credit 1.2	Innovation in Design:	1
		1	Credit 1.3	Innovation in Design:	1
		1	Credit 1.4	Innovation in Design:	1
		0	Credit 2	LEED® Accredited Professional	1

By the analysis of the local case study by the LEED rating system, the results demonstrated that partial parts have been achieved, whereas other parts were not. The reason was either because of failing to achieve the required points, as in (ME) area. It is worth mentioning that the total obtained points in (ME), were (10) points out of (13). But the required or obligatory point was not achieved, therefore it is considered zero. The following is the summary of LEED credits earned by the Kurdish Textile Museum building in Erbil Citadel. See Table '9'.

Table 9. LEED credit earned by the Kurdish textile Museum building, in Citadel of Erbil.

No.	Area	No of Credit	Out of
1	Sustainable Site (SS)	4	14
2	Water Efficiency (WE)	2	5
3	Energy and Atmosphere (EA)	10	17
4	Materials and Resources (MR)	0	13
5	Indoor Environment Quality(IEQ)	6	15
6	Innovation and Design Process (ID)	1	5
		Total =**23**	**69**

To get a LEED Certification, 26 points should be earned, and all prerequisites should be achieved. In the local case study (Kurdish Textile Museum), the building gained lower than the requirement, got 23, and did not achieve all the prerequisite (obligatory) items. The reason is that for building occupants is not easy to reduce the waste materials and resources, despite collecting 10 points in this area, but it was not considered because it did not achieve this obligatory or prerequisite item. Despite the low result obtained according to the LEED rating system, the building demonstrates very significant participation in enhancing building sustainability and that is clear through the achievement of several points reaching 34 points out of 69. However low awareness about the LEED certificate requirement reduced the rating to only 23 over 69.

5. Conclusion

As a reaction front of increasing the need for adaptive reuse of historic buildings for a different function to save these buildings from dilapidating by upgrading their overall performances, on one side. And the serious effect of building construction and maintenance on global energy consumption, and resource depletion, in addition to their responsibility for the great part of emission (GHG), to the atmosphere, on another side. The transparent process of the LEED rating system could represent a significant way for orienting the building sector towards sustainable ways and reducing the problems in the environment. Therefore, two adaptive reuse historical buildings have been selected as case studies to demonstrate their sustainable advantages based on the LEED rating system. One of them is an international case study from Denver in the United States, '4240' Architecture, Inc. Studio, and another is local in Erbil city, Kurdish Textile Museum, built, inside the Citadel historical area. The results demonstrated that adaptive reuse is a very effective way to enhance sustainability in the building sector, and it is an effective way to save architectural identity. The LEED rating system for the international case study which was a warehouse built in 1903 and changed in the use to be Architectural Design Company, demonstrated that it gained (a silver rating). The most effective factors that affect the rating system in LEED are the awareness of certificate prerequisites and the application of renewable technologies and materials during the construction or maintenance processes. Therefore, the local case study in Erbil, which was a historical house, and changed its function to be a Textile Museum in 2004, was affected by the previously mentioned factors. The building demonstrated very important sharing of sustainable factors, but because it has not implemented some of the prerequisites.

The building did not employ renewable technology or strategies, and materials led to a loss of a lot of points and were under the requirement of the LEED rating system by only 2 points.
LEED rating system is shown to be a very effective tool for evaluating the sustainability of buildings, Therefore, the research recommends applying the LEED rating system in the Kurdistan of Iraq, but with modifications to be suitable for this region, because the requirements are not always adaptable to each place in the world.

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Conflicts of interest
The Authors declare that there is no conflict of interest.

Data availability statement
The original contributions presented in the study are included in the article/supplementary material; further inquiries can be directed to the corresponding authors/s.

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APPENDIX A

LEED PROJECT CHECKLIST

This appendix shows the LEED rating system's five environmental impact areas plus the sixth one which is Innovation & Design Process, with their checklist and credit.

