

A Framework for Developing Sustainable Practices in Historical Buildings

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Abstract There is an international interest in utilizing sustainability principles and practices in the adaptive reuse of historical buildings. Egypt is one of the countries with a large number of historically significant buildings. Many historical houses and palaces have been reused due to the availability of a large number of them as well as their unique historical and architectural values. However, adaptive reuse processes face numerous challenges due to a lack of innovative methodologies for utilizing sustainability principles and practices. The research problem discussed in this article is that historical houses and palaces in Egypt lack innovative methods that contribute to employing sustainability principles and improving sustainability practices through adaptive reuse. This study aims to create a framework that helps to utilize sustainability principles in reusing historical buildings in Egypt. Qualitative methods were used to collect data through the study of literature, data analysis using the descriptive analysis method, field surveys, observation, and interviews with specialists. The results revealed the problems that prevent the effective use of sustainability principles in the local case studies and the methodologies used in the international case studies for utilizing sustainability principles in historical buildings. Based on the results, we reached some conclusions and proposed some recommendations. A framework has been created to provide an innovative methodology to utilize sustainability principles in reusing historical buildings in Egypt.

Keywords Historical Buildings, Buildings of Value, Reuse of Historical Buildings, Adaptive Reuse,

Sustainability, Sustainability Indicators, Creative Thinking

1. Introduction

Many countries worldwide have a rich architectural heritage, which is an essential resource for sustainable development because it can achieve social welfare and economic development while protecting the environment and resources. However, several problems are difficult to solve by traditional methods, such as the lack of modern technologies and sustainable practices, affecting the architectural heritage in Egypt. Consequently, the adaptive reuse of historical buildings in Egypt requires an innovative approach to utilize sustainability principles in historical buildings. Many historical buildings have been reused, such as Beit Al-Kardelia and Baron Palace, but many problems negatively impact reusing these buildings [1].

1.1. The Historical Buildings Definition

Historical buildings have been defined as buildings of crucial historical value through their architectural and aesthetic distinction, their long life, or significant events that occurred in the region [2]. There is a strong complementary relationship between the process of reuse and sustainability, as the process of reusing the historical building depends on the possible optimal use of its

resources; thus, supporting the requirements of a new use that provides the needs of the community while respecting the historical value of the building.

1.2. Definition of the Reuse of Historical Buildings

It is the process of finding a new use for a building. It is often described as a process by which old buildings are developed for new uses that have economic benefits [3].

1.3. Definition of Adaptive Reuse

Adaptive reuse is the process of changing the function of a building without affecting its historical and cultural values. Some modifications can sustainably be applied to the building spaces to preserve the building and achieve many benefits [4].

1.4. Sustainability Definition

Sustainability is defined in the report published in 1999 by the United Nations, which states: "Sustainability is meeting the needs of the present without compromising the ability of future generations to meet their own needs"[5]. In other words, sustainability aims to achieve the following objectives: the continuous life cycle of the building, reducing environmental load through adaptive reuse for historical buildings, reduced carbon, and pollution emissions compared to new construction, reduced demolition waste, and energy reuse [6].

1.5. Sustainability Indicators in Historical Buildings

Several sustainable practices have been achieved in historical buildings, and many tools have been used to measure the performance of sustainability dimensions [7].

1.6. Creative Thinking

Creative thinking is the mental process of creating new ideas based on perception, knowledge, and innovation [8].

2. Research Problem

The research problem is the lack of optimal sustainability principles in reusing historical houses and palaces in Egypt. In addition, there is no innovative approach to sustainable practices. Many of Egypt's historical houses and palaces have been reused to preserve them from deterioration and achieve social and economic benefits. However, the reuse processes lacked innovative methodologies; traditional methods and ideas were used. Moreover, the lack of creativity negatively affected the

historical and architectural elements of the buildings and achieved poor benefits.

3. Research Aim

- The research aims to create a framework that presents an innovative methodology for utilizing sustainability principles and practices in historical houses and palaces in Egypt. This framework depends on the creative thinking concept that helps solve the problems of practicing sustainability in historical buildings and the optimal use of available sustainable resources.
- Establishing a proposal for many sustainable practices that can be applied to historical buildings in Egypt. These practices will contribute to preserving historical buildings and achieving sustainable development goals.

4. Literature Review

The study's theoretical part focused on different methods of incorporating sustainability principles into reusing historical buildings. The descriptive analysis approach was used to study and analyze scientific literature that discussed sustainability and adaptive reuse in historical buildings. Many studies have identified the relationship between adaptive reuse and sustainability, which depends on the characteristics of the historical building and sustainable properties such as the age of the building, historical values, materials, resources, and architectural design [9]. Some studies discussed sustainability indicators and methods for achieving them to develop sustainable practices in historical buildings.

4.1. The European Union's Approach to Sustainable Heritage

Some research papers included a summary of the European Union's approach to cultural heritage, which discussed the impact of cultural heritage on the four domains of sustainability: social, economic, environmental, and cultural. Some results of these studies are summarized in Figure 1. The results in Figure 1 revealed that cultural heritage affects one or more domains of sustainability and that each domain affects the other domains [10].

The European Union's approach to cultural heritage discusses the sustainable resources and unique values in historical buildings that help achieve sustainable development goals. It depends on creative thinking and innovation to interact with historical buildings.

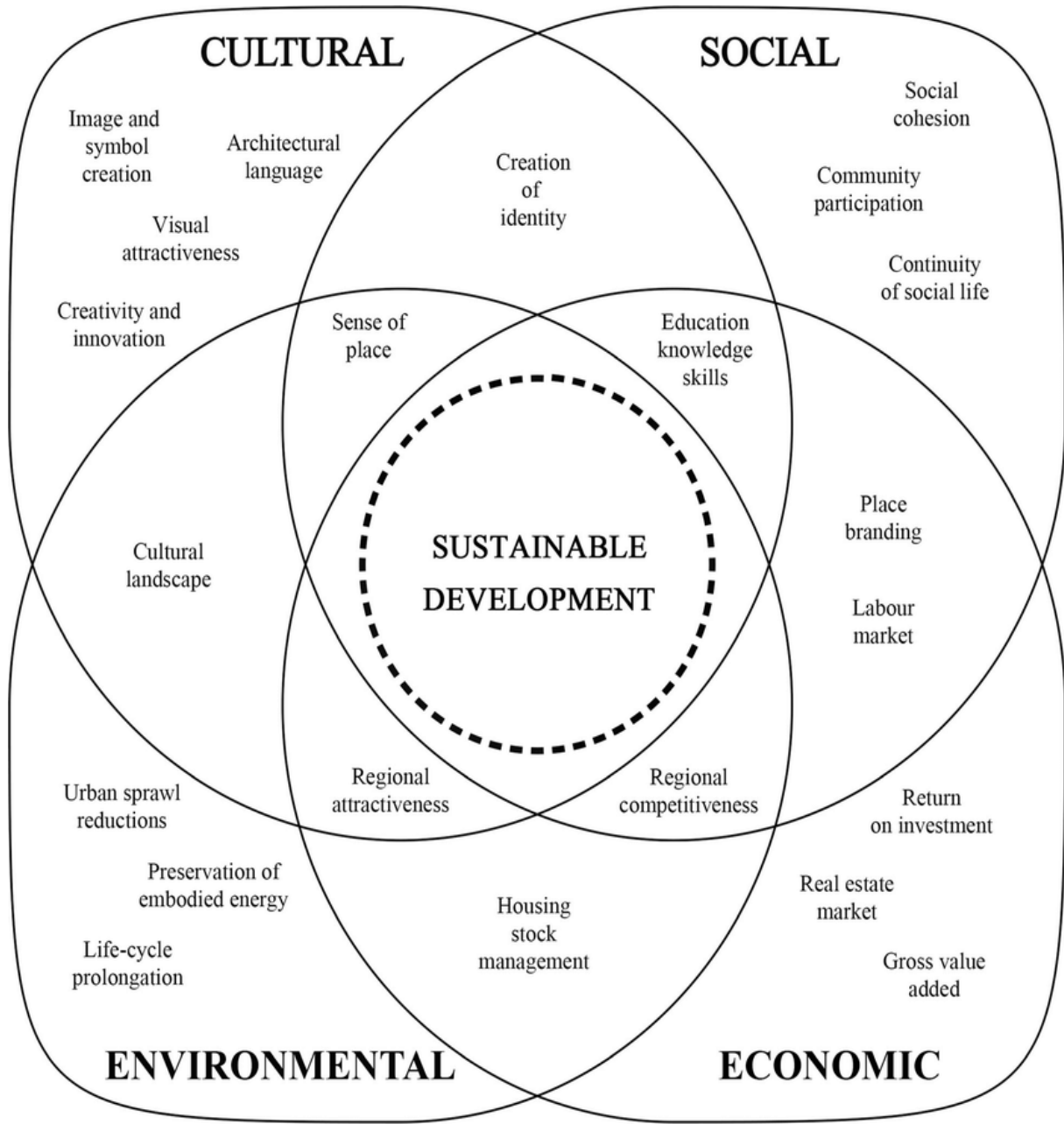


Figure 1. The four dimensions of the European Union's approach to sustainable heritage (source: Europa Nostra, 2015).