Project Checklist

Sustainable Sites

14 Possible Points

Y			Prereq 1	**Erosion & Sedimentation Control**	Required
Y	?	N	Credit 1	**Site Selection**	1
Y	?	N	Credit 2	**Urban Redevelopment**	1
Y	?	N	Credit 3	**Brownfield Redevelopment**	1
Y	?	N	Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
Y	?	N	Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
Y	?	N	Credit 4.3	**Alternative Transportation**, Alternative Fuel Vehicles	1
Y	?	N	Credit 4.4	**Alternative Transportation**, Parking Capacity	1
Y	?	N	Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1
Y	?	N	Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1
Y	?	N	Credit 6.1	**Stormwater Management**, Rate and Quantity	1
Y	?	N	Credit 6.2	**Stormwater Management**, Treatment	1
Y	?	N	Credit 7.1	**Heat Island Effect**, Non-Roof	1
Y	?	N	Credit 7.2	**Heat Island Effect**, Roof	1
Y	?	N	Credit 8	**Light Pollution Reduction**	1

Water Efficiency

5 Possible Points

Y	?	N	Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
Y	?	N	Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
Y	?	N	Credit 2	**Innovative Wastewater Technologies**	1
Y	?	N	Credit 3.1	**Water Use Reduction**, 20% Reduction	1
Y	?	N	Credit 3.2	**Water Use Reduction**, 30% Reduction	1

Energy & Atmosphere

17 Possible Points

Y	Prereq 1	**Fundamental Building Systems Commissioning**	Required
Y	Prereq 2	**Minimum Energy Performance**	Required
Y	Prereq 3	**CFC Reduction in HVAC&R Equipment**	Required
Y ? N	Credit 1	**Optimize Energy Performance**	1–10
Y ? N	Credit 2.1	**Renewable Energy**, 5%	1
Y ? N	Credit 2.2	**Renewable Energy**, 10%	1
Y ? N	Credit 2.3	**Renewable Energy**, 20%	1
Y ? N	Credit 3	**Additional Commissioning**	1
Y ? N	Credit 4	**Ozone Depletion**	1
Y ? N	Credit 5	**Measurement & Verification**	1
Y ? N	Credit 6	**Green Power**	1

LEED

Materials & Resources

13 Possible Points

Y	Prereq 1	**Storage & Collection of Recyclables**	Required
Y ? N	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Shell	1
Y ? N	Credit 1.2	**Building Reuse**, Maintain 100% of Shell	1
Y ? N	Credit 1.3	**Building Reuse**, Maintain 100% Shell & 50% Non-Shell	1
Y ? N	Credit 2.1	**Construction Waste Management**, Divert 50%	1
Y ? N	Credit 2.2	**Construction Waste Management**, Divert 75%	1
Y ? N	Credit 3.1	**Resource Reuse**, Specify 5%	1
Y ? N	Credit 3.2	**Resource Reuse**, Specify 10%	1
Y ? N	Credit 4.1	**Recycled Content**, Specify 5% (p.c. + $^1/_2$ p.i.)	1
Y ? N	Credit 4.2	**Recycled Content**, Specify 10% (p.c. + $^1/_2$ p.i.)	1
Y ? N	Credit 5.1	**Local/Regional Materials**, 20% Manufactured Locally	1
Y ? N	Credit 5.2	**Local/Regional Materials**, of 20% in MRc5.1, 50% Harvested Locally	1
Y ? N	Credit 6	**Rapidly Renewable Materials**	1
Y ? N	Credit 7	**Certified Wood**	1

Indoor Environmental Quality — 15 Possible Points

Y	Prereq 1	**Minimum IAQ Performance**	Required
Y	Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
Y ? N	Credit 1	**Carbon Dioxide** (CO_2) **Monitoring**	1
Y ? N	Credit 2	**Ventilation Effectiveness**	1
Y ? N	Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
Y ? N	Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
Y ? N	Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
Y ? N	Credit 4.2	**Low-Emitting Materials**, Paints	1
Y ? N	Credit 4.3	**Low-Emitting Materials**, Carpet	1
Y ? N	Credit 4.4	**Low-Emitting Materials**, Composite Wood	1
Y ? N	Credit 5	**Indoor Chemical & Pollutant Source Control**	1
Y ? N	Credit 6.1	**Controllability of Systems**, Perimeter	1
Y ? N	Credit 6.2	**Controllability of Systems**, Non-Perimeter	1
Y ? N	Credit 7.1	**Thermal Comfort**, Comply with ASHRAE 55-1992	1
Y ? N	Credit 7.2	**Thermal Comfort**, Permanent Monitoring System	1
Y ? N	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
Y ? N	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

Innovation & Design Process — 5 Possible Points

Y ? N	Credit 1.1	**Innovation in Design**	1
Y ? N	Credit 1.2	**Innovation in Design**	1
Y ? N	Credit 1.3	**Innovation in Design**	1
Y ? N	Credit 1.4	**Innovation in Design**	1
Y ? N	Credit 2	**LEED™ Accredited Professional**	1

Project Totals — 69 Possible Points

Certified 26-32 points **Silver** 33-38 points **Gold** 39-51 points **Platinum** 52-69 points