4.2. The United Nations Commission on Sustainable Development (UNCSD)

The United Nations general assembly established the United Nations commission on sustainable development (CSD) in December 1992 as a follow-up to the United

Nations conference on environment and development (UNCED), also known as the Earth Summit [9]. The UNCED discussed sustainability indicators as a tool to measure the performance of sustainability dimensions, as shown in Figure 2 [11].

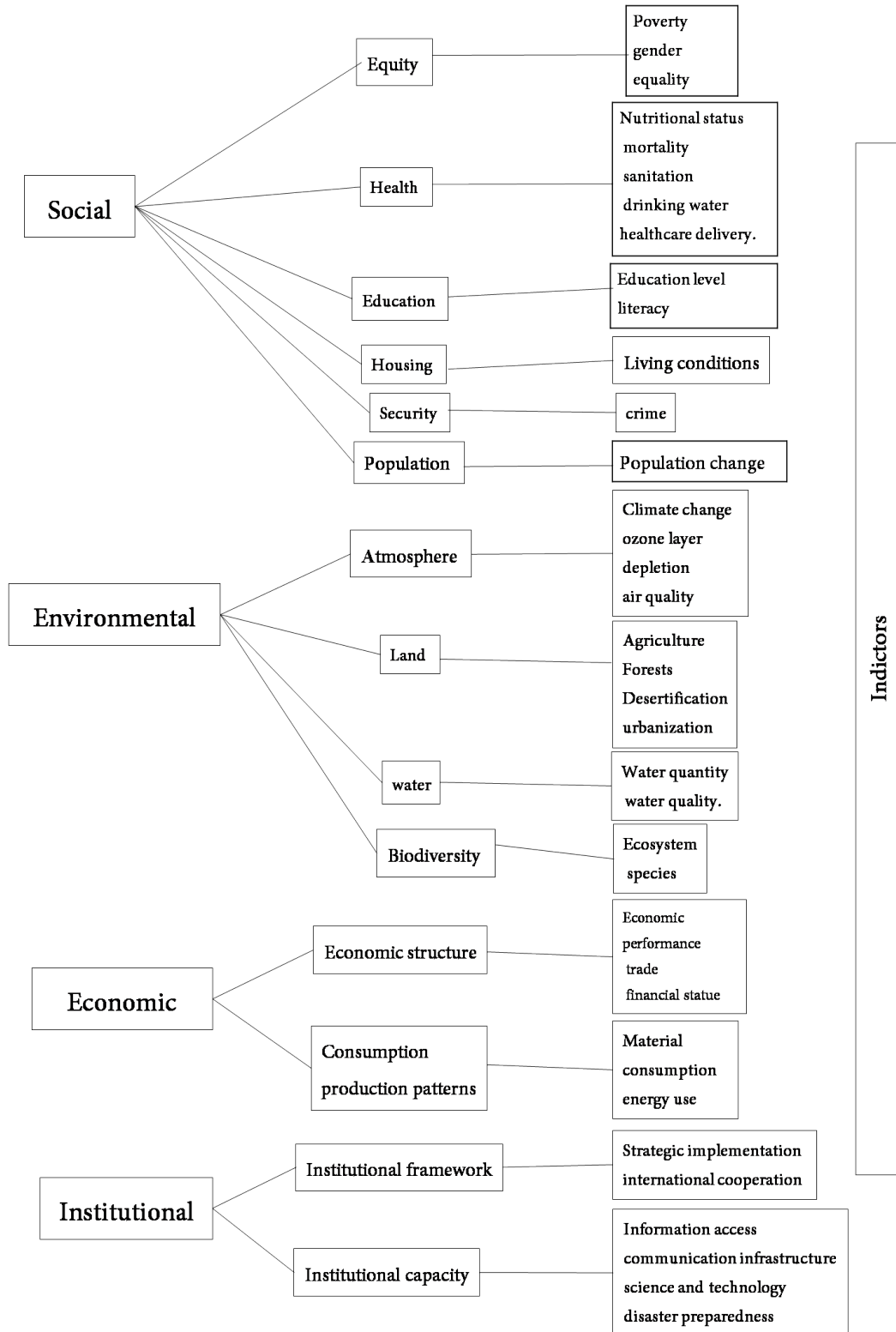


Figure 2. Illustration of the theme-based indicator framework adopted from UNCSD in 2001 [11]

4.3. A Framework for Developing Indicators of Historic Sustainability by Michael Stubbs

In 2004, Michael Stubbs discussed the environmental, economic, social, and cultural dimensions of sustainability and ways to develop indicators to measure the performance of sustainability criteria in historical buildings, as shown in Table 1 [12, 13].

4.4. Unique Values of Historical Buildings

Building values can be historical, cultural, architectural, or aesthetic values representing meanings and symbols that express human experiences in the past. Some buildings express an essential historical era or an architectural style from ancient times [1, 9].

4.4.1. Valued buildings

Buildings with an architectural value tell the history of cities by being linked to events, people, or activities from a specific historical era [14].

4.4.2. The fundamental values that characterize historical buildings according to guide line No. 1

Following Law No.119 of 2008in Egypt, the Supreme

Council for Planning and Urban Development approved the basis and criteria for urban coordination for historical buildings and areas of outstanding value in 2010.

- Historical value of a building: A building with historical value is linked to national historical aspects and is built by a significant local or international person with a passion for important national events. It has a long life and historical symbolism.
- Artistic architectural value: A building with artistic architectural value has a unique architectural style, distinguished architectural design, and unique artistic creativity that represents a significant era in the history of art and architecture.
- Urban value: In this case, the building is part of an integrated urban heritage group in terms of shape and construction style, characterized by unique urban planning.
- Social and moral value: The building is associated with critical social functions and reflects a belief, thought, or social tradition.
- Local traditional value: The building is a part of urban, rural, or desert architecture with an integrated architectural nature. It is designed to suit specific climatic requirements and expresses traditional ideas, crafts, and ancient experiences [15].

Table 1. A framework for developing indicators of historic sustainability [13]

Dimensions	Criteria and indicators	
Environmental	Building construction/ Energy efficiency	<ul style="list-style-type: none"> • Measurement of carbon emissions and energy efficiency. • Compliance with building methods/ techniques. • Ability to harvest environmentally benign energy.
	Visitor mode of travel	<ul style="list-style-type: none"> • Split between car/non-car-based modes. • Policies/ aspirations to create a modal shift in favor of public transport.
	Climate change	<ul style="list-style-type: none"> • Appraisal of physical change.
Social& cultural	Civic pride and sense of place	<ul style="list-style-type: none"> • Association with a place or artifact.
	Social inclusion and community	<ul style="list-style-type: none"> • Ability to engender skills. • Links to education and learning in the community.
	Virtual heritage	<ul style="list-style-type: none"> • Visits to heritage websites and appraisal of the relevance of such sites.
	Culture and arts	<ul style="list-style-type: none"> • Promotion of leisure and arts-based programs.
Economic	Financial resources and employment	<ul style="list-style-type: none"> • Resources available to heritage projects. • Employment created by the heritage sector. • Wider benefits of visitors to the local economy.
Generic	Perception/ evaluation	<ul style="list-style-type: none"> • Public/visitor understanding and awareness of the heritage sector and links to sustainability. • Appraisal of the relevance of the heritage sector to everyday lives.

4.5. Historical Buildings and Sustainability

Historical buildings have traditional sustainability principles. They used architectural solutions to keep the interior environment cool in summer and warm in winter. Since these buildings do not depend on modern mechanical systems, they are given higher efficiency and lower energy consumption by using natural light sources, ventilation, thick walls, large windows, high ceilings, courtyards, and paying attention to gardens and site elements [8]. Hence, it can be concluded that historical buildings have sustainable elements. These elements include large windows, double-height ceilings, courtyards, a good location, the availability of wells, building spaces, the properties of building materials, and the availability of renewable resources and sources for energy generation. The elements mentioned above can be used effectively through an innovative approach to utilize the principles and modern sustainability techniques without affecting the building's historical value. This process aims to achieve sustainable development goals, considering that historical buildings are a critical resource for sustainable development. These goals include the dimensions of social, environmental, economic, and cultural sustainability [9,11].

4.6. Adaptive Reuse, Sustainability, and Creativity

There is an integrative relationship between the adaptive reuse process and sustainability principles, as each aims to achieve social, economic, and cultural benefits while preserving the environment and resources [7]. Many studies and modern approaches have tended to confirm the importance of cultural heritage as a resource for sustainable development, which aims to achieve social benefits and economic development while preserving the environment and supporting the cultural dimension [16]. Creative thinking can be used as an innovative method to utilize sustainability principles and practices in historical buildings because these buildings have special requirements, unique values, and complex problems that need innovative solutions from outside [17].

4.6.1. Criteria for adaptive reuse in historical buildings

- The new use should be appropriate to the values and architectural design of the building.

- The new use must achieve social, economic, and cultural benefits and support the maintenance and preservation of the building.
- Adaptive reuse processes should not require significant building modifications or high costs.
- Adaptive reuse methodologies should include innovative methods to utilize sustainability principles and creative ideas [17, 18].

4.6.2. Criteria for sustainability in historical buildings

- Achieving societal well-being by supporting positive interactions between the community and the building. The building contributes to community awareness of the importance of historical values and training in sustainable practices [1].
- Achieving economic development by generating revenues from the reuse of the building, providing job opportunities, and supporting the local economy.
- Preserving the environment and resources through optimal use of sustainable capabilities and innovative sustainable practices.
- Promoting local culture and preserving the values of the building [7].

4.7. Summary of the Literature Review

- Adaptive reuse is a form of sustainable development that aims to achieve social, economic, environmental, and cultural benefits.
- Most of the studied historical buildings have unique values and traditional sustainable potentials, and many problems need innovative solutions.
- In historical buildings, sustainability inputs include the social, economic, environmental, and cultural dimensions. These dimensions have several criteria. The achievement of sustainability criteria can be measured through sustainability indicators, as shown in Figure 3; this is the first step in creating the proposed framework.
- Utilizing sustainability principles and practices in the adaptive reuse of historical buildings requires an innovative methodology that relies on creative thinking.

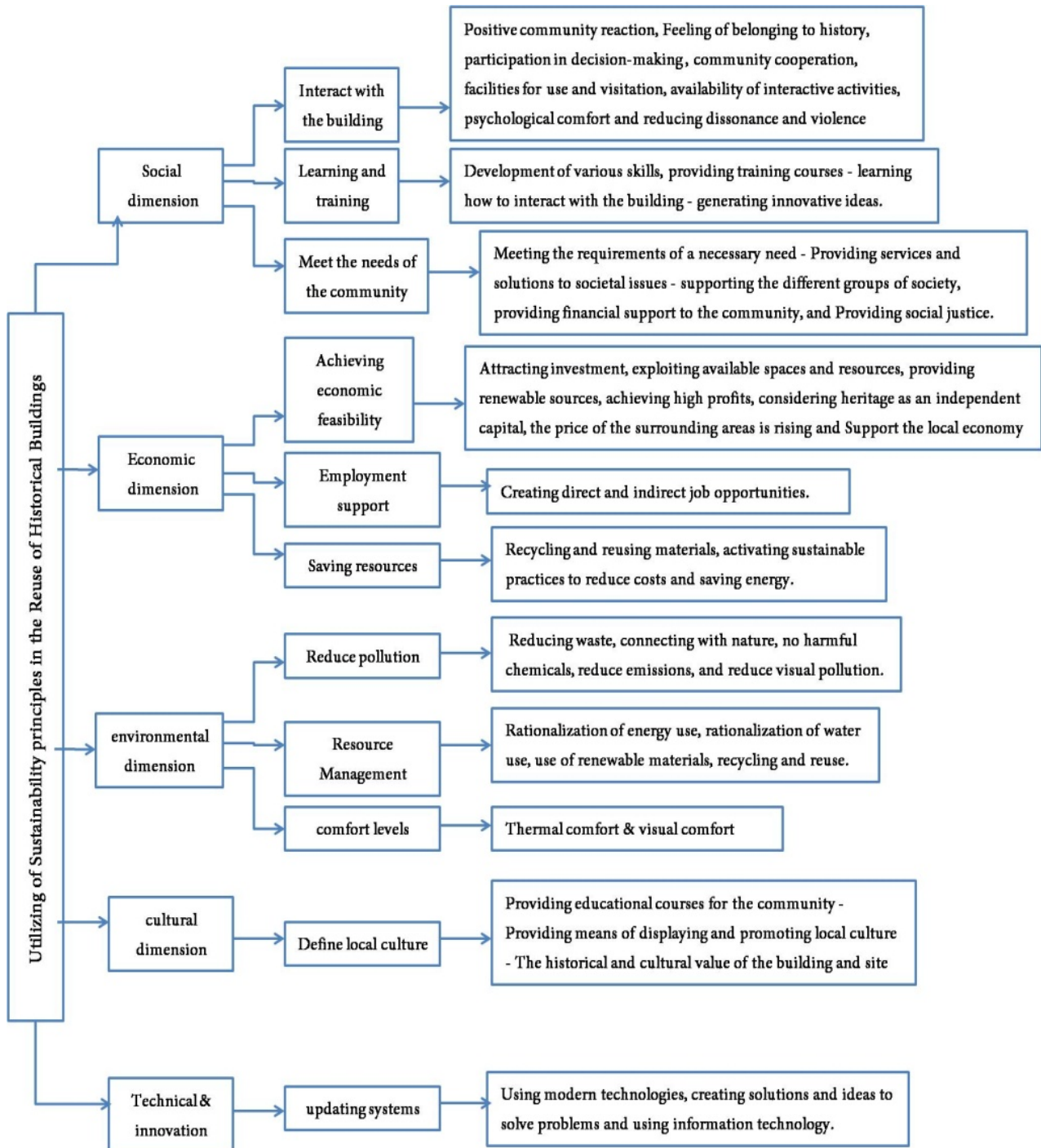


Figure 3. The sustainability inputs in historical buildings

5. Materials and Methods

Data were collected by searching the literature for all related studies. Next, the international case studies were analyzed by the descriptive analysis method. Then, the data for the local case studies were gathered through field surveys, observations, interviews with specialists, and observations of building users. Finally, the data were analyzed to discover problems in the local case studies, and a framework was created for solving these problems. The

data collection methodology relied on the following steps:

- Analyzing and comparing international and local case studies.
- Concluding the inputs and outputs of sustainability from the literature review.
- Analysis of case studies.
- Comparing international and local case studies.
- Summarizing sustainable practices and techniques for their application in case studies.
- Creating the proposed framework.

6. Case Studies

Historical houses and palaces were selected as case studies. These buildings have unique historical and architectural values, sustainable potentials such as architectural solutions, sustainable materials, and sustainable resources, and are located in a significant historical location. International case studies were selected that are similar to local case studies in having unique values, designs, and architectural solutions with the same challenges. A summary of the analysis of sustainable practices for international case studies showing innovative methodologies used in historical buildings is shown in Table 3. As shown in Table 4, local case studies are analyzed and compared with international case studies to discover problems and solutions.

6.1. Criteria for Selecting Case Studies

6.1.1. Criteria for selecting international case studies

The selected buildings from international case studies must:

- Following the principles and practices of sustainability that can be applied in Egyptian case studies to improve the efficiency and sustainability of historical buildings in Egypt.
- Achieving the goals of sustainable development with high rates of sustainability assessment.
- Having unique historical and architectural values.
- Implementing creative thinking and innovative solutions to meet the challenges of practicing sustainability, contributing to the success of sustainable adaptive reuse.

6.1.2. Criteria for selecting local case studies

Reused historical buildings with unique values have been selected, where some sustainability practices have recently been applied. They are considered the best locally in terms of employing and practicing sustainability. However, there are many problems and challenges due to following traditional approaches and solutions and the lack of innovation and creativity in implementing sustainable solutions.

6.2. Criteria for Analyzing Case Studies

The analysis criteria were determined according to the following:

- The unique values and sustainable potentials of the historical building.
- Challenges and solutions.
- Sustainable practices to achieve criteria for sustainability in social, economic, environmental, and cultural dimensions.
- Creative ideas and innovative methodologies used in sustainable practices

6.3. Comparison of Local and International Case Studies

- The comparison was performed using the principles and inputs of sustainability summarized from the literature review, as shown in Figure 3. It consists of social, economic, environmental, and cultural sustainability dimensions; these dimensions include some criteria. Achieving these criteria can be studied by identifying the achieved sustainability indicators, as shown in Table 5.
- As shown in Tables 6 and 7, the comparison seeks to identify sustainability challenges in local case studies to identify partially achieved and not achieved sustainability indicators.
- This study adopted the qualitative measurement method by setting a set of values for each indicator, where the indicator's complete verification is symbolized by a number (1), (0.5) if the indicator was partially achieved or achieved with problems, and (0) if the indicator is not achieved, as shown in Table 2.

Table 2. The symbols of sustainability indicators in the proposed model

Sustainability Indicators (Elements of Assessment)	Symbol
Indicators were achieved entirely	1
Indicators were achieved with problems or partially achieved	0.5
Indicators were not achieved	0

Table 3. Analysis of international case studies




The building's name	<p>Sede Centrala Ca Foscari, Italia.</p>  <p>Sede Centrala Ca Foscari palace, source: (https://commons.wikimedia.org/wiki/File:Palazzo_Foscari_lato_Canal_Grande.jpg).</p>	<p>Chettinadu Mansion, India.</p>  <p>Chettinadu Mansion Palace, source: (https://yummraj.com/chidamabara-vilas-kadiapatti-chettinad-village-area-tamil-nadu).</p>	<p>Fay House, United States.</p>  <p>Fay House, source: (http://www.gwalighting.com/fay-house-historic.html).</p>
Location	It is located on a UNESCO World Heritage Site opposite the Grand Canal in Venice, Italy.	The building is located in Chettinadu, India, and has unique historical and architectural values.	It is located on Garden Street in Cambridge, Massachusetts, in the United States.
Old and new use	The building had been built in 1453 as a palace. It was used as an educational building of Ca' Foscari University in 1935 [19]	The building was built in 1906 as a palace. It was used as a tourist hotel in 2011 [21].	It was built in 1807 as a house. It was reused as an educational building for Harvard University [23].

Table 3 Continued

Available advantages, challenges of utilizing sustainability, and solutions used	Unique values	The building has significant historical and aesthetic values and unique architectural design and features. It is in a unique historical location and overlooks a wonderful landscape with a large lake in front of it.	The building is related to critical historical stories and eras and has an architectural vocabulary representing unique and rare values.	The building has historical and cultural values as it was part of a historical era and witnessed critical historical events. Many important politicians lived in this building.	
	Sustainable potential	<p>Architectural Design</p> <ul style="list-style-type: none"> The building consists of 4 floors. It was built of stones, wood, and plaster. It has architectural design solutions such as large windows, double-height ceilings, a patio, and sun orientation that help use ventilation and natural light. It has unique architectural elements. It is designed in the Gothic style, which helps attract the community and increase their interaction inside the building while providing psychological comfort. It has wide spaces that help with diverse uses and activities. <p>Materials and resources</p> <ul style="list-style-type: none"> The building has sustainable materials, such as wood and stones. <p>Building site</p> <ul style="list-style-type: none"> The site has significant historical value and has sustainable materials. It is located near public facilities and services and is easily accessible. There is landscaping, a lake, and renewable sources of energy generation like geothermal. 	<p>Architectural Design</p> <ul style="list-style-type: none"> The building consists of two floors. It has a large central courtyard and a smaller secondary one. It has vast spaces and double-height ceilings. There are large windows, which provide natural lighting and ventilation. It has rare aesthetic and architectural elements that attract the community and tourists. <p>Materials and resources</p> <ul style="list-style-type: none"> The building was built from sustainable materials such as local bricks, stucco, and wood. Granite, marble, terracotta tiles, and Belgian glass were also used. There is a water well inside the building. <p>Building site</p> <ul style="list-style-type: none"> The building is in a unique historical location, and the site has landscaping and sustainable materials used to restore historical buildings. It is located near public facilities and services and is easily accessible. 	<p>Architectural Design</p> <ul style="list-style-type: none"> The building consists of two floors. The building has many large spaces and architectural design solutions that help use ventilation and natural light. <p>Materials and resources</p> <ul style="list-style-type: none"> The building has sustainable materials, such as wood and stones. <p>Building site</p> <ul style="list-style-type: none"> It is located near public facilities and services and is easily accessible. There are green areas surrounding the building and renewable sources of energy generation at the building site. It has wide spaces that diversity of uses and activities. 	
	Challenges	<ul style="list-style-type: none"> Preservation laws imposed by UNESCO prohibit additions or modifications to the building. Lack of community awareness of the importance of building and sustainable practices. The limited flexibility of the building. High costs are required for adaptive reuse processes that use sustainability. The difficulty of integrating modern sustainability technologies with the historical building. 			
	Solutions	<ul style="list-style-type: none"> Using innovative ideas to add some modifications without affecting the different values of the building. Establishing training and education centers for the community inside and outside the building, training them on sustainability practices, and showing them the history of the building and its cultural impact through time. The application of sustainable practices such as recycling, resource, and waste management contributed to reducing costs. 			

Table 3 Continued

Sustainability indicators and practices	Social dimension	<ul style="list-style-type: none"> Supporting different groups in society. Providing psychological comfort to users. Providing financial support for building workers and their families and providing them with transportation. Educating the community on how to interact with the historical building. Providing sustainable practices training courses. Supporting social interaction [19]. 	<ul style="list-style-type: none"> Supporting a sense of pride and belonging to history. Community participation in decision-making and reuse processes. Providing tools and programs to teach sustainable practices to students. Providing psychological comfort to users. 	<ul style="list-style-type: none"> The new use of the building provides a necessary societal need. Creating interactive spaces. Improving comfort and efficiency through building systems. Providing spaces for student and staff interaction in the building. Providing psychological comfort to users. Making tools and programs available to teach sustainable practices [23].
	Economic dimension	<ul style="list-style-type: none"> Achieving financial profits. Providing employment. Saving energy and resources. Providing waste management and recycling program. Supporting the local economy. Use eco-friendly cleaning products. 	<ul style="list-style-type: none"> Achieving financial profits. Providing direct and indirect job opportunities. Saving energy and resources. Providing waste management and recycling program. Contributing to the local economy [21]. 	<ul style="list-style-type: none"> Achieving financial profits. Providing direct and indirect job opportunities. Saving energy and resources. Providing waste management and recycling program. Supporting the local economy.
	Environmental dimension	<ul style="list-style-type: none"> Generating energy from a renewable source, utilizing passive systems. Treating grey water and rainwater that is stored and reused, using plumbing fixtures to rationalize water flow. Using a heating and cooling system consisting of pipes dug outside the building and passed inside the building in hidden areas with vertical air columns through which hot and cold-water pipes pass. Following a program to recycle materials and waste, using recycled materials in the restoration and reuse operations, and using local, sustainable materials [20]. 	<ul style="list-style-type: none"> Using natural lighting. Natural ventilation through windows and patios and the appropriate building orientation. Generating energy from a renewable source. Grey water treatment and rainwater storage and reuse in toilets and plant irrigation. Using a waste management and recycling program. Using sustainable materials and matching the original materials of the building. Using recycled materials. Sustainable practices to conserve energy and resources. 	<ul style="list-style-type: none"> Generating energy from a renewable source. Using energy-saving and sensor systems, which help reduce the intensity of lighting energy. Using natural ventilation and lighting and providing the required thermal comfort and indoor air quality. Using low-flow sanitary installations Treating grey water. Using sustainable and recycled materials. Using a waste management and recycling program [24].
	Cultural dimension	<ul style="list-style-type: none"> The building has a significant historical value. The building supports the cultural dimension by facilitating visits to the building. Using methods to support culture and history. 	<ul style="list-style-type: none"> The building has a significant historical value. The building supports the cultural dimension by facilitating visits to the building. Employing techniques to support culture and history [22]. 	<ul style="list-style-type: none"> The building is part of the region's culture and supports the cultural dimension by providing a large library, training rooms, and laboratories inside the building.

Table 3 Continued

<p>Sustainability indicators and practices</p>	<p>Techniques, tools, and creative thinking</p>	<ul style="list-style-type: none"> • Using modern technologies in the building, such as sensors, energy-saving lighting units, and data display units. • Using grey water treatment techniques [19]. • Using an underground heating and cooling unit. • Using innovative solutions to hide the electrical supply and cooling pipes. • Using paper recycling techniques [20]. • Communicating with nature by planting trees and plants. • Establishing units to teach sustainable practices and paper recycling and allocating spaces for drawing, sculpting, and writing activities. • Designing a commercial brand for the building and versatility of secondary uses. 	<ul style="list-style-type: none"> • Using innovative methodologies to create sustainable materials, the same as the original building materials. • Using grey water treatment techniques. • Using information technology. • Communicating with nature by planting trees and plants with medicinal benefits. • Establishing a unit to manage sustainable practices and train users. • Establishing a center for managing materials and passive systems in the building. • Providing entertainment services and interactive social activities. • Designing a commercial brand for the building and versatility of secondary uses. • A theater to represent historical stories[22]. 	<ul style="list-style-type: none"> • Using modern technologies in the building, such as ECM sensors, energy-saving lighting units, and data show. • Using gray water treatment techniques. • Using innovative solutions to overcome challenges. • Using information technology. • Using solar panels and installing them on umbrellas in the building's garden. • Establishing a unit to manage sustainable practices and train users. • Providing training courses for the psychological rehabilitation of users and training them on how to interact with people and the building.
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Table 4. Analysis of local case studies




The building's name	<p>Baron palace, Heliopolis</p>  <p>Baron palace.</p>	<p>Beit Al-Karidleya</p>  <p>Gayer Anderson Museum</p>	<p>Beit Al- Senary, Sayeda Zainab</p>  <p>Beit Al- Senary.</p>
Location	Heliopolis, Cairo.	Ahmed Ibn Tulun Square, Sayeda Zeinab, Cairo.	The Nasiriyah district of Sayeda Zeinab, Cairo.
Old and new use	The building was built in 1907 as a palace. It was reused as a museum in 2020 [25].	The building merges two buildings and connects them through a corridor. The first building was built in 1540, and the second was built in 1631 and used as houses. The building was reused as a museum in 1935 [26].	It was built in 1794 as a house. It was reused in 2012 as a scientific and cultural center belonging to the Alexandria Library.

Table 4 Continued

Available advantages, challenges of utilizing sustainability, and solutions used	Unique values	The building has a unique architectural value. Edward Empan, a Belgian engineer, was the building's original owner. Alexandre Marcel designed the building in the Hindu style and has many Indian decorations and statues.	It is one of the most significant historical houses in Egypt. Moreover, it is one of the unique Islamic monuments that belong to Mamluk and Ottoman history.	It has a significant historical value. It was designed in the Islamic style [27]. The building had critical historical events at the end of the Ottoman era and the advent of the French campaign in Egypt.
	Sustainable potential	<p>Architectural design</p> The building consists of two floors, a basement, and a roof. It has a tower with a height of four floors.	<p>Architectural design</p> <ul style="list-style-type: none"> The building consists of two merged houses connected by a corridor. It has four floors in each building and a large number of rooms. It expresses the style of old Islamic houses with sustainable architectural solutions such as high ceilings, large windows, and many spaces and courtyards. It has unique architectural elements that attract the community and tourists. 	<p>Architectural design</p> <ul style="list-style-type: none"> The building consists of 3 floors, has many halls and secondary rooms, and has a large courtyard. It expresses the style of old Islamic houses with sustainable architectural solutions such as high ceilings, large windows, and many spaces.
		<p>Materials and resources</p> The building is built using bricks and concrete and has some sustainable materials such as wood, marble, and granite.	<p>Materials and resources</p> <ul style="list-style-type: none"> The building has sustainable materials such as wood, stones, marble, and a water well. 	<p>Materials and resources</p> <ul style="list-style-type: none"> The building has sustainable materials, such as wood and stones.
		<p>Building site</p> <ul style="list-style-type: none"> The building site has significant historical value. It is located near public facilities, Cairo airport, and services and is easily accessible. It has a large garden that contains rare plants. It has sustainable resources and materials 	<p>Building site</p> <ul style="list-style-type: none"> The building is in a significant historical location, and many tourism and commercial activities are on site. It is located near public facilities, the Cairo airport, and other services and is easily accessible. It has a large garden. It has sustainable resources and materials. 	<p>Building site</p> <ul style="list-style-type: none"> The building site has significant historical value. It is located near public facilities and services and is easily accessible. It has sustainable resources and materials.
Challenges	<ul style="list-style-type: none"> Preservation laws prohibit additions or modifications to the building. Lack of community awareness of the importance of building and sustainable practices. The limited flexibility of the building. High costs are required for adaptive reuse processes that use sustainability. Lack of modern technologies for sustainability. The lack of innovative methodologies to utilize sustainability principles in historical buildings and the lack of creative specialists. The difficulty of integrating modern sustainability technologies with the historical building. 			
Solutions	Traditional approaches and methods are used to solve problems with limited use of modern technologies.			

Table 4 Continued

Sustainability Indicators and Practices	Social dimension	<ul style="list-style-type: none"> • Providing psychological comfort to users. • Support social interaction. • Creating interactive spaces. • Making it possible for visitors to visit the building. • Providing training courses for drawing and practicing other talents. 	<ul style="list-style-type: none"> • Supporting a sense of pride and belonging to history. • Providing psychological comfort to users. • Supporting social interaction. • Making it possible for visitors to visit the building. • Providing training courses for drawing and practicing other talents. 	<ul style="list-style-type: none"> • Supporting social interaction. • Allowing facilities to visit the building • Supporting a sense of pride and belonging to history.
	Economic dimension	<ul style="list-style-type: none"> • Achieving limited financial profits. • Providing direct and indirect jobs. • Supporting the local economy. 	<ul style="list-style-type: none"> • Achieving limited financial profits. • Providing direct and indirect jobs. • Supporting the local economy. 	<ul style="list-style-type: none"> • Achieving limited financial profits. • Providing direct and indirect jobs.
	Environmental dimension	<ul style="list-style-type: none"> • Utilizing passive systems. • Using sustainable materials. • Utilizing sustainable practices to conserve energy and resources. • Using low-emission materials. 	<ul style="list-style-type: none"> • Using natural lighting. • Using natural ventilation through windows and patios. • Using sustainable materials. • Utilizing sustainable practices to conserve energy and resources. 	<ul style="list-style-type: none"> • Using natural ventilation and lighting and providing the required thermal comfort and indoor air quality. • Using low-flow sanitary installations • Using sustainable and recycled materials.
	Cultural dimension	<ul style="list-style-type: none"> • The building has a unique architectural value. • Supporting and educating the community about the importance of history and heritage. 	<ul style="list-style-type: none"> • The building has a significant historical value. • The building supports the cultural dimension by facilitating the visit to the building. • Using methods to support culture and history, such as seminars and educational sessions for the community. 	<ul style="list-style-type: none"> • The building has a significant historical value. • Supporting and educating the community about the importance of history and heritage.
	Techniques, tools, and creative thinking	<ul style="list-style-type: none"> • Using some devices, such as heating and cooling devices, industrial lighting, and control devices. • Using information technology, such as BIM programs. • Making elements and furniture from sustainable materials and having the same historical style as the building, such as trash cans, benches, and umbrellas in the garden. 	<ul style="list-style-type: none"> • Using limited techniques, such as traditional lighting lamps and some air fans. 	

Table 5. Comparison of local and international case studies

	Dimensions	Criteria	Sustainability indicators (Elements of assessment)	International case studies			Local case studies		
				Sede Centrala Ca Foscar	Chettinadu Mansion	Fay House	Baron Palace	Beit Al- Karidleya	Beit Al- Senary
Utilizing of sustainability principles in the reuse of historical buildings	Social dimension	Interact with the building	Positive community reaction	1	0.5	0.5	1	1	0.5
			Feeling of belonging to history	1	0.5	1	1	1	1
			Community participation in decision making	0	0	1	0	0	0
			Community cooperation	0.5	0.5	0.5	0.5	0.5	0.5
			Facility to use and visit	1	1	1	1	1	1
			Availability of interactive activities	1	0.5	1	0.5	0.5	0.5
			Psychological comfort	1	1	1	1	0.5	0
		Reducing disharmony and violence	0	0.5	0.5	1	0.5	0	
		Learning and training	Development of different skills	1	0.5	1	0.5	0.5	0.5
			Providing training courses	1	1	1	0	0	0
			Learning how to interact with the building	1	0.5	1	0	0.5	0.5
			Creating innovative ideas	1	0.5	0.5	0	0	0
		Providing needs of the community	Providing necessary requirements	1	0	1	0.5	0	0
			Providing services and solutions to societal issues	0	0	0	0	0	0
			Supporting the different groups of society	0.5	0.5	0.5	1	0.5	0.5
			Providing financial support to the community	1	0	0	0	0	0
			Providing social justice	0.5	1	0.5	0.5	0.5	0.5

Table 5 Continued

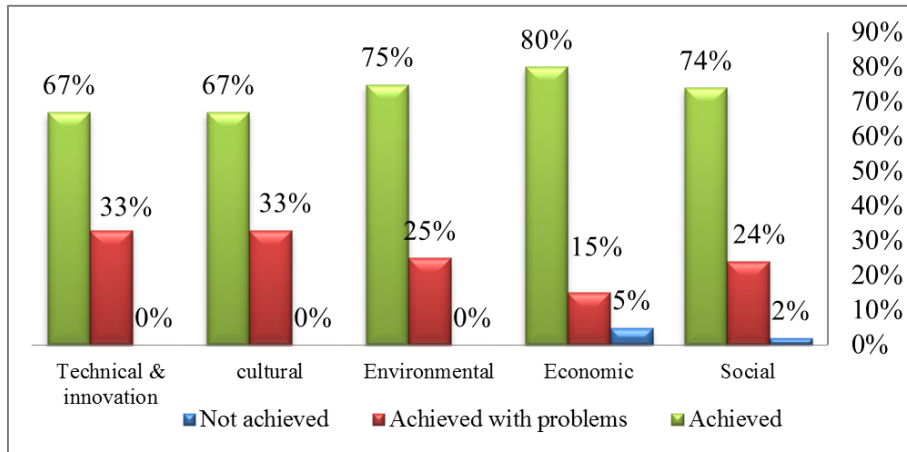
Utilizing of sustainability principles in the reuse of historical buildings	Economic dimension	Achieving economic feasibility	Investment attraction	1	1	0.5	1	0.5	0
			Exploiting available space and resources	1	1	1	0.5	0.5	0.5
			Providing renewable resources	1	1	1	0.5	0.5	0.5
			Achieving high profits	1	1	0.5	1	0.5	0.5
			Consider heritage as an independent capital	0.5	1	0	0.5	0	0
			The price of the surrounding areas is rising	1	1	0	1	1	0.5
			Supporting the local economy	0.5	1	0.5	0.5	0	0
		Employment support	Creating direct jobs	1	0.5	1	1	0.5	0.5
			Creating indirect job	1	1	1	1	1	1
		Saving renewable resources	Recycling and using materials	1	0.5	0.5	0.5	0	0
			Activating sustainable practices to reduce costs	1	1	1	0.5	0	0
			Energy saving	1	0.5	1	0.5	0.5	0.5
		Environmental dimension	Reducing pollution	Facing climate challenges	1	0.5	0.5	1	0.5
	Waste reduction			1	0.5	0.5	1	0.5	0.5
	Connecting with nature			1	1	0.5	1	0.5	1
	Not using harmful chemicals			0.5	1	1	0.5	0.5	0.5
	Emission reduction			0.5	0.5	0.5	0.5	0.5	1
	Reducing visual pollution			0.5	0	0.5	1	0.5	0.5
	Resource Management		Rationalizing the use of energy	1	0.5	1	0.5	0.5	0.5
			Rationalizing the use of water	1	1	1	0.5	0.5	0.5
			Using sustainable materials	1	1	1	0.5	1	0.5
			Material recycling	1	1	1	0.5	0	0
	comfort levels		Thermal comfort	1	1	1	0.5	0.5	0.5
Visual comfort			1	1	1	1	1	0.5	

Table 5 Continued

Utilizing of sustainability principles in the reuse of historical buildings	Cultural dimension	Define local culture	Providing educational courses for the community	1	1	0.5	1	0.5	0.5
			Provide presentations to educate the community about the culture	1	0.5	1	0.5	0	0
			The historical and cultural value of the building	1	0.5	1	1	0	0
	Technical & innovation	Updating systems	Using modern technologies	1	0.5	0.5	0.5	0.5	0.5
			Creating solutions and ideas to solve problems	1	1	1	1	1	1
			Using information technology	1	1	1	1	1	1

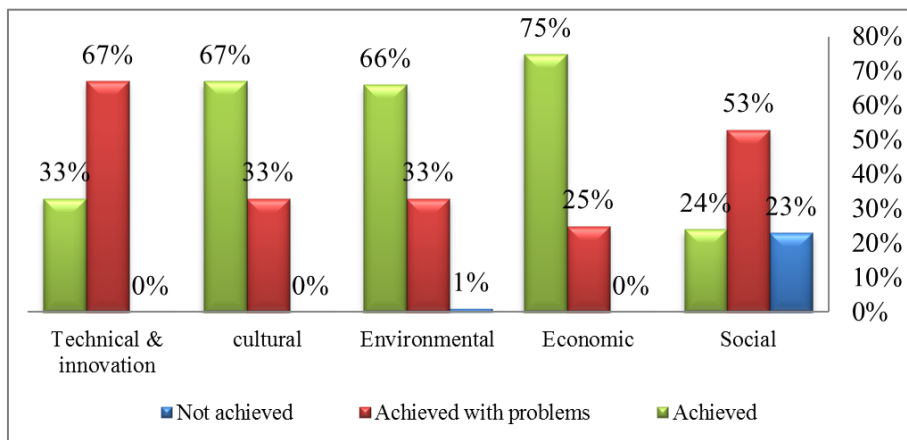
Table 6. Evaluating sustainability indicators in international case studies

Sustainability indicators in Sede Centrale Ca Foscari Palace			
Dimensions	Achieved entirely	Achieved with problems	Not achieved
Social	74%	24%	2%
Economic	80%	15%	5%
Environmental	75%	25%	0%
Cultural	67%	33%	0%
Technical& innovation	67%	33%	0%



Percentages of Sustainability indicators achieved, achieved with problems and indicators not achieved, in Sede Centrale Ca Foscari, Source.

Sustainability Indicators in Chettinadu Mansion Palace			
Dimensions	Achieved entirely	Achieved with problems	Not achieved
Social	24%	53%	23%
Economic	75%	25%	0%
Environmental	66%	33%	1%
Cultural	67%	33%	0%
Technical & Innovation	33%	67%	0%



Percentages of sustainability indicators achieved, achieved with problems and indicators not achieved, in Chettinadu Mansion.

Table 6. Continued

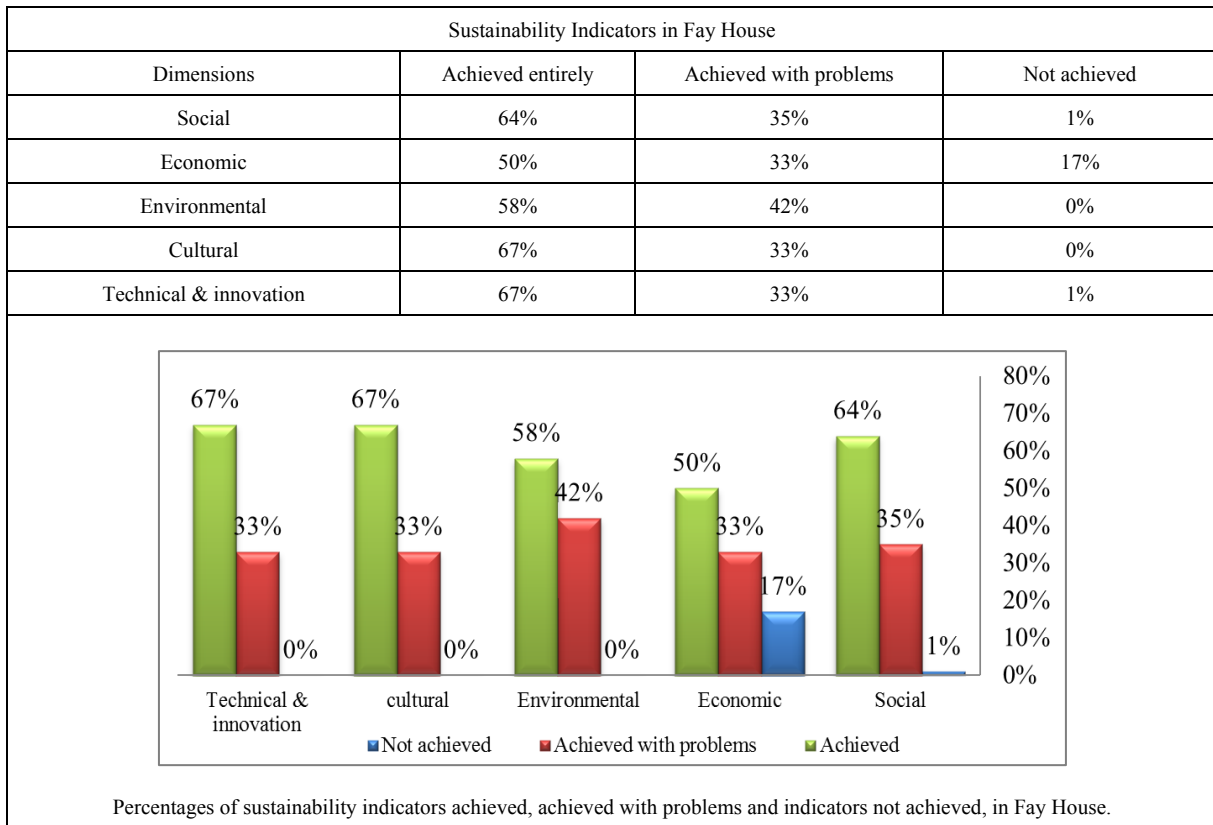


Table 7. Evaluating sustainability indicators in local case studies

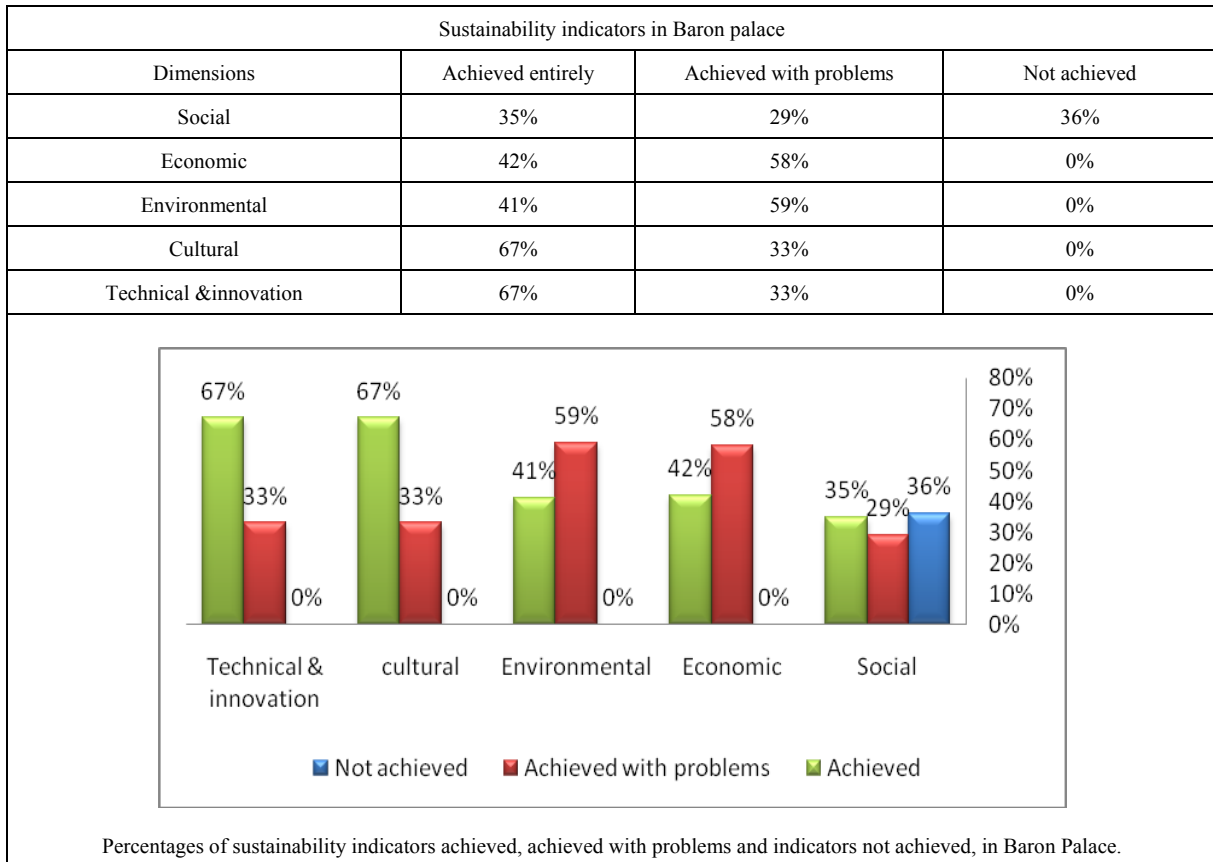
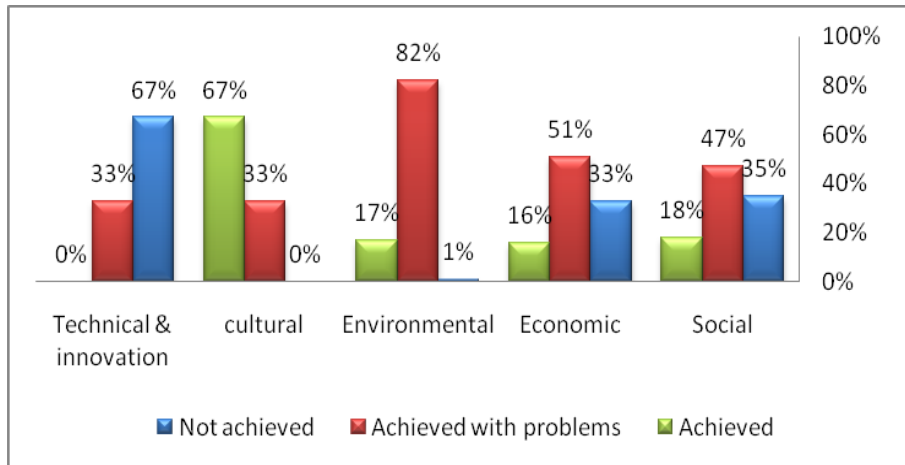


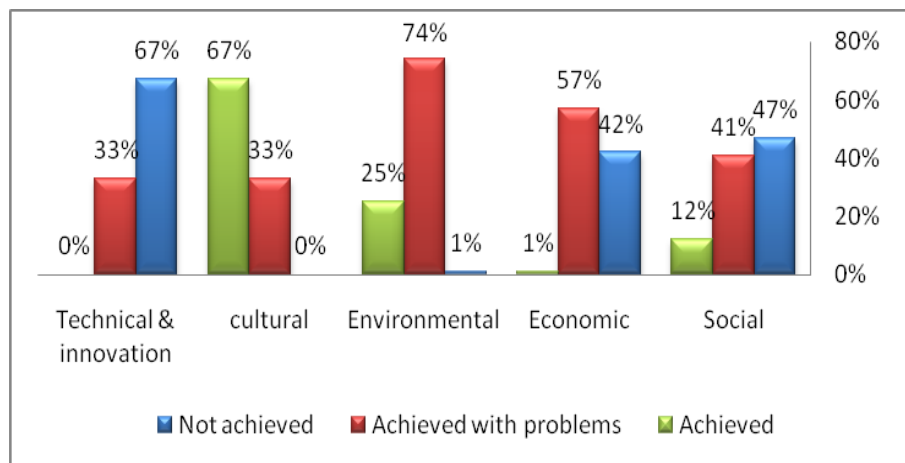
Table 7. Continued

Sustainability indicators in Beit Al-Karidleya			
Dimensions	Achieved entirely	Achieved with problems	Not achieved
Social	18%	47%	35%
Economic	16%	51%	33%
Environmental	17%	82%	1%
Cultural	67%	33%	0%
Technical & innovation	0%	33%	67%



Percentages of sustainability indicators achieved, achieved with problems and indicators not achieved, in Beit Al-Karidleya.

Sustainability indicators in Beit Al-Senary			
Dimensions	Achieved entirely	Achieved with problems	Not achieved
Social	12%	41%	47%
Economic	1%	57%	42%
Environmental	25%	74%	1%
Cultural	67%	33%	0%
Technical& innovation	0%	33%	67%



Percentages of sustainability indicators achieved, achieved with problems and indicators not achieved, in Beit Al-Senary.

7. Results and Discussion

- Historical buildings are an essential resource for sustainable development because they have unique values and sustainable potential.
- Adaptive reuse of historical buildings is a form of sustainability. There is a complementary relationship between adaptive reuse and sustainability criteria, each aiming to achieve social, economic, environmental, and cultural benefits.
- Integrating adaptive reuse techniques with the principles and techniques of sustainability in historical buildings increases the percentage of achieving sustainability indicators, which leads to many benefits while preserving the building from deterioration.
- When employing the principles of sustainability in historical buildings, many criteria must be present, including the following:
 - (a) The building must have unique and significant values.
 - (b) It must have a sustainable architectural design that contains passive systems and traditional sustainability principles, such as architectural solutions that help use natural lighting and ventilation.
 - (c) The building must be in a unique location with historical value, sustainable materials, and resources, close to services, and easy to access.
 - (d) The building must have multiple spaces, a flexible design, and a roof or garden.
 - (e) The new use of the building must meet societal needs, not cause pollution, and rely on sustainable practices and materials.
- The process of utilizing sustainability principles in historical buildings aims to improve traditional sustainability practices to make building systems more efficient.
- The process of improving sustainable practices in historical buildings requires an innovative methodology and creative solutions to meet challenges and achieve sustainability indicators.
- Egypt has a massive number of historical buildings. Therefore, many buildings were reused, including historical houses and palaces. However, the reuse processes lacked the optimal employment of sustainability principles, and traditional solutions were used, leading to the deterioration of some buildings.
- Through a field survey and analysis of local case studies, it was found that there are reused historical palaces and houses, but there are many problems. These problems are due to the lack of clarity in the criteria and methodologies for adaptive reuse, the lack of optimal use of the building's capabilities, the insufficient awareness of the importance of the values of historical buildings in the community, and the lack of financial resources and creative skills.
- Local case studies achieved many social, economic, environmental, and cultural sustainability indicators with limited use of modern technological techniques. It was found that the Baron Palace is the best local case study in employing the principles and inputs of sustainability, but there are many problems.
- Adaptive reuse approaches and the use of sustainability in historical palaces and houses in Egypt rely on traditional techniques and ideas, with a lack of community participation in decision-making and a lack of studies and research concerned with the sustainability of historical buildings, resulting in negative outcomes and the possibility of building deterioration due to inappropriate practices.
- The problems of utilizing sustainability principles in local case studies can be summarized as follows:
 - (a) The use of traditional methodologies in historical buildings, and the use of creative thinking are limited, and there are problems that traditional thinking cannot solve.
 - (b) Lack of study of society's psychological and material needs and the society's lack of awareness of the importance of historical buildings.
 - (c) Historical buildings in Egypt have not achieved international sustainability certificates, and there is no tool for assessing sustainability in historical buildings.
 - (d) Resources, materials, and spaces are not used optimally due to the lack of waste management, recycling, and reuse programs.
 - (e) Modern sustainability technologies are limited.
 - (f) There is a lack of necessary services for visitors and building users, and there are no training centers on sustainable practices.
 - (g) Buildings do not provide solutions to social problems, do not support the needs of society, ignore the needs of the elderly and the disabled, and lack interactive community activities.
 - (h) There are no innovative approaches to utilizing sustainability principles in reusing historical buildings.
 - (i) The lack of interactive community activities that enhance a sense of belonging to the place and pride in its history, activities that encourage creativity, exchange experiences, and showcase talents, and the existence of a methodology to benefit from creative energies and ideas.
 - (j) The lack of a recycling and waste management program.

Table 8. A framework for developing sustainable practices in historical buildings

Sustainability inputs		Methodology		Sustainability outputs	
Dimensions	Criteria	Sustainability practices	Techniques, tools, and creative thinking	Sustainability indicators	
Social dimension	Achieving social welfare	Interact with the building	<ul style="list-style-type: none"> • Providing interactive spaces to practice a variety of creative and social activities. • Supporting talented and creative people and providing them with tools to practice their creative hobbies and produce artistic pieces or beneficial innovative ideas. • Providing transportation to the building site and facilitating the visit. • Creating a psychological rehabilitation center and supporting the spirit of teamwork. 	<ul style="list-style-type: none"> • Using unused spaces inside or outside the building as a center for community psychological rehabilitation to provide lectures that support cooperation and psychological peace between people and the importance of human interaction. This center needs technologies such as projectors, paper publications, writing tools, illustrations, and humanities specialists. • Allocating different spaces for artists and creators, such as sitting places on the roof or in the garden, sitting in front of the building, and providing drawing, sculpting, and writing tools for them so that they can contemplate the unique architectural elements and produce works of art, such as paintings and creative ideas. • The basement can be used, or a separate unit can be created in the garden of the building to train users on sustainable practices and provide recycling techniques, sustainability programs, and specialists in the sustainability of historical buildings. • Creating a fund for social support under the auspices of the building to support services for users and poor people. • Conducting periodic meetings to discuss the most critical societal issues and provide innovative solutions. 	<ul style="list-style-type: none"> • Positive community reaction. • Feeling of belonging to history. • Community participation in decision making • Community cooperation. • Facility to use and visit. • Availability of interactive activities. • Psychological comfort. • Reducing disharmony and violence. • Development of different skills. • Providing training courses. • Learning how to interact with the building. • Creating innovative ideas. • Providing necessary requirements. • Providing services and solutions to societal issues. • Supporting the different groups of society. • Providing financial support to the community. • Providing social justice.
		Learning and training	<ul style="list-style-type: none"> • Providing a training center for sustainable practices for users and the community. • Exploiting unused spaces in the basement or the garden. • Publishing of publications on the sustainability and importance of historical buildings. 		
		Providing the needs of the community	<ul style="list-style-type: none"> • Providing financial support for the poor. • Providing free services for the disabled and the elderly. • Discussing societal problems and finding innovative solutions. 		

Table 8 Continued

Economic dimension	Achieving economic development	Achieving economic feasibility	<ul style="list-style-type: none"> Promoting the unique values of the building to attract investors and using these values to create a brand. Supporting secondary uses in the building that achieve economic benefits, such as holding temporary exhibitions or selling the products of traditional artisans. Marketing the products of productive families through the building. Diversity of use in the building. Achieving revenue from the reuse of the building. 	<ul style="list-style-type: none"> Creating a brand design for the building. Providing spaces for showing commercial products and creating capsules to display products in the garden of the building. Use part of the roof to sell art and heritage products for productive families and handmade products. Supporting small projects inside the building, such as providing spaces for a restaurant and cafe, selling gifts, and the possibility of paid photography. Using sustainable materials available on the building site to manufacture furniture and tools. Through the recycling unit and programs, new materials and tools can be produced, such as recycling paper and converting it into paper covers or making toilet paper. Using energy-saving lighting and operating the building from renewable energy sources. Drinking water can be provided through the grey water treatment unit. 	<ul style="list-style-type: none"> Investment attraction. Exploiting available space and resources. Providing renewable resources. Achieving high profits. Considering heritage as an independent capital. The price of the surrounding areas is rising Supporting the local economy. Creating direct job opportunities. Creating indirect job opportunities. Recycling and using materials. Activating sustainable practices to reduce costs. Energy saving.
		Available jobs	<ul style="list-style-type: none"> Support direct and indirect employment for a large segment of society. 		
		Saving resources	<ul style="list-style-type: none"> Using local renewable materials. Following recycling practices. Saving energy and water. 		
Environmental dimension	Preserving the environment	Reducing pollution	<ul style="list-style-type: none"> Generating energy from clean sources. Using low-emission selling materials. Solving noise and audio pollution problems. Using alternative transports. Recycling wastes in methods that do not pollute the environment. 	<ul style="list-style-type: none"> Using green cleaning techniques. Using natural materials for sound insulation to protect users from any audio pollutants outside the building. Exploiting available renewable energy sources, such as establishing an underground unit to generate energy from geothermal heat, establishing umbrellas in the garden of the building and installing solar panels on them, or installing energy trees to generate energy from sunlight and wind. Using low-flow devices for water and establishing a grey water treatment center for its reuse in toilets and irrigation of plants, this unit can be set up underground. Establishing a unit to manage passive systems in the building and provide natural ventilation. Planting trees and plants and taking care of landscaping. 	<ul style="list-style-type: none"> Facing climate challenges. Waste reduction. Connecting with nature. Not using harmful chemicals. Emission reduction. Reducing visual pollution. Rationalizing the use of energy. Rationalizing the use of water. Using sustainable materials. Materials recycling. Thermal comfort. Visual comfort.
		Resource management	<ul style="list-style-type: none"> Providing a center for waste management. Providing a center for managing materials and resources. Using renewable materials and generating energy from clean sources. 		
		Comfort levels	<ul style="list-style-type: none"> Attention to the quality of the internal environment. Providing a center for managing passive systems in the building. Connecting with nature. 		

Table 8 Continued

Cultural dimension	Supporting the cultural and historical dimension	Define local culture	<ul style="list-style-type: none"> • Presenting lectures on the history of the building and its influence in the past and present. • Providing methodologies to support the historical and cultural dimensions and raising awareness of the impact of architectural heritage on the social, economic, and environmental dimensions. • Raising awareness of the role of heritage in achieving economic development goals and attracting society to the history and importance of the building. 	<ul style="list-style-type: none"> • Simulating the history of the building and the stories it expresses through simulation programs, or making a historical panorama using technological techniques in a hall inside the building. The history of the building can be transformed into theatrical stories and displayed. • Providing data show to raise awareness of the importance of the building and its historical value. • Making historical books and magazines available to the community. 	<ul style="list-style-type: none"> • Awareness of the importance of history. • Promoting local culture. • Community attraction for historical products.
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8. A Framework for Developing Sustainable Practices in Historical Buildings

The proposed framework consists of the inputs and outputs of sustainability and the practices used to achieve sustainability standards in historical buildings in Egypt. The proposed framework aims to identify the most critical sustainable practices that will contribute to solving the problems of local case studies, as shown in Table 8.

9. Conclusion

Many challenges face the success of utilizing sustainability in historical buildings in Egypt. In addition, the lack of availability of modern sustainable technologies can be overwhelmed by combining an innovative approach with historical buildings to overcome deficiencies and increase the possibility of achieving goals efficiently. Moreover, the proposed framework helps define the dimensions and criteria for sustainability in historical buildings and methodologies that support the optimal use of building resources using an innovative approach based on creative thinking. Furthermore, sustainability indicators can be met with the help of a creative approach that helps analyze details, connect things in new ways, and find solutions.

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